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FINAL

REMEDIAL INVESTIGATION REPORT
OPERABLE UNIT NO. 9 (SITE 65)

MARINE CORPS BASE
CAMP LEJEUNE, NORTH CAROLINA

VOLUME I

CONTRACT TASK ORDER 0312

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LIST OF ACRONYMS AND ABBREVIATIONS

µg/kg	microgram per kilogram
µg/m^3	microgram per cubic meter
µg/g	micrograms per gram
µg/L	microgram per Liter
ABS	adsorption factor
AF	soil to skin adherence factor
AMTRAC	amphibious tractor
AQTESOLV	Aquifer Test Solver Program
AQUIRE	Aquatic Information Retrieval Database
ARARs	applicable or relevant and appropriate requirements
ARL	Aquatic Reference Level
ASTM	American Society for Testing Materials
AT	averaging time
ATc	averaging time carcinogen
ATnc	averaging time noncarcinogen
AWQC	Ambient Water Quality Criteria
Baker	Baker Environmental, Inc.
BCF	biological concentration factor
bgs	below ground surface
BI	biotoxic index
BOD	biological oxygen demand
BRA	baseline risk assessment
BW	body weight
CADD	computer aided design drafting
CAMA	Coastal Area Management Act
CDI	chronic daily intake
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CF	conversion factor
CFR	Code of Federal Regulations
CLEAN	Comprehensive Long-Term Environmental Action Navy
CLP	Contract Laboratory Program
COC	contaminants of concern
COD	chemical oxygen demand
COPC	contaminant of potential concern
CRAVE	Carcinogen Risk Assessment Verification Endeavor

LIST OF ACRONYMS AND ABBREVIATIONS
(Continued)

CRDL	Contract Required Detection Limit
CRQL	Contract Required Quantitation Limit
CSF	carcinogenic slope factor
4,4'-DDD	dichloro-diphenyl-dichloroethane
4,4'-DDE	dichloro-diphenyl-dichloroethylene
4,4'-DDT	dichloro-diphenyl-trichloroethane
DEM	Division of Environmental Management
DoN	Department of the Navy
ED	exposure duration
EF	exposure frequency
Eh	oxidation reduction potential
EL	exposure level
EMD	Environmental Management Division
ER-L	Effects Range - Low
ER-M	Effects Range - Median
ERA	ecological risk assessment
ET	exposure time
FFA	Federal Facilities Agreement
F_i	fraction ingested from source
f_{oc}	sediment particle grain size
FS	Feasibility Study
FSAP	Field Sampling and Analysis Plan
gpm	gallons per minute
H	mean species diversity
HA	health advisory
HEAST	Health Effects Assessment Summary Tables
HI	hazard index
HQ	hazard quotient
HQW	high quality water
IAS	Initial Assessment Study
ICR	incremental cancer risk
ID	inside diameter
IDW	investigative derived wastes

LIST OF ACRONYMS AND ABBREVIATIONS
(Continued)

IR	ingestion rate
IRIS	Integrated Risk Information System
IRP	Installation Restoration Program
K_d	soil sorption coefficient
K_{oc}	organic carbon partition coefficient
K_{ow}	octanol-water partition coefficient
LANTDIV	Naval Facilities Engineering Command, Atlantic Division
LOAEL	lowest-observed-adverse -effect level
MBI	Macroinvertebrate Biotic Index
MCB	Marine Corps Base
MCL	Maximum Contaminant Level
MF	Modifying Factor
MI	Mobility Index
msl	mean sea level
NC DEHNR	North Carolina Department of Environment, Health and Natural Resources
NCMFC	North Carolina Marine Fisheries Commission
NCSPCS	North Carolina State Plane Coordinate System
NCWQC	North Carolina Water Quality Criteria
NCWQS	North Carolina Water Quality Standards
NCWRC	North Carolina Wildlife Resources Commission
NEHC	Navy Environmental Health Center
NOAA	National Oceanographic and Atmospheric Administration
NOAEL	No-Observed-Adverse-Effect-Level
NOEL	No-Observed-Effect-Level
NPL	National Priorities List
NPS	National Park Service
NSW	nutrient sensitive waters
NTU	Nephelometric turbidity unit
NUS	NUS Corporation
NWI	National Wetlands Inventory

LIST OF ACRONYMS AND ABBREVIATIONS
(Continued)

OU	Operable Unit
ORNL	Oak Ridge National Laboratory
PAH	polynuclear aromatic hydrocarbon
PC	permeability constant
PCBs	polychlorinated biphenyls
PEF	particulate emissions factor
PID	photoionization detector
POL	petroleum, oil, lubricants
ppb	parts per billion
ppm	parts per million
PVC	polyvinyl chloride
QA/QC	quality assurance/quality control
QI	quotient index
RA	risk assessment
RBC	risk-based concentration
RCRA	Resource Conservation and Recovery Act
RfD	reference dose
RI	Remedial Investigation
ROD	Record of Decision
S	water solubility
SA	exposed skin surface area
SARA	Superfund Amendments and Reauthorization Act
SCS	Soil Conservation Service
SI	Site Inspection
SMCL	Secondary Drinking Water Regulations
SOP	Standard Operating Procedures
SQC	Sediment Quality Criteria
SSV	Sediment Screening Value
SSSV	Surface Soil Screening Value
SVOC	semivolatile organic compound
SWSV	surface water screening value
TAL	Target Analyte List
TCL	Target Compound List
TCLP	Toxicity Characteristic Leaching Procedure

LIST OF ACRONYMS AND ABBREVIATIONS
(Continued)

TDS	total dissolved solids
TEF	toxicity equivalency factor
TICs	tentatively identified compounds
TKN	total Kjeldahl nitrogen
TOC	total organic carbon
TPH	total petroleum hydrocarbons
TRVs	terrestrial reference values
TSS	total suspended solids
UCL	Upper Confidence Limit
UF	uncertainty factor
USCS	Unified Soil Classification System
USDA	Untied States Department of Agriculture
USDI	United States Department of Interior
USEPA	United States Environmental Protection Agency
USGS	United States Geological Survey
USMC	United States Marine Corps
VOC	volatile organic compound
WAR	Water and Air Research, Inc.
WQSV	water quality screening values
WS	Wilderness Society

EXECUTIVE SUMMARY

This document was prepared by Baker Environmental, Inc. (Baker) to report on the activities and findings of the Remedial Investigation (RI) conducted at Operable Unit No. 9, Site 65 - Engineer Area Dump, in the spring of 1995.

The purpose of the RI is to evaluate the nature and extent of the threat to public health and the environment caused by the release or threatened release of hazardous substances, pollutants, or contaminants (USEPA, 1988). The RI at Site 65 was conducted through the sampling of several media (surface and subsurface soil, groundwater, surface water, sediment, and benthic and aquatic species), evaluating the resultant analytical data, and performing human health and ecological risk assessments (RAs). This RI has been conducted in accordance with the requirements delineated in the National Oil Hazardous Substance Pollution Contingency Plan (NCP) for remedial actions [40 Code of Federal Regulations (CFR) 00.430]. The USEPA's document Guidance for Conducting Remedial Investigations and Feasibility Studies Under CERCLA (USEPA, 1988a) has been used as guidance for preparing this document.

Site Description and History

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

Operable Unit No. 9 is located in the Courthouse Bay area of MCB, Camp Lejeune, south of Hadnot Point, on the eastern shore of the New River. Site 65, the Engineer Area Dump, is a primarily wooded area located immediately west and north of the Marine Corps Engineer School which occupies property between Site 65 and Courthouse Bay north of the site is NC Route 72. The eastern edge of Site 65 is bordered by a several acre parcel used by the Engineer School to conduct heavy equipment training activities. To the east of the heavy equipment training area are two small ponds. Portions of the area surrounding the ponds are marshy.

Site 65 reportedly operated from 1952 to 1972. Two separate disposal areas have been reported including: (1) a battery acid disposal area; and, (2) a liquids disposal area. There are no historical maps or figures which depict the location of the disposal areas, and neither area is currently discernible due to heavy overgrowth. Aerial photographs, dating from 1956 through 1993, are available at the base Forestry Division and through the United States Department of Agriculture Aerial Photography Field Office. The photos through 1983 depict disturbed areas east of the Engineer School which represent perhaps the best available means for approximately locating the site. In addition, Camp Lejeune base maps, available via Computer-Aided Design Drafting, indicate the location of a burn area which was identified as part of Site 65 under the Initial Assessment Study (IAS) by Water and Air Research (WAR, 1983). Like the disposal area, the location of the burn area is not currently discernible from the surrounding landscape.

Previous Investigations

The following is a summary of the previous investigations performed at Site 65.

Initial Assessment Study

MCB, Camp Lejeune was placed in the National Priority List (NPL) on October 4, 1989 after the IAS in 1983 identified 76 potentially contaminated sites at the base (Water and Air Resources, 1983). Site 65 was mentioned in the report as a site which did not warrant further investigation. Sampling and analysis of environmental media was not conducted during the IAS. The IAS did not indicate that hazardous wastes were disposed of at Site 65.

Site Inspection

Do we know why?

NUS Corporation prepared Site Inspection (SI) Project Plans in the spring of 1991 (NUS, May 1991). This report identified both petroleum, oil, and lubricant wastes and batteries as having been disposed of at Site 65. The basis upon which it was concluded that battery disposal occurred at Site 65 is unknown. Baker conducted an SI at Site 65 in July and August, 1991, and published the Final Site Inspection Report on January 31, 1994. The objectives of the SI were to: (1) determine whether there was a release or potential release of hazardous substances and the nature of the associated threats; (2) preliminarily assess the extent of contamination and the volume/type of wastes at the site; and, (3) determine if further action or investigations are required.

Groundwater samples collected from the three shallow monitoring wells all exhibited elevated metal concentrations (e.g., arsenic, beryllium, chromium, copper, lead and manganese) above either North Carolina groundwater regulatory levels and/or federal primary/secondary drinking water standards. Organic contaminants in groundwater were limited to one detection of a pesticide below regulatory levels. Low levels of polynuclear aromatic hydrocarbons (PAHs) were detected in two of the eight surface soil samples. Various pesticides were also detected in three of the eight surface soil samples and one subsurface soil sample. Aroclor-1254, a polychlorinated biphenyl (PCB), was detected in one subsurface soil sample (65SB0212) at 230 µg/kg.

Federal surface water standards were exceeded for lead, copper, and iron, while barium and chromium exceeded state surface water standards. Sediment samples collected from the ponds exhibited low levels of phenolic constituents (76 µg/kg of phenol and 930 µg/kg of 4-methylphenol). Sediment screening values for the protection of biota were exceeded in the marsh sample for copper, lead, zinc, and pesticides dichloro-diphenyl-dichloroethane (4,4'-DDD) and dichloro-diphenyl-dichloroethylene (4,4'-DDE).

The SI recommended that: (1) a Remedial Investigation/Feasibility Study be conducted to provide data for the evaluation of the nature and extent of soil and groundwater contamination, and a baseline human health and ecological risk assessment; (2) historical aerial photographs be obtained to determine the locations where disposal activities occurred; (3) background and upgradient shallow groundwater quality be assessed to better determine whether inorganic contamination of the shallow aquifer is due to disposal operations; and (4) groundwater quality in the deeper portions of the shallow aquifer as well as the Castle Hayne be assessed including the possible influence of the supply wells on groundwater flow.

Study Area Investigation

The RI field program at Site 65 consisted of: a soil investigation; a groundwater investigation; surface water and sediment investigations; an ecological investigation; a site survey; and investigation derived waste (IDW) handling. The RI field activities conducted were initiated April 3 and concluded May 25, 1995. Additional work (IDW management, surveying, and groundwater elevation measurements) was conducted between May 26 and August 21, 1995. All field activities were performed in accordance with the Field Sampling and Analysis Plan (FSAP) (Baker, 1995), and USEPA Region IV Standard Operating Procedures.

Soil Investigation

A soil investigation was conducted at Site 65 to assess the nature and extent of previously detected contamination and to assess human health, ecological, and environmental risk associated with contact, inhalation and possible ingestion of surface and subsurface soil particles. The soil investigation included soil borings and test pit excavation.

Baker supervised the advancement of 14 soil borings for the purpose of sample collection, geologic identification and description, and monitoring well installation. One surface soil sample was collected from each boring/well cluster location, a total of 13, from zero to 12 inches below the ground surface. A total of 13 subsurface soil samples were also taken, each from immediately above the soil/groundwater interface. Drilling and soil boring sampling activities at the site were initiated on April 4, 1995, and were completed on April 20, 1995. All drilling was performed using a truck-mounted drill rig supplied and operated by Parrott Wolff, Inc.

As part of the soil investigation, Baker conducted an exploratory test pit investigation at Site 65 to determine the presence and nature of buried material in the debris piles at the southwestern portion of the site. Observations of waste disposal such as fill material, debris or depressions were used in locating the test pit excavations. Six test pits were excavated, and one subsurface soil sample was taken from each pit.

The analytical program initiated for the soil investigation at Site 65 focused on the suspected contaminants of concern which were based on previous disposal practices, site activities and findings of previous investigations. In general, soils at the site, including quality assurance/quality control (QA/QC) samples, were analyzed for Target Compound List (TCL) organic compounds and Target Analyte List (TAL) metals. In addition, a single soil sample was submitted for engineering parameters analyses. For a complete summary of soil samples taken during the RI, refer to Appendix B.

Groundwater Investigation

The groundwater investigation at the Site 65 consisted of several activities including construction of shallow and deep monitoring wells, well development, groundwater sampling, static water measurement and aquifer testing. The investigation was designed to confirm the presence or absence of shallow and deep groundwater contamination, evaluate the horizontal and vertical extent of potentially impacted groundwater, and evaluate the shallow and deep groundwater flow patterns in the area.

Seven of the soil borings advanced as part of the soil investigation were drilled to be converted into groundwater monitoring wells. Four Type II shallow monitoring wells were installed and three Type III deep monitoring wells. Two well clusters, one shallow and one deep groundwater monitoring well, were established, two by setting deep wells next to existing shallow wells (65-DW01 and 65-DW02) and one as an upgradient, background well cluster (65-MW04 and 65-DW04).

The remaining three shallow monitoring wells (65-MW05, 65-MW06, and 65-MW07) were spaced across the study area. After being properly developed, a single round of groundwater samples was collected from each of the seven newly installed wells and the three existing wells to confirm the presence or absence of contamination in the surficial and Castle Hayne aquifers.

Three rounds of water levels were collected at Site 65 on April 20, 23, and August 21, 1995 to establish shallow groundwater flow in the Engineer Area Dump region. Measurements were collected within a four-hour time period during each event. Hydraulic conductivity testing was conducted on three shallow wells at Site 65 to evaluate shallow groundwater flow characteristics. Monitoring wells 65-MW04, 65-MW05 and 65-MW07 were tested on May 22 and 23, 1995.

Ten groundwater samples, plus QA/QC samples, were analyzed for TCL organics, and TAL metals. In addition, one sample was collected for the analysis of engineering parameters. For a complete summary of groundwater samples taken during the RI, refer to Appendix B.

Surface Water/Sediment Investigation

A surface water and sediment investigation was performed in Courthouse Bay Pond and Powerline Pond to assess possible impacts from Site 65 and to assist in human health and ecological RAs. A single sample location was established in each pond. Sample 65SW/SD-04 was collected from the middle of Courthouse Bay Pond and Sample 65SW/SD-05 was collected from the eastern portion of Powerline Pond. Two additional sample locations in the marshy area near the ponds were not sampled due to the particularly dry season and lack of surface water.

Surface water/sediment samples were analyzed for TCL organics, TAL metals and total organic carbon (TOC). In addition, the zero- to six-inch sample for each location was analyzed for TOC and particle-size distribution. A complete summary of the sample numbers and analytical parameters is provided in Appendix B.

Ecological Investigation

Baker conducted an ecological investigation at Site 65 to provide data to support the ecological RA. Biological samples collected as part of this investigation included fish and benthic macroinvertebrates from Courthouse Bay Pond and Powerline Pond. The samples were collected to obtain population statistics for fish and benthic macroinvertebrates and to obtain fish tissue samples for chemical analysis. A total of nine fish samples were collected; four fillet samples and five whole-body samples. One benthic macroinvertebrate sample was taken from each pond.

Whole-body and fillet samples were collected from the fish and analyzed for TCL organics and TAL metals. The samples were prepared in accordance with USEPA Region IV protocols by the laboratory. Refer to Appendix B for a complete summary of the sample numbers and analytical parameters. The benthic macroinvertebrate samples were analyzed for species density in individuals per square meter.

Physical Characteristics of the Study Area

The physical characteristics of Site 65 were evaluated during all phases of the RI. These characteristics include: surface features, climatology and meteorology, hydrology, geology, soils, hydrogeology, land usage, ecology, and the water supply for the area. The site specific information was obtained from the RI field activities. Information regarding regional characteristics was taken from available literature pertaining to MCB, Camp Lejeune.

Topography and Surface Features

The topography of Site 65 is gently pitched to the southeast. The site has numerous areas where the natural topography has been modified by the removal and redistribution of earth materials (i.e., training exercises) or by past dumping practices. A 4.5-percent grade exists between monitoring wells 65DW-04 (located near the ponds east of the site) and 65DW-02 (located on the southeastern edge of the site). Infiltration is high at the site due to the lack of man-made drainage ditches and impervious surfaces such as paved roads, parking lots or buildings.

Surface Water Hydrology

Due to the sandy surface soils at Site 65, there is relatively little stormwater runoff. The limited surface water runoff tends to drain radially to the east, south, and west, away from the site or collect in local surface depressions.

The ponds located east of Site 65 have not been classified by NC DEHNR. The ponds are freshwater ponds not used for consumptive purposes, and are not used for primary recreation. They were, therefore, assigned a Class C classification. This classification is reserved for freshwater bodies in which aquatic life propagation and survival, fishing, wildlife, secondary recreation and agricultural uses may occur. During the wet seasons, a marshy area exists near these two ponds.

Geology

Soil conditions are generally uniform throughout the study area. In general, the shallow soils consist of unconsolidated deposits of sand and silty sand. These soils represent the Quaternary age "undifferentiated" deposits which overlay the River Bend Formation. Sands are primarily very fine to fine grained and contain varied amounts of silt and clay. Underlying these soils is a loose to medium dense, greenish gray, fine sand containing little clay (approximately 10-35%) and trace silt. This soil unit constitutes the Belgrade Formation in the semi-confining unit separating the Quaternary sediments from the Castle Hayne aquifer. The semi-confining unit appears to be approximately 7.5 to 15 feet thick, generally thickening toward the north. Beneath this unit resides the River Bend Formation. Borings were only advanced 10 to 15 feet into this formation during the RI, therefore providing limited knowledge of specific details regarding the condition of the River Bend beneath the study area. The upper portion of the River Bend was described as a partially cemented, gray, fine sand with some shell fragment and limestone fragments encountered periodically.

Hydrogeology

Hydrogeologic characteristics in the vicinity of the site were evaluated by reviewing existing information and installing a network of shallow and deep monitoring wells. Groundwater was encountered at varying depths during the drilling program. This variation is primarily attributed to topographical changes. In general, the groundwater was encountered between 7.5 and 11 bgs feet during field activities performed at the site.

Three rounds of groundwater level measurements were obtained on April 20, 23 and August 21, 1995, from the shallow and deep monitoring wells within the study area. Using the data from August 21, 1995, shallow groundwater flow patterns were evaluated. The data indicates that the groundwater flow is toward the south-southwest, with an average gradient of 9.7×10^{-3} ft/ft. The southwestern portion of the site has a steeper gradient (an average of 1.2×10^{-2} ft/ft) than the rest of the site (an average of 8.2×10^{-3} ft/ft). Hydraulic conductivity tests were performed at the site on May 22, 1995. The average conductivity for the surficial aquifer is 0.722 ft/day (2.55×10^{-4} cm/sec).

Groundwater elevations and flow patterns for the upper portion of the Castle Hayne aquifer were also evaluated. Given the limited number of points, groundwater flow direction and gradient is estimated to flow in a southern to southwestern direction with a gradient of 2.3×10^{-03} to 2.7×10^{-03} ft/ft.

Water Supply

Potable water for MCB, Camp Lejeune is supplied entirely by groundwater. All of the water supply wells utilize the Castle Hayne aquifer. Five active wells are located within a one-mile radius of Site 65. Production well BB44 is located approximately 1,200 feet west of the site. The total depth of this well is 62 feet bgs and is screened from 32 to 62 feet bgs. This well is suspected to have been impacted by surficial groundwater infiltration due to its relatively shallow screen.

Ecological Characteristics

During May 15 to 24, 1995, Baker conducted a qualitative habitat evaluation of the terrestrial environment at Site 65. The site and surrounding areas are dominated by a mixed forest composed of pine and deciduous trees. Cleared, sandy areas are located to the south and southeast of the site. Buildings, mowed grass, and paved surfaces are located to the west, and an earth moving training area is located east of Site 65. Mixed forest extends across Site 65, and is interspersed around the aforementioned zones. The following four habitat types are present at Site 65: forested areas, two separate wetland areas, and a low-lying drainage area.

Nature and Extent of Contamination

The nature and extent of contamination at Site 65 was determined based on the analytical results of the surface soil, subsurface soil, test pits, groundwater, surface water, sediment, and fish sampling performed. A summary of site contamination, by media, is provided in Table 4-3. The Data Frequency Summaries for all media at Site 65 are presented in Appendix O.

Soils

A total of 13 surface soil samples were collected from various locations across Site 65. Six of the samples were collected near the waste piles and burn area. The remaining samples were collected from other locations potentially impacted by historical activities at the site.

Six volatile organic compounds (VOCs) were detected in the surface soil samples, although four of the compounds were determined to be laboratory contaminants. The two remaining VOCs detected at low levels in surface soils were ethylbenzene and total xylenes. The concentrations of these compounds do not indicate a specific source, but may have originated from vehicles and heavy equipment passing through the site.

A total of 19 semivolatile organic compounds (SVOCs) were detected in surface soils. SOVCs were detected in 12 of 13 surface soil samples. The most widespread compound was bis(2-ethylhexyl) phthalate which was detected at nine locations, with a maximum concentration of 87J µg/kg. This phthalate is a common plasticizer in rubber and plastic products, such as tires. All of the sample locations with estimated concentrations of these phthalates are near roads or equipment training areas. Polynuclear aromatic hydrocarbon (PAH) constituents were detected in three samples, all near existing or previously existing debris piles. The suspected source of the PAH contamination is the debris and historic burning at the site. The highest PAH concentrations were found in Sample 65-DW01-00, the sample location closest to the former burn area. Di-n-butyl phthalate was detected at two locations near the waste piles, with a maximum concentration of 390J µg/kg. A specific source for this contaminant cannot be identified.

Pesticides were detected in all areas of the site. The levels detected in the samples are similar to base-wide concentrations from the historical use of pesticides at Camp Lejeune. PCB compound Aroclor 1260 was detected in one location near the burn area and the southernmost debris piles. The compound was detected in sample 65-DW01-00 at a concentration of 52J µg/kg. Historical records do not indicate the disposal of PCBs; however, PCBs were detected in a subsurface soil sample collected from soil boring 65SB-02 during the SI conducted in 1991 (Baker, 1994). The detection of PCBs within the vicinity of the debris piles indicates that some product containing PCBs may have been spilled or disposed at the site.

Surface soil sample analytical results for TAL metals were compared to a screening level of two times average background concentrations as listed in Appendix L. Seven of 13 sample locations exceeded two times average base background for one or more elements. The contamination was observed in the heavy equipment training area and the southernmost debris pile. The distribution of the metals indicate that the contamination may be the result of rusting metal debris disposed at the site and the heavy equipment used for training.

Subsurface Soil

A total of 13 subsurface soil samples were collected from the same locations within Site 65 as the surface soil samples.

Five VOCs were detected in the subsurface soil samples, although four of the contaminants were determined to be laboratory contaminants. Xylene was the only remaining VOC detected in subsurface soils and it was detected at five locations with a maximum concentration of 3J µg/kg. Xylenes are a constituent of petroleum products which may have been deposited by heavy equipment.

Sixteen SVOCs were detected in the subsurface soils at 11 locations. The most widespread compound was bis(2-ethylhexyl) phthalate which was detected at all 11 locations, with a maximum concentration of 370 µg/kg. The source of this contaminant is assumed to be the same as for detections in surface soil although this compound is also commonly a laboratory and field contaminant. Di-n-butyl phthalate was detected at the same two locations as it was detected in the surface soils with the maximum concentration at 340J µg/kg. The remaining 14 SVOCs, all PAH constituents, were detected at 65SB-06 at a depth of three to five feet. The total PAH concentration was 1,635 µg/kg. Twelve of the 16 SVOCs detected in subsurface sample 65SB-06 were also present in the surface soil sample for this location.

Pesticide results for subsurface soil samples included detections at four of 13 locations. Detections mainly occurred in areas where the soils have been either disturbed by excavation or disposal. The occurrence of pesticide contamination may be attributed to the historical use of pesticides at MCB, Camp Lejeune. PCBs were not detected in the subsurface soil samples collected during the field investigation.

Nine of 13 subsurface soil sample locations exceeded two times the average base background for one or more metals. The majority of the metal contamination occurred in either the heavy equipment training area or the debris piles. The suspected source of contamination is rusting metal.

Test Pits

A total of six subsurface soil samples were collected from test pits near the waste piles and burn area.

Three VOCs were detected in the soil samples from the test pits, although all of the compounds were detected in the QA/QC blanks and determined to be laboratory contaminants. Fifteen SVOCs were detected in the subsurface soil samples from six test pit locations. The most widespread compound was di-n-butyl phthalate which was detected at all six test pit locations at a maximum concentration of 280 µg/kg. Bis(2-ethylhexyl) phthalate was detected at four test-pit locations. The remaining 13 SVOCs were all detected at 65TP-07 at a depth of 10 feet. All of these compounds are PAHs with a total concentration of 1,873 µg/kg.

Pesticide results for subsurface test-pit soil samples included detections at four of six locations. All six test pit sample locations exceeded two times the average base background for two or more elements. The suspected source of the metal contamination is the rusting debris disposed of in these piles.

Groundwater

One round of groundwater samples was collected from the three existing and seven newly installed monitoring wells at Site 65.

Carbon disulfide was the only VOC detected in the groundwater samples that was not detected in any of the blank samples collected during the RI. It was detected in one upgradient sample location at a concentration of 5J µg/L. The SVOC naphthalene was detected in one sample collected at the site at an estimated concentration of 3J µg/L. As with the detection of carbon disulfide, naphthalene was detected in an upgradient location and is suspected to have originated from an off-site source. Groundwater samples collected from the monitoring wells contained no detectable concentrations of pesticides or PCBs.

Metal concentrations were, on average, one or two orders of magnitude below the base background levels for groundwater (Baker, 1994). Only two of the elements were detected at concentrations that exceed the state and/or federal standards. Iron concentrations in five samples exceeded the North Carolina Water Quality Standards (NCWQS) of 0.3 mg/L (300 µg/L) with the highest detected level being 6,580 µg/L. Manganese values exceeded the NCWQS of 0.05 mg/L (50 µg/L) in six samples. The highest detected concentration was 186 µg/L. Neither iron nor manganese concentrations exceeded the federal Maximum Contaminant Level value in any of the samples collected at the site.

Surface Water

A total of two surface water samples were collected from Powerline Pond and Courthouse Bay Pond during the RI at Site 65. There were no organic compounds detected in surface water which were not attributable to laboratory contaminants. A total of 13 of the 23 TAL metals were detected in the surface water samples collected at the site. Aluminum, barium, copper, iron, lead, manganese, vanadium and zinc exceeded the lowest Surface Water Screening Value (SWSV). All of the detected element concentrations except iron exceeded the average reference station concentration established at Camp Lejeune. The only sources of recharge for the ponds are groundwater and stormwater runoff. Water evaporation and soil erosion are suspected causes of elevated metals in the ponds.

Sediment

A total of four sediment samples were collected from Courthouse Bay Pond and Powerline Pond during the field investigation at Site 65. Two VOCs not attributable to laboratory contaminants were detected in sediment samples. Carbon tetrachloride and tetrachloroethene were detected in two of four samples with maximum concentrations of 18 µg/L and 15J µg/L, respectively. The sources of these contaminants have not been determined. The detected levels do not exceed sediment screening values. Only a single SVOC, di-n-butylphthalate, was detected in the sediment samples in all four samples with a maximum concentration of 1,600J µg/L. This phthalate ester was detected in blank samples collected during the RI. However, the concentrations within the blanks were substantially lower than the results obtained from the sediment samples. Only one sample contained concentrations of di-n-butylphthalate that exceeded the Lower Effects Range criteria.

Pesticides were detected in all four sediment samples. Beta-BHC was detected in only one sample at a concentration of 8.3NJ µg/L and 4,4'-DDD and 4,4'-DDE were detected in two samples with maximum concentrations 84J µg/L and 19NJ µg/L, respectively. All of these compounds exceeded the lowest SSV and the average reference concentration. These concentrations are similar to the concentrations detected in the surface soils across the site.

Thirteen of 23 TAL metals were detected in the sediment samples collected during the field investigation. Copper, lead and zinc were detected at a concentration exceeding the lowest SSV only one time; however, all of the elements exceeded the average reference concentration at least one time. The elemental contamination detected in the sediments of the two ponds is suspected to be the result of precipitation of the metals contained within the surface water as evaporation occurs. In addition, the surrounding soils may contribute to the sediments via erosion, especially considering the turbidity of Courthouse Bay Pond, thus increasing the contamination within the sediments.

Fish

A total of nine fish samples were collected from the two ponds located east of the site. Four samples were collected for fillet analysis and five for whole-body analysis.

The only organics detected in the fillet samples were acetone and 4,4'-DDD. Acetone was detected in two samples with a maximum concentration of 7,900 µg/kg. 4,4'-DDD was detected in one sample at a concentration of 5.7J µg/kg. Twelve of the 23 TAL metals were detected in the fish fillet samples collected during the RI. Aluminum, barium, calcium, copper, magnesium, manganese, mercury, potassium, selenium, sodium, thallium, and zinc were the detected inorganic elements.

Four VOCs were detected in the whole-body samples collected during the field investigation, which are probably attributed to laboratory conditions. There were no SVOCs detected in the samples; but there were two pesticides detected. 4,4'-DDE was detected in a single sample at a concentration of 15J µg/kg; 4,4'-DDD was detected twice with a maximum concentration of 40J µg/kg. No PCBs were detected in any of the whole-body samples. Seventeen of the 23 TAL metals were detected in the whole-body samples. The elements detected were aluminum, antimony, arsenic, barium, beryllium, calcium, copper, iron, lead, magnesium, manganese, mercury, potassium, selenium, sodium, thallium, and zinc. Mercury contamination is not related to Site 65 or the local environment. Other potential sources for mercury in fish could be that these fish may be transported to these ponds or that bioaccumulation is occurring through a food chain.

Baseline Risk Assessment

The baseline risk assessment (BRA) evaluates environmental media at Site 65, in terms of human health risks, current and future, due to contaminants of potential concern (COPCs). The BRA process examines the data generated during the sampling and analytical phase of the RI and identifies COPCs with respect to the geographic, demographic, physical, and biologic characteristics of the study area for each media. COPCs for Site 65 were selected according to the USEPA's Risk Assessment Guidance for Superfund (USEPA, 1989a). A list of these COPCs is presented in Table 6-10.

Potential receptors at Site 65 include future residential children and adults, current military personnel (trainees and recreational users), fisherman (adult and child), and future construction workers. Total site Incremental Cancer Risk (ICR) and Hazard Index (HI) per receptor group is estimated by summing the ICRs and HIs for each specific exposure pathway likely to affect the given receptor.

The total site ICR and HI values associated with current and future receptors at Site 65 are presented in Table ES-1. All incremental lifetime cancer risk estimates for the five receptor groups were between 8.2E-09 and 2.8E-06, thus all cancer risks are either insignificant or within the acceptable USEPA range of 1.0E-06 to 1.0E-04. The HI value for a young child consuming fish exceeded the reference value of 1.0 primarily due to mercury in fish tissue. The remaining estimated HIs for noncarcinogens were all less than 0.47.

TABLE ES-1

TOTAL SITE RISK
SITE 65 - ENGINEER AREA DUMP
REMEDIAL INVESTIGATION, CTO-0312
MCB, CAMP LEJEUNE, NORTH CAROLINA

Receptors	Soil		Groundwater		Surface Water/Sediment		Fish Tissue		Total	
	ICR	HI	ICR	HI	ICR	HI	ICR	HI	ICR	HI
Current Military Personnel - Trainee	7.3E-07 (100)	0.06 (100)	NA	NA	NA	NA	NA	NA	7.3E-07	0.06
Current Military Personnel - Recreational User	3.5E-07 (100)	<0.01 (100)	NA	NA	NA	NA	NA	NA	3.5E-07	<0.01
Future Child Resident	3.7E-06 (99.8)	0.01 (2)	--	0.1 (20)	8.2E-09 (<1)	0.36 (78)	NA	NA	3.7E-06	0.47
Future Adult Resident	2.8E-06 (99.7)	<0.01 (<1)	--	0.04 (40)	9.5E-09 (<1)	0.06 (60)	NA	NA	2.8E-06	0.1
Future Construction Worker	1.3E-07 (100)	0.08 (100)	NA	NA	NA	NA	NA	NA	1.3E-07	0.08
Fisherman - Child Receptor	NA	NA	NA	NA	8.2E-09 (100)	0.36 (22)	--	1.3 (78)	8.2E-09	1.7
Fisherman - Adult Receptor	NA	NA	NA	NA	9.5E-09 (100)	0.06 (18)	--	0.27 (82)	9.5E-09	0.33

Notes:

ICR	=	Incremental Lifetime Cancer Risk
HI	=	Hazard Index
( )	=	Approximate percent contribution to the total ICR or HI values
Total	=	Soil + Groundwater + Surface Water/Sediment + Fish Tissue
NA	=	Not Applicable
--	=	No carcinogenic COPCs selected

Ecological Risk Assessment

The objective of the environmental risk assessment (ERA) was to evaluate if past reported disposal practices at Site 65 are potentially adversely impacting the aquatic and terrestrial communities on, or adjacent to, the site.

Aquatic Ecosystem

Based on the results of the field investigation and the ERA evaluation, a change in the structure of the benthic macroinvertebrate communities and/or a potential reduction of an aquatic receptor population or subpopulation may be attributable to contaminants detected in the surface water and/or sediment, although none of these contaminants are thought to be site-related. The low number of species and benthic macroinvertebrates in Courthouse Bay Pond most likely is due to the low dissolved oxygen concentration (2.0 ppm) and suspended solids in the pond. Since one benthic macroinvertebrate species collected in Powerline Pond is indicative of excellent water quality, and another is indicative of good to fair water quality, the benthic macroinvertebrate population in this pond does not appear to be adversely impacted. The decreased fish population in Courthouse Bay Pond also is most likely due to the high suspended solids concentration in this pond.

Overall, there is a moderate potential risk to aquatic life in Courthouse Bay Pond, with most of the risk associated with the non-site-related suspended solids in the surface water. There is only a slight risk to aquatic life in Powerline Pond due to pesticide contamination. Based on the ERA, no further investigations are deemed necessary. However, it is recommended that controls be established to prevent runoff from the heavy equipment training area to Courthouse Bay Pond.

Terrestrial Ecosystem

The ERA concluded that some potential impacts to soil invertebrates and plants may occur as a result of site-related contaminants in surface soil. It should be noted that there is much uncertainty in the surface soil screening values. A potential decrease in the terrestrial vertebrate population from site-related contaminants is not expected based on the terrestrial intake model.

Conclusions

Overall, the conclusion of the Site 65 RI is that there are no releases of hazardous substances from the waste disposal areas that result in a risk to human health or the environment. Based upon the conclusions of the RI, Baker recommends no further studies at this site, including no Feasibility Study. Although a "no action" Feasibility Study could be performed, there is no benefit to the environment or the administrative process.

The next step in the administrative process appears to be a proposed plan describing the no action alternative for review and concurrence by the Department of the Navy, United States Environmental Protection Agency, and North Carolina Department of Environment, Health and Natural Resources.

1.0 INTRODUCTION

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

The Fiscal Year 1995 Site Management Plan for MCB, Camp Lejeune, a primary document referenced in the FFA, identifies 27 sites that require Remedial Investigation/Feasibility Study (RI/FS) activities. Six additional sites have been identified since the distribution of the Site Management Plan, bringing the total number of sites to 33. These 33 sites have been divided into 17 operable units to simplify proceeding with RI/FS activities. Operable Unit (OU) No. 9, comprised of Sites 65 and 73, is the general focus of this report. This report specifically addresses Site 65 and a separate RI report addresses Site 73. Figures 1-1 and 1-2 depict MCB, Camp Lejeune and the location of Site 65. (Note that tables and figures are provided at the back of each section.)

The purpose of the RI is to evaluate the nature and extent of the threat to public health and the environment caused by the release or threatened release of hazardous substances, pollutants, or contaminants (USEPA, 1988). The RI at Site 65 was conducted through the sampling of several media (surficial and subsurface soil, groundwater, sediment, surface water, and benthic and aquatic species), evaluating the resultant analytical data, and performing a human health risk assessment (RA) and ecological RA. Furthermore, the RI report provides information to support a Feasibility Study (FS) and Record of Decision (ROD) for a final remedial action.

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

The following subsections describe the characteristics and history of Site 65. In addition, Section 1.1 provides an overview of the RI Report Organization.

1.1 Report Organization

Volume I of this RI report for Site 65 is comprised of text, tables, and figures separated into the following sections:

1.0 Introduction (includes OU and site descriptions, and site histories)
2.0 Study Area Investigation
3.0 Physical Characteristics of the Study Area
4.0 Nature and Extent of Contamination
5.0 Contaminant Fate and Transport

6.0 Baseline Risk Assessment
7.0 Ecological Risk Assessment
8.0 Conclusions and Recommendations

The appendices that complete this RI report for Site 65 are contained in Volume I and Volume II. The appendices provide field investigation data, sampling data, statistical data, reference data, and risk assessment models, calculations and data.

1.2 Operable Unit Description

Operable units are formed as an incremental step toward addressing individual site concerns and to simplify the specific problems associated with a site or a group of sites. The total number of sites under the Installation Restoration Program (IRP) at MCB, Camp Lejeune is 33, which have been grouped into 17 operable units. Site 65 is one of two sites within OU No. 9, both located in close proximity to each other. OU No. 9 includes the Amphibious Vehicle Maintenance Area (formerly known as Courthouse Bay Liquids Disposal Area) - Site 73, between Courthouse Bay and Sneads Ferry Road, and the Engineer Area Dump (Site 65) which is approximately one mile east/southeast of Site 73. Courthouse Bay is located south of Hadnot Point, on the eastern shore of the New River. The area is accessible via Marine's Road and North Carolina Route 172. Courthouse Bay was selected for the Engineers' School and the 2nd Amphibious Tractor (AMTRAC) Battalion because of its protected natural harbor with direct water access.

The 255 acres of development at Courthouse Bay are distributed on the northwest and southeast sides of the bay itself, with major land uses in three clusters on the southeastern side. Training facilities, which account for the largest single land use, cover about 73 acres of land. Classroom training facilities and supply and storage buildings for heavy equipment are located in two irregular areas on the southeastern side of the bay, while personnel support, administration, medical facilities, and some supply buildings overlook the New River. Two clusters of troop housing facilities exist at Courthouse Bay. One overlooks the New River, while the other is on the western edge of the bay. Nine family housing quarters are sited along the New River on a peninsula of land which forms the entrance to the bay. Large land areas for heavy equipment training are located further to the southeast and are used by the Engineers' School (Site 65). An area of maintenance and supply buildings located on the northwestern side of the bay are solely used by the 2nd AMTRAC Battalion for maintenance and storage of large vehicles (Site 73). The area includes a wharf along the bay and a boat ramp.

1.3 Site Description and History

Site 65 is a primarily wooded area located immediately west and north of the Marine Corps Engineer School which occupies property between Site 65 and Courthouse Bay. The school is used for maintenance, storage, and operator training of amphibious vehicles and heavy construction equipment. The school also utilizes a several acre parcel located just east of Site 65 to conduct heavy equipment training activities.

Site 65 is situated in a topographically high area that is gently pitched to the south-southeast with an average elevation of about 40 feet above mean sea level (msl). Due to the sandy surface soils, there is relatively little storm water runoff. The limited surface water runoff tends to drain radially to the east, south, and west, away from the site or collect in local surface depressions. Immediately east of Site 65 is the equipment training area which occupies the area between Site 65 and two small ponds located to the southeast. Portions of the area surrounding the ponds are marshy.

Site 65 reportedly operated from 1952 to 1972. Two separate disposal areas have been reported including: (1) a battery acid disposal area; and, (2) a liquids disposal area. There are no historical maps or figures which depict the location of the disposal areas, and neither area is currently discernible due to heavy overgrowth. Aerial photographs, dating from 1956 through 1993, are available at the base Forestry Division and through the United States Department of Agriculture (USDA) Aerial Photography Field Office. Enlargements of four of these photographs have been included as Figures 1-3 through 1-6, for the years 1956, 1970, 1983, and 1993. The photos up through 1983 depict disturbed areas east of the Engineer School which represent perhaps the best available means for approximately locating the site. In addition, Camp Lejeune base maps, available via Computer-Aided Design Drafting (CADD), indicate the location of a burn area which was identified as part of Site 65 under the Initial Assessment Study (IAS) by Water and Air Research (WAR, 1983). Like the disposal area, the location of the burn area is not currently discernible from the surrounding landscape. Beginning in 1970, nearly the full extent of the current heavy equipment training area appears disturbed.

The types of liquids which were reportedly disposed at Site 65 include petroleum, oil, and lubricant products (POL). The IAS did not indicate that hazardous wastes were disposed at Site 65. Site Inspection (SI) Project Plans prepared by NUS Corporation (NUS, May 1991) identify both POL wastes and batteries as having been disposed at Site 65; however, the basis for the inclusion of batteries is not known since no other background report or document references the disposal of batteries at this site.

1.4 Summary of Previous Investigations

As indicted previously, Site 65 is mentioned in the IAS Report (WAR, 1983) as a site not requiring further confirmation. However, a decision to perform an SI was subsequently made by the DoN in 1991.

On January 31, 1994, Baker published the results of the Final Site Inspection that was conducted for Site 65 in July and August, 1991. The objectives of the SI were to: (1) determine whether there was a release or potential release of hazardous substances and the nature of the associated threats; (2) preliminarily assess the extent of contamination and the volume/type of wastes at the site; and, (3) determine if further action or investigations are required.

Figure 1-7 identifies the sample locations for activities conducted during the SI at Site 65. The activities included the installation of three shallow monitoring wells to approximately 20 feet bgs and the advancement of five, 15-foot deep soil borings. Soil samples were collected from each of the monitoring well borings and the soil borings. The wells were developed and subsequently sampled. Three surface water/sediment samples were also collected from the two on-site ponds and the adjacent marsh area.

Each of the groundwater, soil, surface water and sediment samples were analyzed for Target Compound List (TCL) organics and the Target Analyte List (TAL) inorganics (Level IV data quality). Validation of all samples was in accordance with USEPA protocols.

Groundwater samples collected from the three monitoring wells all exhibited metal contaminants (e.g., arsenic, beryllium, chromium, copper, lead and manganese) above either North Carolina groundwater regulatory levels and/or federal primary/secondary drinking water standards. No organic contaminants were detected in the groundwater samples with the exception of dichloro-diphenyl-dichloroethane (4,4'-DDD at 0.53 µg/L) in well MW02. Low levels of polynuclear aromatic hydrocarbons (PAHs) were detected in two of the eight surface soil samples. The pesticides 4,4'-DDD, dichloro-diphenyl-dichloroethylene (4,4'-DDE) and dichloro-diphenyl-trichloroethane (4,4'-DDT) were detected in three of the eight surface soil samples at levels ranging from 18 to 72 µg/kg. One subsurface soil sample exhibited low levels of 4,4'-DDD (58 µg/kg). Aroclor-1254, a polychlorinated biphenyl (PCB), was also detected in one subsurface soil sample (65SB0212) at 230 µg/kg. The distribution of organic contaminants found during the SI is presented in Figure 1-8.

Federal surface water standards were exceeded for lead, copper, and iron. Barium and chromium exceeded state surface water standards. One sediment sampled collected from the marsh was contaminated with low levels of 4,4'-DDD and 4,4'-DDE and elevated levels of metals. Sediment samples collected from the ponds exhibited low levels of phenolic constituents (76 µg/kg of phenol and 930 µg/kg of 4-methylphenol). Elevated metals, which were observed in the marsh sediment, were not observed in either pond. Sediment screening values for the protection of biota were also exceeded in the marsh sample for copper, lead, zinc, 4,4'-DDD and 4,4'-DDE. The SI Report (Baker, 1994) identifies the sediment sample locations and results.

The SI recommended that: (1) a remedial investigation/feasibility study be conducted to provide data for the evaluation of the nature and extent of soil and groundwater contamination, and a baseline human health and ecological risk assessment; (2) historical aerial photographs be obtained to determine the locations where disposal activities occurred; (3) background and upgradient shallow groundwater quality be assessed to better determine whether inorganic contamination of the shallow aquifer is due to disposal operations; and (4) groundwater quality in the deeper portions of the shallow aquifer as well as the Castle Hayne be assessed including the possible influence of the supply wells on groundwater flow.

Aerial photographs of the site from 1962 through 1989 were reviewed by Baker staff at the base Forestry Department. Five aerial photographs from 1956 through 1993 were also ordered from the USDA Aerial Photography Field Office. Particular observations were as follows:

- Aerial photographs from 1956 (see Figure 1-3) and 1964 appear mostly unchanged. A large kidney-shaped disturbed training area and a smaller rounded disturbed training area to the east are visible in the general area where Site 65 was reportedly located. In the 1956 photograph, it appears as though there were four small ponds to the east of the site, but by 1962 backfilling of one pond seems to have begun.

- The aerial photograph from 1970 (see Figure 1-4) depicts for the first time a disturbed area which nearly matches the limits of today's equipment training area. Roadways to the area are not as obvious as in earlier views. The number of small ponds to the east of the site is down to two by 1970. The two southern and westernmost ponds appear to have been backfilled. The waste disposal area in 1970 is located along the southern perimeter of the western heavy equipment area (see Figure 1-9).

- The aerial photograph from 1973 depicts a very distinctive "heavy equipment training area" (track marks are evident) that is slightly larger than the same area noted in the 1970 photograph. The kidney-shaped disturbed area to the west of the training area is beginning to recede in size. The kidney-shaped disturbed area continues to be visible up through 1983, but becomes more overgrown (see Figure 1-5).

- In the most recent aerial photographs available, dated 1989 and 1993 (Figure 1-6), the heavy equipment training area is clearly visible; however, the kidney-shaped disturbed area is indistinguishable. A mound of soil (containing debris based on visual reconnaissance) appears at the western corner of the training area.

1.5 Data Limitations

Upon review of available information, data limitations at Site 65 were identified. One of the most significant data limitations, although contamination was detected in some soils and groundwater samples, was that the extent of the contamination has not been adequately defined. In addition, data from other media (i.e., surface water, sediments, biota, etc.) was also required to support the Risk Assessment. Listed below are the various media from which additional data was needed:

- Surficial soil
- Subsurface soil
- Waste Piles
- Surficial groundwater
- Deeper Groundwater
- Surface Water
- Sediments
- Biota

Specific data needs are listed below:

- Determine the physical and chemical characteristics of surface and subsurface soil within the boundaries of Site 65, in the area downgradient of Site 65, in the adjacent heavy equipment training area, and in an upgradient location. This data is needed to determine the nature and extent of contamination (if any) in soil and to support a human health and ecological risk assessment and evaluation of remedial alternatives.

- Determine the extent of PCB contamination in the vicinity of existing soil boring 65SB02 where, during the SI, PCBs (230 µg/kg of Aroclor-1254) were detected at 12 to 14 feet bgs.

- Determine the physical composition and chemical characteristics of the various piles of earth and debris located within the Site 65 boundary. This data is needed to afford an evaluation of the debris piles as a potential source of contamination, to support a human health and ecological risk assessment, and evaluation of remedial alternatives.

- Obtain surface water, sediment, fish and benthic samples from the surface water bodies (i.e., ponds, marsh, and intermittent stream) located east of the site. This data is needed primarily to support a human health and ecological risk assessment as well as to afford an evaluation of the presence or absence of contamination in these media.

- Obtain additional data regarding the presence or absence of contamination in shallow (i.e., at the water table surface) groundwater downgradient (south) of Site 65 and west of existing shallow monitoring well 65MW02. A shallow monitoring well in this area is needed to add confidence that the downgradient perimeter of Site 65 has been sufficiently investigated.

- Obtain shallow groundwater data from the area east of Site 65 and west of the surface ponds. This data is needed to evaluate the environmental impact of ongoing activities at the heavy equipment training area. If contamination is identified in the surface water bodies west of Site 65, this data will be used to evaluate whether the source is Site 65 or the heavy equipment training area.

- Obtain shallow groundwater data from an upgradient location to provide for a comparison to data obtained from other locations potentially impacted by Site 65.

- Determine the chemical characteristics of the groundwater zone situated below shallow (water table surface) groundwater at three locations across the site including near the center of the suspected Site 65 disposal area, and downgradient and upgradient of Site 65. This data is needed to confirm the presence or absence of the vertical migration of contaminants from the shallow zone to a deeper zone. Ideally the deeper zone to be investigated should correspond to the upper-most screened intervals of the nearest water supply wells. Data from this zone will also be used to support a human health risk assessment since supply water is drawn from this zone from nearby wells for human consumption.

From these site-specific data needs, RI objectives were established to meet the data deficiencies for Site 65. RI objectives are presented in the following section.

1.6 Remedial Investigation Objectives

The purpose of this section is to define the RI objectives aimed at characterizing releases of hazardous substances from past waste disposal activities at Site 65, assessing potential impacts to public health and environment, and providing feasible alternatives for consideration during preparation of the ROD. The RI objectives presented in this section have been identified through review and evaluation of existing background information and the previous investigation, assessment of potential risks to public health and environment, and consideration of feasible remediation technologies and alternatives. Table 1-1 presents both the RI objectives identified for Site 65 and the criteria necessary to meet those objectives. In addition, the table provides a general description of the study or investigation efforts required to obtain the necessary information.

1.7 References

Baker Environmental, Inc. 1995. Remedial Investigation/Feasibility Study Work Plan, Operable Unit No. 9 (Sites 65 and 73), Marine Corps Base, Camp Lejeune, North Carolina. Prepared for the Department of the Navy, Atlantic Division, Naval Facilities Engineering Command, Norfolk, Virginia. Final. March 7, 1995.

Baker Environmental, Inc. 1994. Site Inspection Report, Site 65 Engineer Dump Area, Marine Corps Base, Camp Lejeune, North Carolina. Final. January 31, 1994.

Federal Facilities Agreement (FFA) between USEPA, Region IV; NC DEHNR; and DoN for MCB, Camp Lejeune and Marine Corps Air Station, New River, North Carolina. December 6, 1989.

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

NUS, 1991. Site Inspection Project Plans. May, 1991.

U.S. Environmental Protection Agency (USEPA), 1988. Guidance for Conducting Remedial Investigations and Feasibility Studies Under CERCLA. Office of Emergency and Remedial Response, OSWER Directive 9355.3-01, October 1988.

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

TABLES

TABLE 1-1

RI OBJECTIVES FOR OPERABLE UNIT NO. 9
REMEDIAL INVESTIGATION STUDY, CTO-0312
SITE 65 - ENGINEERING AREA DUMP
MCB, CAMP LEJEUNE, NORTH CAROLINA

Medium or Area of Concern		RI/FS Objective	Criteria for Meeting Objective	Proposed Investigation/Study
1. Site 65 - Soil	1a.	Assess the extent of soil contamination in the former dump area, the area near the ponds and the area presently used for heavy equipment training.	Characterize contaminant levels in surface and subsurface soils at the former dump area, the area near the ponds, and the heavy equipment training area.	Drill soil borings and obtain surface and subsurface soil samples
	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.	Conduct human health and ecological risk assessment
	1c.	Determine the composition and chemical nature of debris piles located throughout the site.	Observe the internal materials comprising the debris piles and obtain soil samples.	Excavate test pits and obtain soil samples
Site 65 - Groundwater	2a.	Determine whether soil contamination is migrating to groundwater.	Characterize shallow groundwater quality across the site.	Install shallow groundwater wells.
	2b.	Assess the extent of shallow and deep groundwater contamination across the site.	Determine the horizontal and vertical extent of shallow groundwater contamination; determine if shallow contamination has migrated vertically to a lower zone.	Install shallow and deep groundwater wells.
	2c.	Define hydrogeologic characteristics for fate and transport evaluation and remedial technology evaluation, if required.	Estimate hydrogeologic characteristics of the shallow aquifer (flow direction, hydraulic conductivity, permeability, etc.).	Perform field aquifer tests.
	2d.	Assess health risks posed by potential future usage of the shallow and intermediate zone groundwater.	Evaluate groundwater quality and compare to ARARs and health-based action levels.	Conduct human health risk assessment.

TABLE 1-1 (Continued)

RI OBJECTIVES FOR OPERABLE UNIT NO. 9
REMEDIAL INVESTIGATION STUDY, CTO-0312
SITE 65 - ENGINEERING AREA DUMP
MCB, CAMP LEJEUNE, NORTH CAROLINA

Medium or Area of Concern	RI/FS Objective	Criteria for Meeting Objective	Proposed Investigation/Study
3. Site 65 - Surface Water	3a. Assess the presence or absence of surface water contamination in the unnamed creek and ponds.	Characterize surface water quality.	Obtain surface water samples from the unnamed creek and ponds.
4. Site 65 - Sediment	4a. Assess human health and ecological risks associated with exposure to sediments in the unnamed creek and ponds.	Characterize nature and extent of contamination in sediment.	Obtain sediment samples from the unnamed creek and ponds. Conduct a risk assessment.
5. Site 65 - Biota	5a Assess potential ecological impacts posed by contaminated surface water or sediments in the unnamed creek and ponds.	Qualitatively evaluate stress to benthic and fish communities.	Obtain fish and benthic samples from the unnamed creek and ponds. Conduct an ecological risk assessment.

FIGURES

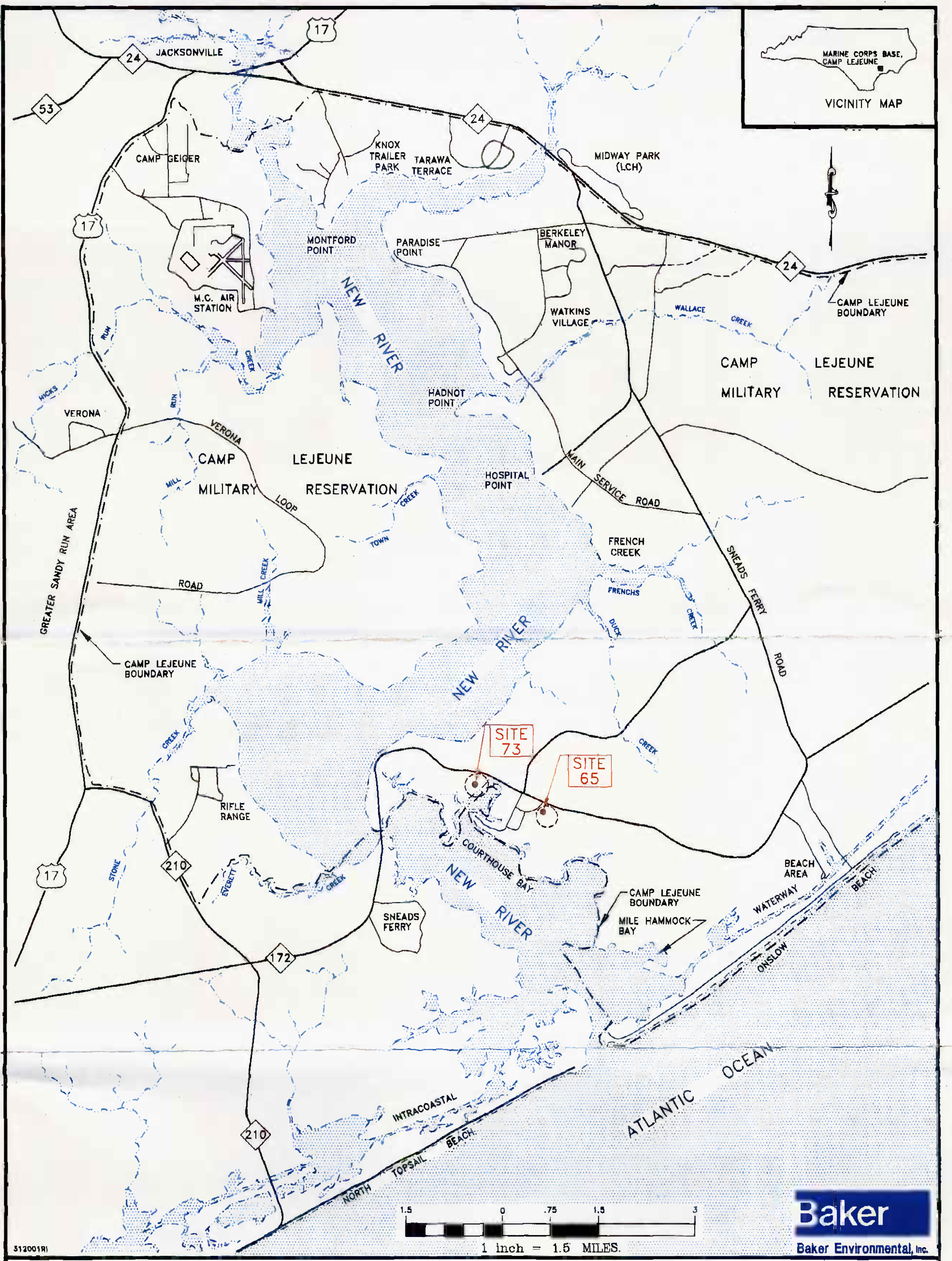
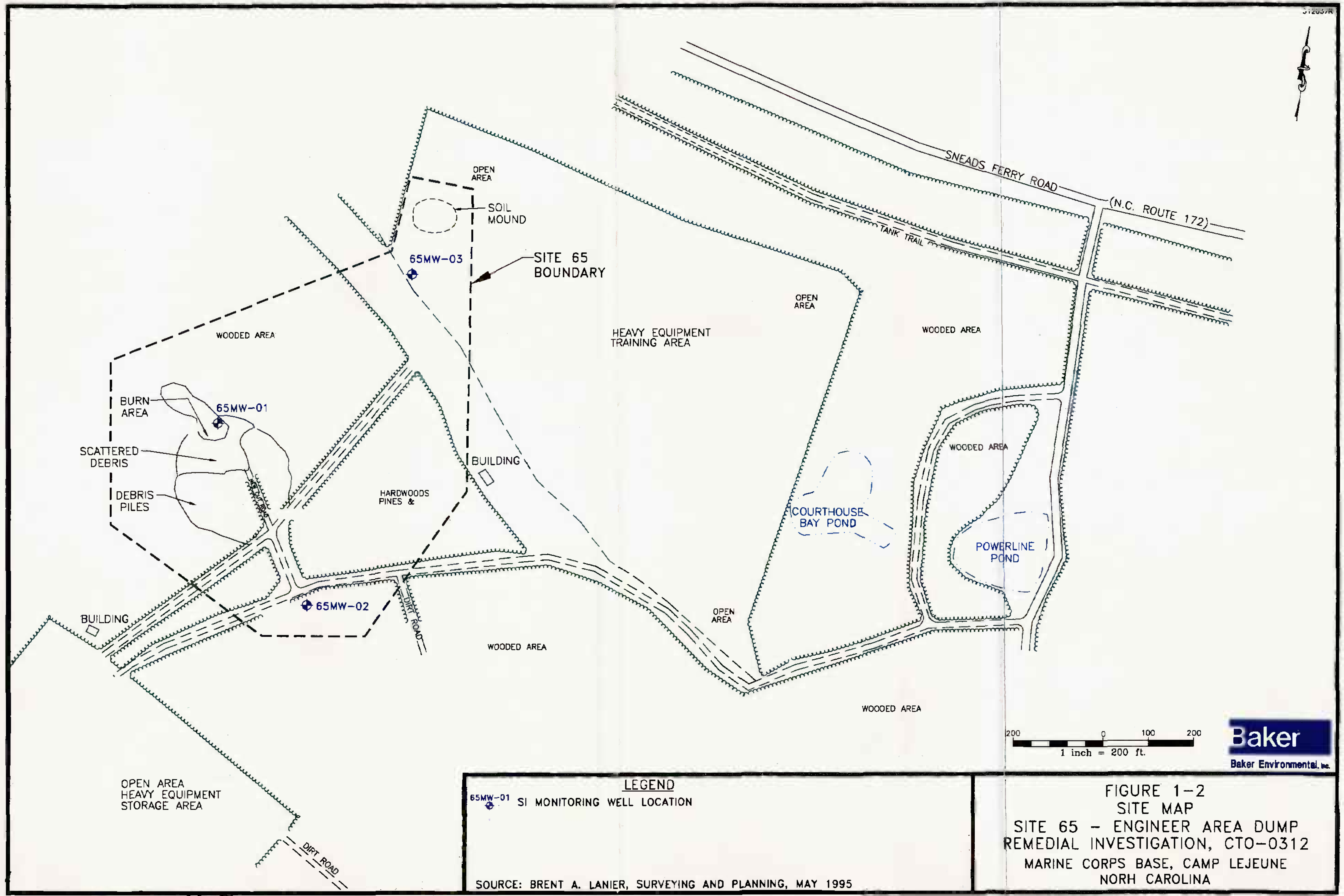


FIGURE 1-1
LOCATION MAP
SITE 65 – ENGINEER AREA DUMP AND
SITE 73 – AMPHIBIOUS VEHICLE MAINTENANCE AREA
REMEDIAL INVESTIGATION, CTO-0312

MARINE CORPS BASE, CAMP LEJEUNE
NORTH CAROLINA

00145001Y



SOURCE: BRENT A. LANIER, SURVEYING AND PLANNING, MAY 1995

FIGURE 1-2
SITE MAP
SITE 65 - ENGINEER AREA DUMP
REMEDIAL INVESTIGATION, CTO-0312
MARINE CORPS BASE, CAMP LEJEUNE
NORH CAROLINA

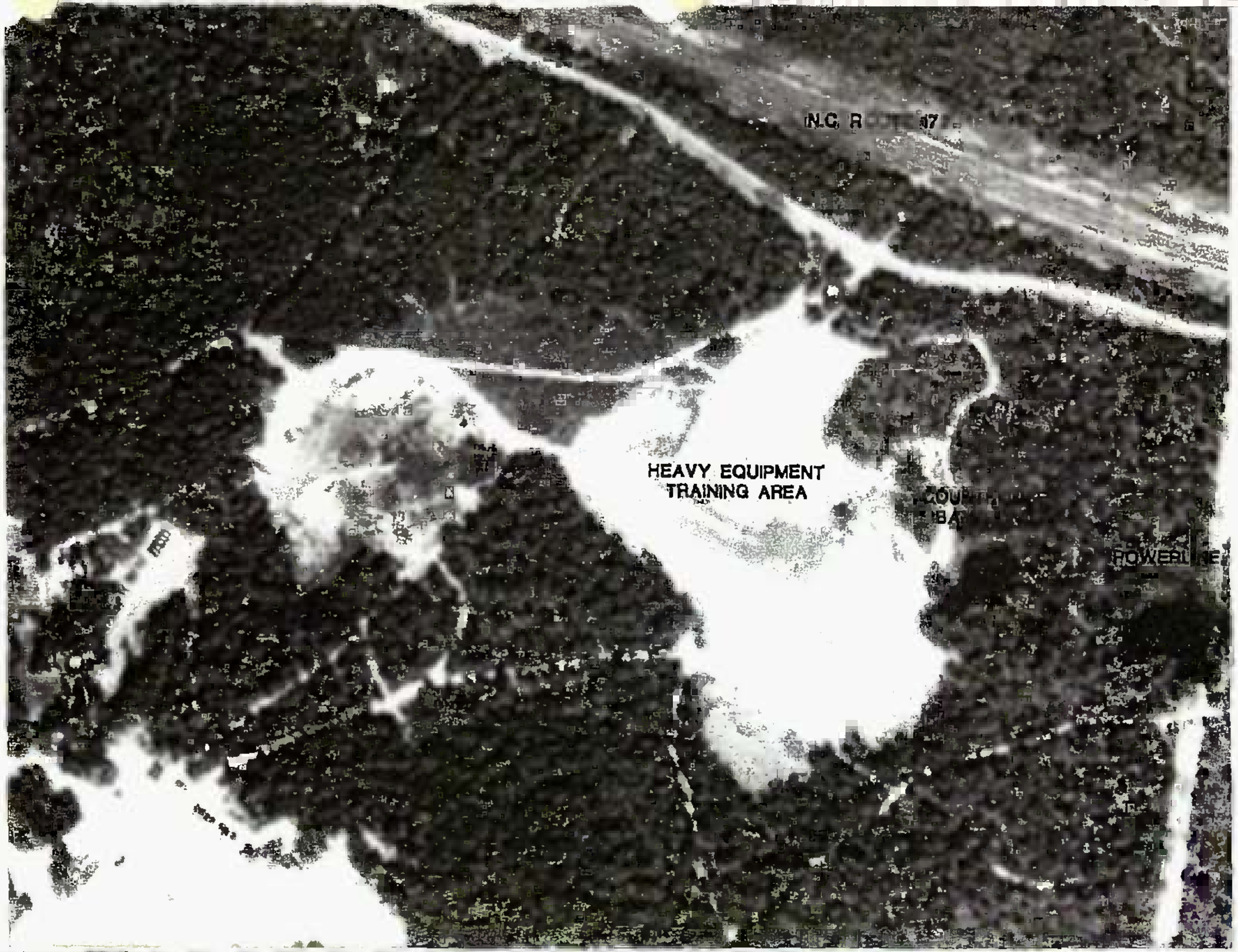
Baker

Baker Environmental, Inc.

FIGURE 1-3
AERIAL PHOTOGRAPH, FEBRUARY 1, 1956
SITE 65 - ENGINEER AREA DUMP
REMEDIAL INVESTIGATION, CTO-0312
MARINE CORPS BASE, CAMP LEJEUNE
NORTH CAROLINA

312030RI

00145003Y

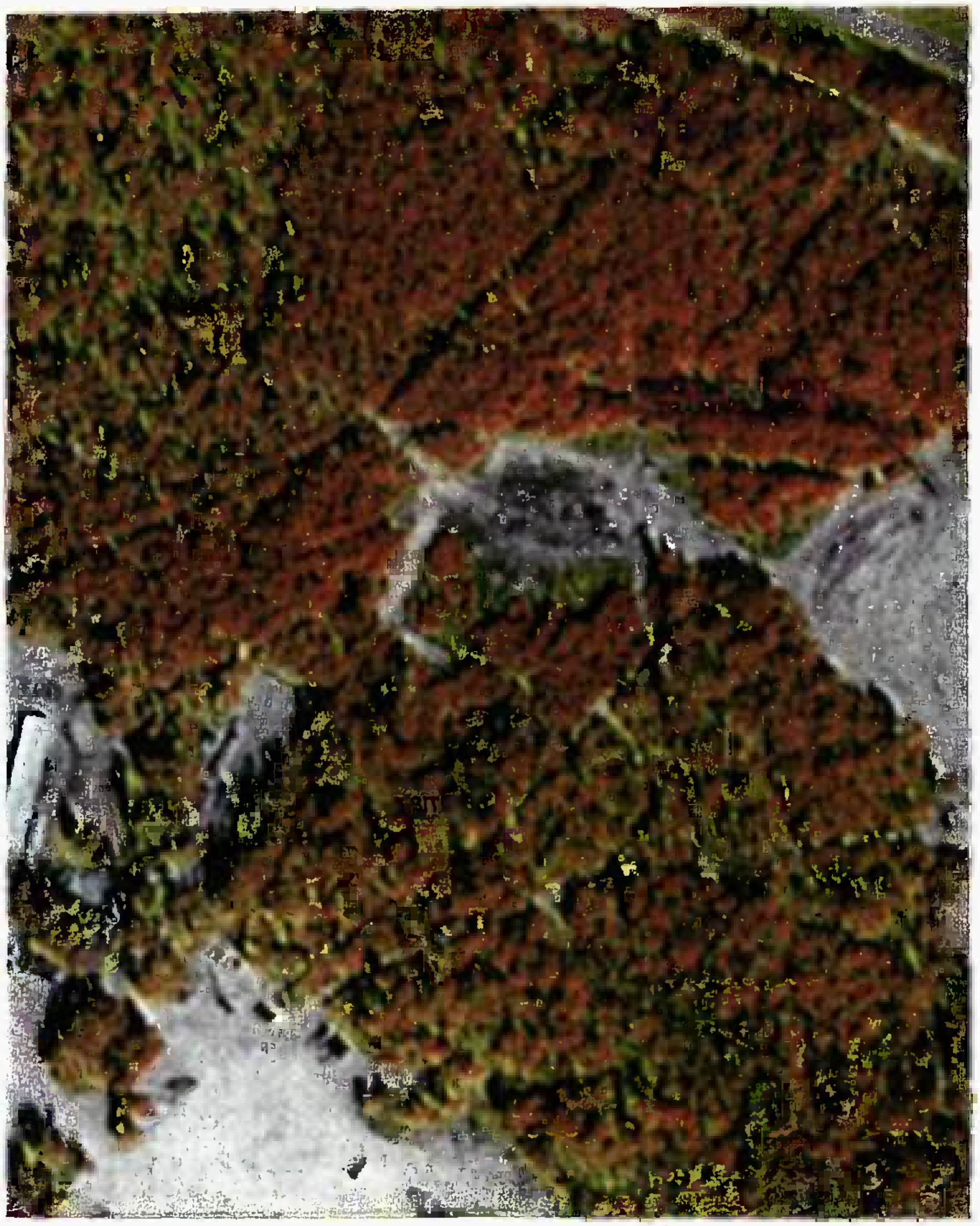


Baker
Baker Environmental, Inc.

FIGURE 1-4
AERIAL PHOTOGRAPH, OCTOBER 4, 1970
SITE 65 - ENGINEER AREA DUMP
REMEDIAL INVESTIGATION, CTO-0312
MARINE CORPS BASE, CAMP LEJEUNE
NORTH CAROLINA

312031RI

00145004Y



Baker Environmental, Inc.

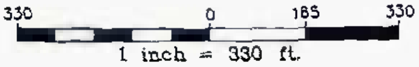


FIGURE 1-5
AERIAL PHOTOGRAPH, FEBRUARY 15, 1983
SITE 65 - ENGINEER AREA DUMP
REMEDIAL INVESTIGATION, CTO-0312
MARINE CORPS BASE, CAMP LEJEUNE
NORTH CAROLINA

312032RI

Baker Environmental, Inc.

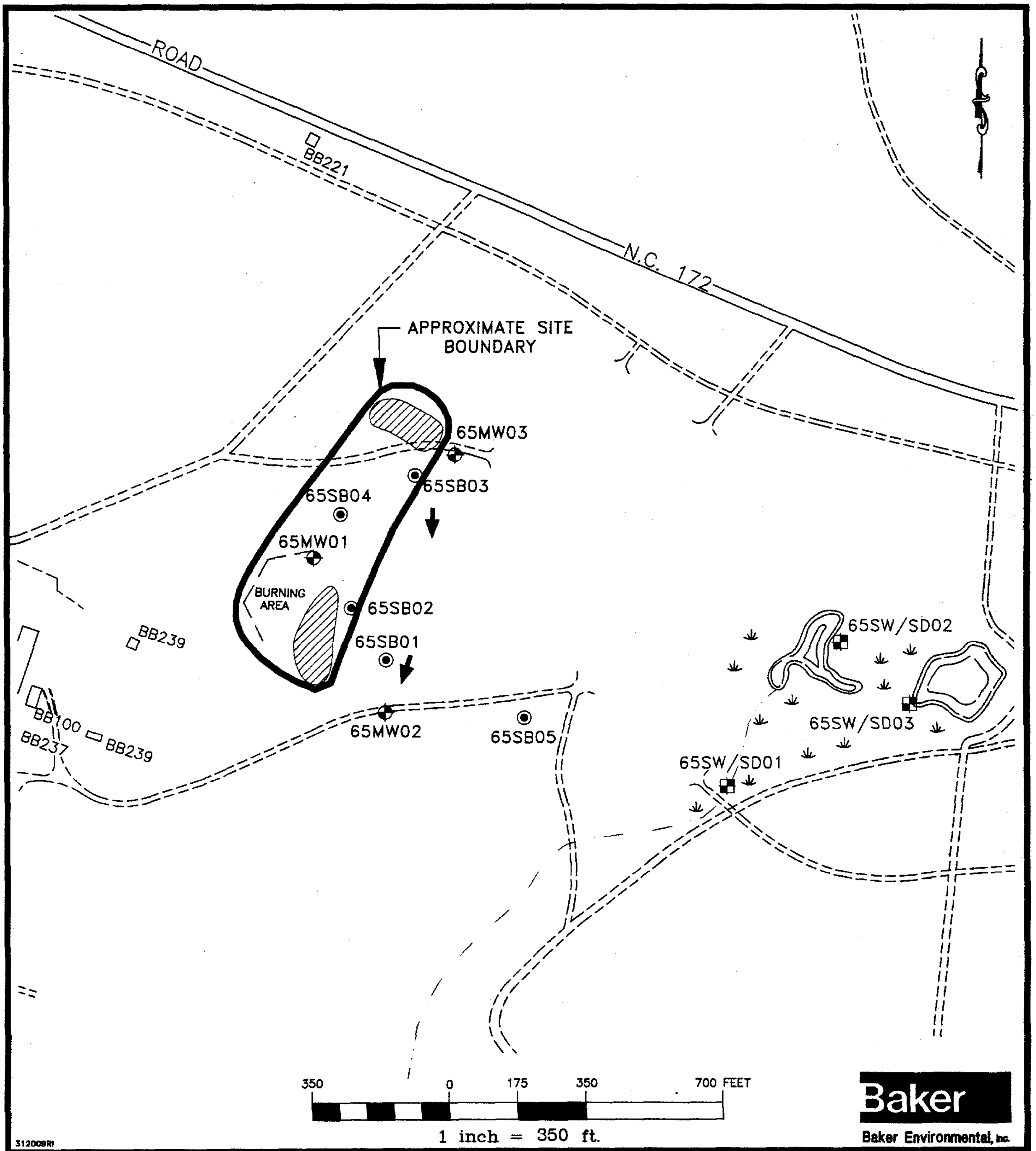
330 0 165 330

1 inch = 330 ft.

312033R1

FIGURE 1-6
AERIAL PHOTOGRAPH, MARCH 6, 1993
SITE 65 - ENGINEER AREA DUMP
REMEDIAL INVESTIGATION, CTO-0312
MARINE CORPS BASE, CAMP LEJEUNE
NORTH CAROLINA

00415006X



LEGEND

▣ SURFACE WATER/SEDIMENT SAMPLE LOCATION

→ APPROXIMATE GROUNDWATER FLOW DIRECTION

◉ SOIL BORING LOCATION

— — APPROXIMATE INTERMITTENT STREAM LOCATION

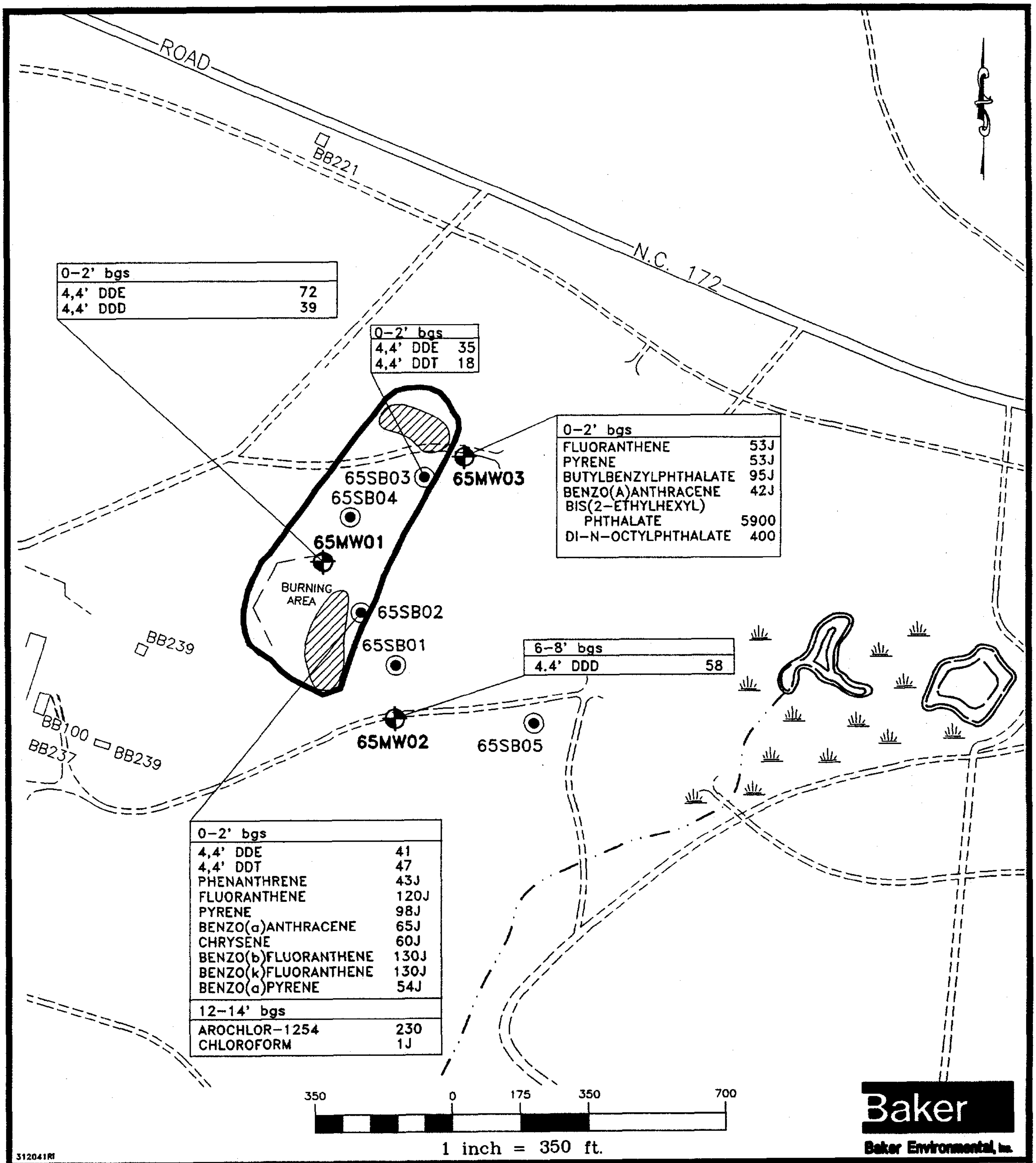
⊕ MONITORING WELL LOCATION

▨ APPROXIMATE LOCATION OF VISIBLE DEBRIS PILES

* SOIL BORING AND SURFACE WATER/SEDIMENT LOCATIONS WERE NOT SURVEYED

FIGURE 1-7
SITE INVESTIGATION SAMPLE LOCATIONS (BAKER, 1994)
SITE 65 - ENGINEER AREA DUMP
REMEDIAL INVESTIGATION, CTO-0312

MARINE CORPS BASE, CAMP LEJEUNE
NORTH CAROLINA

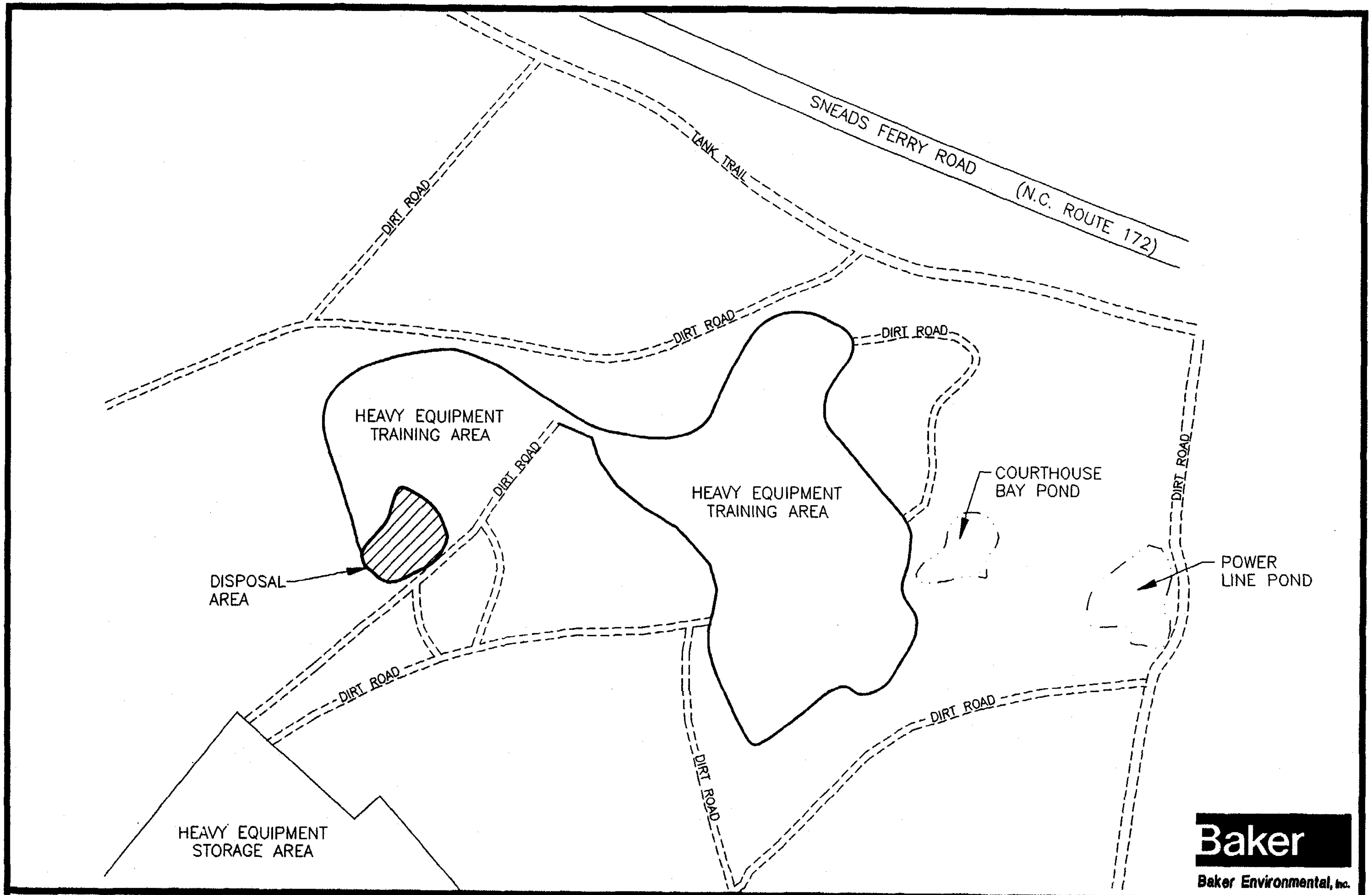


LEGEND

◉	SOIL BORING LOCATION
⊕	MONITORING WELL LOCATION
J	ANALYTE PRESENT. REPORTED VALUE MAY NOT BE ACCURATE OR PRECISE
— · · —	APPROXIMATE INTERMITTENT STREAM LOCATION
0-2' bgs	SAMPLE INTERVAL DEPTH BELOW GROUND SURFACE
▨	APPROXIMATE LOCATION OF VISIBLE DEBRIS PILES

NOTE: ALL RESULTS REPORTED IN MICROGRAMS PER KILOGRAM (ug/kg)

FIGURE 1-8
DISTRIBUTION OF ORGANIC CONTAMINANTS IN SOIL(BAKER, 1994)
SITE 65 - ENGINEER AREA DUMP
REMEDIAL INVESTIGATION, CTO-0312
MARINE CORPS BASE, CAMP LEJEUNE
NORTH CAROLINA



Baker

Baker Environmental, Inc.

FIGURE 1-9
APPROXIMATE WASTE DISPOSAL LOCATION, 1970
SITE 65 - ENGINEER AREA DUMP
REMEDIAL INVESTIGATION, CTO-0312
MARINE CORPS BASE, CAMP LEJEUNE
NORTH CAROLINA

312031R1

2.0 STUDY AREA INVESTIGATION

The field program at Site 65 was initiated to characterize potential environmental impacts and threats to human health, ecology and the environment resulting from previous activities. The investigation conducted at the site was generally designed to define potential impacts to surface and subsurface soil, groundwater, sediments and surface waters. Specifically, this study was intended to provide:

- Data regarding the nature and extent of environmental impact on aquatic and benthic species in two surface ponds located east of the site adjacent to the heavy equipment training area.
- Additional soil and groundwater data to support a quantitative, site-wide environmental risk assessment.
- Soil and groundwater data sufficient to afford an evaluation of the source, nature, and extent of potentially impacted groundwater and the shallow and deep groundwater flow patterns in the area.

The RI field activities conducted at Site 65 were initiated April 3 and concluded May 25, 1995. Additional work (primarily waste management, surveying, and groundwater elevation measurements) was conducted between May 26 and August 21, 1995. The field program consisted of: a soil investigation; a groundwater investigation; surface water and sediment, and ecological investigations; a site survey; and investigation derived waste (IDW) handling. All field activities were performed in accordance with the Project Plans (submitted by Baker, March 1995). A summary of these activities and details of any modifications to the plans, are discussed in the following sections.

2.1 Soil Investigation

A soil investigation was conducted at Site 65 to assess the nature and extent of previously detected contamination and to assess human health, ecological, and environmental risk associated with contact, inhalation and possible ingestion of surface and subsurface soil particles. The following subsections describe the drilling procedures, sample locations, sample methods and analytical program for the site.

Baker supervised the advancement of 14 soil borings (65-SB06, -SB07, -SB08, -SB09, -SB10, -SB11, -SB12, 65-DW01, -DW02, -DW04, -MW04, -MW05, -MW06 and -MW07) for the purpose of sample collection, geologic identification and description, and monitoring well installation. Drilling and soil sampling activities at the site were initiated on April 4, 1995, and were completed on April 20, 1995, using a truck-mounted drill rig supplied and operated by Parrott Wolff, Inc. Soil cuttings obtained during the drilling program were contained and handled in accordance with procedures outlined in Section 2.5. Drilling and sampling activities were performed using Level D personal protection and operations were continuously monitored with a photoionization detector (PID) and lower explosive limit/oxygen meter. All soil boring/monitoring well locations are shown on Figure 2-1.

The soil borings were advanced to three ranges of depth. Procedures varied depending upon the type of soil boring needed at each location. Seven borings were advanced for soil classification and sample collection purposes only and were terminated at the water table. These borings were designed for collection of information pertaining to soil contamination in areas where groundwater monitoring wells were not practical due to training activities conducted at the site or in areas where information was needed concerning soils only.

Baker supervised the completion of four soil borings as shallow Type II groundwater monitoring wells extending approximately 10 to 15 feet below the water table. These borings were terminated at approximately 21 to 23 feet bgs using 6.25-inch inside diameter (ID), hollow-stem augers. In some cases, these wells were not logged by the site geologist due to the close horizontal proximity of an adjacent deep boring. The borings were designed to allow construction of monitoring wells with screens that intersect the water table.

Additionally, Baker supervised the advancement of three deep soil borings for the purpose of installing Type III monitoring wells. The deep monitoring wells were extended 10 to 15 feet into the Castle Hayne aquifer terminating at approximately 56 to 70 feet bgs. The deep borings were advanced using fluid (bentonite slurry) rotary drilling methods.

Each boring was advanced using 4-1/4-inch ID, hollow-stem augers to the appropriate completion depth (shallow borings/monitoring wells) or to the top of a stratigraphic segregating layer (deep wells). Those borings designated for monitoring well completion were reamed with 6-1/4-inch ID, augers. Shallow well construction was performed through the larger augers. In the deeper borings, six-inch ID, steel casing was installed through bentonite-cement grout to seal off the surficial aquifer from the underlying Castle Hayne aquifer. The steel casing was set approximately two feet into the a semiconfining unit above the Castle Hayne aquifer.

All borings were continuously sampled to the water table (approximately 7.5 to 11 feet bgs) and then every five feet until termination of the boring with a split-spoon sampling device following methods outlined in ASTM 1586-84 and the Field Sampling and Analysis Plan (FSAP) (Baker, 1995). The sampling protocols were modified in some cases where the site geologist needed more information about a particular soil type or if the formation appeared to be unstable at a particular interval. Soils were considered unstable if problems occurred during drilling that were indicative of borehole collapse. When unstable soils were encountered, samples were not collected until the borehole was advanced beyond the problem interval.

Each split-spoon soil sample was classified by the site geologist. Soils were classified and field screened with a PID. The results were recorded in the field logbook and later transposed onto boring log records. Classification included characterization of soil type, grain size, color, moisture content, relative density (from Standard Penetration Test "blow counts"), plasticity and other pertinent information such as indications of contamination. Lithologic descriptions of site soils are provided on the Test Boring and Well Construction Records in Appendix A.

2.1.1 Surface and Subsurface Soils

Surface and subsurface soil samples were collected from soil boring locations across the site in order to delineate the vertical and horizontal extent of contamination and provide data for human health and ecological risk assessments. As described in the Work Plan (Baker, 1995), selection of soil boring/monitoring well locations was based on Camp Lejeune historical records, previous site investigations and existing boring data. A summary of the sample numbers, sample depths and analytical parameters is provided in Appendix B.

Surface soil samples were collected from 14 borings (see Figure 2-1) using a decontaminated stainless steel spoon to extract each soil sample and place it in an aluminum pan. Samples were collected from zero to 12 inches after the first few inches of top soil and matted roots were scrapped away with a stainless steel trowel. The volatile organic compound (VOC) samples were placed directly into the appropriate laboratory supplied containers immediately after collection. The remaining portion of the sample was composited in an aluminum pan and mixed to homogenize the sample; then the sample was placed into the appropriate sample containers. All samples were temporarily stored in ice-filled coolers until shipment to Quanterra Environmental Services for analyses. The stainless steel spoons were decontaminated prior to sample collection according to the procedures outlined in the FSAP (Baker, 1995).

Soil sampling protocols specified in the FSAP called for two soil samples to be collected from each boring/well cluster location where less than six feet of unsaturated conditions were encountered. These samples were to be collected at the ground surface and directly above the soil/groundwater interface. If greater than six feet of saturated soil conditions were encountered, three samples were to be collected, with the third sample interval to be based on visual observations, field screening using a PID or midway between the surface and the water table. However, the protocols were modified in the field. It was determined that 10 feet of unsaturated soil conditions would better warrant additional samples to be collected. This modification was incorporated into the plans in order to reduce the possibility of collecting an overabundance of unnecessary samples from shallow soil borings.

A vadose zone, subsurface soil sample was collected from directly above the water table in each boring. An additional sample was collected between the surface soil sample depth and the water table from borings in which the depth to water was greater than 10 feet. The intermediate soil samples were collected based on positive PID readings and/or visual contamination. However, if no reading or visible contamination was found, samples were taken from the middle of the (surface to water table) soil column. All subsurface samples were collected via a two- or three-inch diameter, stainless steel, split-spoon sampler. Analytical samples were composited and prepared in the same manner as surface soil samples.

2.1.2 Exploratory Test Pit Investigation

Baker conducted an exploratory test pit investigation at Site 65 to determine the presence and nature of buried material in the debris piles at the southwestern portion of the site (Figure 2-1). Potential test pit locations were identified through visual site inspection. The site inspection sought to identify the extent of the debris piles and the area historically used as the burn area. Observations of waste disposal such as fill material, debris or depressions were used in locating the six test pit excavations.

The investigation employed the use of a backhoe and Level B personal protective equipment (e.g., supplied air). Generally, the soil and debris were removed in lifts of six to 12 inches. The overall dimensions of the test pits were approximately 10 to 15 feet in length and two to three feet in width. The depth of the pits varied depending on the depth of the water table at each location.

Information regarding the type of materials, drums, or possible contamination was recorded in the Test Pit Logs (included in Appendix C) by the site geologist. Additionally, a sketch of each test pit was made to illustrate the location of miscellaneous debris encountered during the excavation. The operations were continuously monitored using a PID and lower explosive limit/oxygen meter during excavation activities. All excavation and sampling equipment was decontaminated prior to and after each test pit excavation following the procedures outlined in the FSAP (Baker, 1995).

A single sample was collected from each of the excavations and submitted for analysis. Each sample was collected from the backhoe bucket following sampling procedures located in Section 5.1.3 of the FSAP (Baker, 1995). Samples were collected from the bottom of each excavation because no visually contaminated soils and/or positive PID readings were observed. Upon completion of sample collection, the excavations were backfilled with materials and soils removed from each pit as per the FSAP (Baker, 1995).

2.1.3 Analytical Program for Soils

The analytical program initiated for the soil investigation at Site 65 focused on the suspected contaminants of concern which were based on previous disposal practices, site activities and findings of previous investigations. In general, soils at the site were analyzed for Target Compound List (TCL) organic compounds and Target Analyte List (TAL) metals. In addition, a single soil sample was submitted for engineering parameters analyses including total phosphorous, total organic carbon (TOC), alkalinity, chemical oxygen demand (COD), microbial count, Total Kjeldahl Nitrogen (TKN), Atterberg Limits, and particle size distribution. The engineering parameters were obtained to assist in selecting potentially applicable remedial technologies during an FS.

All soil samples retained for analysis were prepared and handled according to USEPA Region IV Standard Operating Procedures (SOPs) as outlined in the FSAP (Baker, 1995). Chain-of-Custody documentation, which includes information such as sample numbers, date, time of sampling, and sampling party accompanied the samples to the laboratory and is provided in Appendix D. Samples were shipped via overnight courier to Quanterra Environmental Services in Knoxville, Tennessee.

2.2 Groundwater Investigation

The groundwater investigation at the Site 65 consisted of several activities including construction of shallow and deep monitoring wells, well development, groundwater sampling, static water measurement and aquifer testing. The investigation was designed to confirm the presence or absence of shallow and deep groundwater contamination, evaluate the horizontal and vertical extent of potentially impacted groundwater, and evaluate the shallow and deep groundwater flow patterns in the area.

The field procedures and sampling methods were implemented in accordance with USEPA Region IV SOPs. Specific sampling procedures are detailed in the FSAP (Baker 1995). The following sections summarize the procedures for monitoring well construction, well development, static water level, measurements, aquifer testing, groundwater sampling, and analytical program.

2.2.1 Shallow and Deep Well Construction

Both deep and shallow wells were constructed of two-inch nominal diameter, Schedule 40, flush-jointed and threaded, polyvinyl chloride (PVC) casing with 10-slot screen. The shallow wells were constructed with a 15-foot section of screen and the deep wells were constructed with a 10-foot section of screen. The deep wells required casing to seal off the upper aquifer from the aquifer below. A six-inch ID, 3/16-inch thick, steel casing was installed from the surface and was seated into the first confining unit. A fine-grained sand pack (No. 1 sand) was placed in the annulus between the screen and the borehole wall extending above the screen interval about two feet. The shallow wells were installed with a sodium bentonite seal approximately two feet thick placed on top of the sand pack to prohibit intrusion of grout or surface runoff into the sand pack. The deep wells were installed with a sodium bentonite seal placed on top of the sand pack continuing two to three feet inside the protective casing to prohibit intrusion of grout into the sand pack or the aquifer. The bentonite seal provides additional protection against surficial ground water penetrating the Castle Hayne aquifer.

The remaining annular space between the bentonite seal and the surface was filled with cement/bentonite grout. Each well was protected from the damage and tampering by a locking protective cover, well pad and cement-filled ballards. Well tags containing information regarding the construction of each well and the notation "Caution Not Potable Water" were affixed to the wells. Well construction details are summarized in Table 2-1 for shallow and deep wells.

Baker installed four Type II, groundwater monitoring wells (wells without casing sealing off a confining layer) into the water table aquifer to determine the horizontal extent of contamination (if any) existing within the aquifer, and evaluate the shallow groundwater flow patterns. The shallow wells were installed with a portion of the screen above the water table so that floating organics (if any) may enter the well. The screen intervals were designed to compensate for seasonal fluctuation in the water table. The shallow wells were constructed in accordance with the FSAP (Baker 1995) and USEPA Region IV SOPs. A well construction diagram for a typical Type II well is included as Figure 2-2.

Baker supervised the installation of three Type III, groundwater monitoring wells (wells installed with an outer casing to seal out the shallow aquifer), one in each of the deep soil borings. These wells were designed to:

- Evaluate the vertical and horizontal extent of contamination (if any) residing in the Castle Hayne aquifer;
- Determine if the marker bed between the surficial sediments and the River Bend Formation is confining, semi-confining, or not confining and;
- Evaluate the groundwater flow patterns of the deep aquifer.

A typical Type III well construction diagram is presented in Figure 2-3. Type III well screens were placed in a position to intercept the upper portion of the Castle Hayne aquifer.

Upon completion and curing of the grout, each newly installed well was developed to remove fine-grained sediment from the screen and to establish hydraulic communication between the well and the formation. A minimum of three to five well volumes were removed from each well until the groundwater was essentially sediment-free. Groundwater recovered during development was contained and handled in accordance with procedures outlined in Section 2.5. The wells were developed by a combination of surging and pumping techniques. Hoses used for development were dedicated to each well to minimize the potential for cross contamination and discarded upon completion of development. Measurements of pH, turbidity, conductivity and temperature were recorded frequently to assist in evaluating well stabilization. The wells were considered stable when three consecutive measurements of pH, conductivity and temperature were within 10 percent of the previous measurements. Turbidity stabilization was established when a sample was measured and a value under 10 Nephelometric Turbidity Units (NTUs) was obtained. If turbidity did not stabilize within three hours of purging, the well was considered developed. Well development forms listing all the development parameter measurements are provided in Appendix E.

Three rounds of water levels were collected at Site 65 on April 20, 23, and August 21, 1995 to establish shallow groundwater flow in the Engineer Area Dump region. In addition, two staff gauge readings were collected from Powerline Pond and Courthouse Bay Pond. The groundwater measurements were recorded from the top of the PVC casing using an electronic measuring tape to the nearest 0.01 foot. Measurements were collected within a four-hour time period during each event and can be found on Table 2-2.

Hydraulic conductivity testing was conducted on three shallow wells at Site 65 to evaluate shallow groundwater flow characteristics. Monitoring wells 65-MW04, 65-MW05 and 65-MW07 were tested on May 22 and 23, 1995. Details regarding the results of these tests are discussed in Section 3.0 of this report.

2.2.2 Groundwater Sampling

A single round of groundwater samples was collected from each of the seven newly installed wells and three existing wells to confirm the presence or absence of contamination in the surficial and Castle Hayne aquifers. Prior to collecting the samples, the wells were purged of three to five well volumes of water using a low flow, low turbulence pump. Water recovered during the groundwater sampling program was contained and handled as described in Section 2.5. Temperature, conductivity, turbidity and pH measurements were collected after each well volume was removed to determine when the groundwater had stabilized prior to sampling. The definition of stabilization is the same for development and purging. Table 2-3 summarizes the groundwater sampling field parameter measurements.

Samples were collected using a peristaltic pump and teflon tubing. Flow rates were set at about 0.25-gallons per minute (gpm) to establish low flow purging. This method of purging creates less disturbance within the water column, thus capturing fewer sediments during sampling. High sediment content water creates a false impression of elevated metals in groundwater. In addition, the potential for organic compound volatilization is decreased. The teflon tubing was decontaminated prior to sampling and was discarded after sampling any well suspected of being contaminated and at the end of each day's sampling events.

Groundwater samples were introduced directly from the tubing into the appropriate laboratory supplied sample container and stored on ice in a cooler. Preparation of the samples for shipment to the laboratory incorporated similar procedures as to those described for soil samples and are outlined in the FSAP (Baker, 1995). Chain-of-Custody documentation (provided in Appendix D) accompanied the samples to the analytical laboratory.

2.2.3 Analytical Program for Groundwater Samples

Ten groundwater samples, plus quality assurance/quality control (QA/QC) samples, were analyzed for TCL organics, and TAL metals. In addition, one sample was collected for the analysis of engineering parameters including COD, TOC, TKN, alkalinity, microbial count, and total phosphorus. As with the soils, the engineering parameters were intended to assist in selecting potentially applicable remedial technologies. A summary of the sample numbers and analytical parameters is provided in Appendix B.

2.3 Surface Water/Sediment Investigation

Baker collected surface water and sediment samples from Courthouse Bay Pond and Powerline Pond to assess possible impacts from the site and assist in human health and ecological RAs. The surface water/sediment investigation was conducted between May 5 and 22, 1995. Four sampling locations were proposed in the FSAP (Baker, 1995). A single sample location was established in each pond (Figure 2-1). Sample 65SW/SD-04 was collected from the middle of Courthouse Bay Pond and Sample 65SW/SD-05 was collected from the eastern portion of Powerline Pond. Sampling locations were determined in the field and corresponded roughly with the aquatic/ecological sampling locations. One surface water and two sediment samples (0 to 6 inches and 6 to 12 inches below the sediment surface) were collected from each location.

The additional samples 65SW/SD-06 and 65SW/SD-07 were to be collected from the marshy area adjacent to Courthouse Bay Pond and the drainage way leading from Courthouse Bay Pond in the southwestern direction, respectively. Sample 65SW/SD-06 was not collected because only a small amount of puddled water existed at the sample location and, therefore, it could not be classified as surface water. Sample 65SW/SD-07 was not collected because the drainage way was dry in the location that the sample was to be collected at the time of the sampling activities. Other surface water sample locations were investigated. Water was present in the drainage way several hundred feet downstream of the proposed location, after receiving runoff from other locations not associated with the site. However, it was determined that if samples were collected from the drainage way at this new location that they would not be representative of Site 65.

2.3.1 Surface Water Sample Collection

Baker collected the surface water samples consistent with the procedure described in the FSAP (Baker, 1995). Samples were collected from the approximate mid-vertical point in the pond using a sub-surface grab sampler. A clean laboratory-supplied 1-liter amber sample bottle was attached to the sampler via a clamp. Baker sampling personnel lowered the bottle to the mid-vertical point, twisted off the lid with a suction cup attachment, and allowed the bottle to fill with water. After the bottle was filled, the lid was secured and the bottle was removed from the water. The contents of the bottle were transferred into the remaining sample bottles in accordance with the FSAP (Baker, 1995).

Care was taken when transferring surface water samples for analysis of VOCs to avoid excessive agitation that could result in loss of VOCs. VOC samples were collected prior to obtaining samples for analysis of other parameters. The sample bottles were filled by pouring down the side of the container until it was completely filled leaving no headspace. Each filled bottle was checked for bubbles and rejected if encountered.

Each sampling location was marked by placing a wooden stake and bright colored flagging at the nearest bank. The sampling location was marked with indelible ink on the stake. In addition, the distance from the bank and the approximate location of the sample was estimated and recorded in the field log book of one of the Baker personnel. Photographs were taken to document the physical and biological characteristics of the sampling location.

2.3.2 Sediment Sample Collection

At each sediment sampling station samples were collected at a depth of zero to six inches and six to 12 inches. The samples were collected using a decontaminated, stainless-steel, sediment corer fitted with a new, disposable, plastic liner and a decontaminated plastic nosecone. If necessary, an eggshell catcher was used to minimize loss of the sample. Sampling personnel pushed the sediment corer, using the necessary extension poles, between 15 and 20 inches into the sediment. The sediment corer was then withdrawn and the plastic liner was removed from the corer. Sediment deeper than 12 inches was extruded from the liner and the zero- to six- and six- to 12-inch sediment intervals were placed into separate clean aluminum pans.

Baker collected the samples for the VOC analysis with a clean, stainless-steel spoon. The remaining sediment was homogenized and transferred into their respective sample jars. This process was repeated until enough sediment was obtained to fill all the sample jars.

2.3.3 Surface Water/Sediment Sample Analysis

Surface water/sediment samples were analyzed for TCL organics, TAL metals and TOC. In addition, the zero- to six-inch sample for each location was analyzed for TOC and particle-size distribution. A summary of the sample numbers and analytical parameters is provided in Appendix B. The samples were prepared and handled in accordance with the FSAP (Baker 1995) and USEPA Region IV SOPs.

2.4 Ecological Investigation

Baker conducted an ecological investigation at Site 65 to provide data to support the ecological RA. Biological samples collected as part of this investigation included fish and benthic macroinvertebrates. These were collected to obtain population statistics for fish and benthic macroinvertebrates and to obtain fish tissue samples for chemical analysis.

2.4.1 Fish Sample Collection

Baker personnel collected fish in Powerline Pond (sample number 65FS-05) using a Smith-Root Inc., backpack electrofisher powered by a 5,000-watt, portable generator. A DC current was applied 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.

Baker was not very successful collecting fish via electrofishing for several reasons. Most of the pond was overgrown with a thick algae preventing the fish from surfacing after they were "shocked". The areas of the pond not overgrown with algae were covered with water lily preventing the fish from being visually observed after being "shocked". Baker did not attempt to electrofish Courthouse Bay Pond because the visibility in the pond was approximately one-inch due to the high concentration of suspended sediment.

In addition to the electrofisher, fish samples were collected in Powerline Pond and Courthouse Bay Pond (sample number 65FS-04) using hoop nets. The nets ranged from two to four feet in diameter and 14 to 16 feet in length. Either 10-, 25- or 40-foot wings were attached to the nets at 45-degree angles to direct the fish into the nets. The nets were deployed with the tail end at the shore and the openings facing the middle of the pond. Minnow traps baited with cat food were also deployed; however, no minnows were collected in the traps.

The samples were wrapped in foil and placed in a clean plastic bag for temporary storage in an on site freezer. The samples were subsequently shipped to the laboratory in a cooler packed with dry ice..

2.4.2 Fish Tissue Sample Analysis

Whole body and fillet samples were collected from the fish and analyzed for TCL organics and TAL metals. The samples were prepared in accordance with USEPA Region IV protocols by the laboratory.

2.4.3 Benthic Macroinvertebrate Sample Collection

Baker collected benthic macroinvertebrates proximate to the respective adjacent sediment and surface water sampling locations. Samples 65BN-04 and 65BN-05 were collected from Courthouse Bay Pond and Powerline Pond, respectively. The samples were collected from a boat using a standard ponar grab samples in accordance with the FSAP (Baker, 1995). The dimensions of the standard ponar are 0.229 x 0.229 meters (9 x 9 inches) for a sampling area of 0.0523 square meters (81 inches). The sampling area of the ponar is used to calculate the species density in individuals per square meter.

2.5 Investigation Derived Waste

Investigation derived waste (IDW) was generated during the field program at OU No. 9. The IDW generated includes soil and mud cuttings, purge and development groundwater, used personal protective equipment, and spent decontamination fluids. The following paragraphs describe the procedures for IDW management for Site 65.

Soil cuttings (and drilling mud) generated during soil boring and monitoring well installation, and spoil generated from test pit excavation were placed back into the boring or test pit in the same order in which it was taken out, or spread out on the ground surface where wells were constructed in the borehole. The philosophy of this methodology is that if the soil cuttings were contaminated, they would be remediated with the soils at the remediation stage of the remedial action process.

Spent decontamination fluids and groundwater generated during well development and purging was managed in one of two ways. Groundwater collected from monitoring wells 65MW-01, -03, -04, -06, -07, 65DW-01 and -04 was discharged onto the ground surface. The groundwater collected from these wells did not exhibit visual contamination (e.g., nonaqueous-phase liquid or oily sheen) or unusual odors (e.g., fuel or sulfur odors) and were located in an upgradient direction from the southernmost debris piles (the suspected source of possible contamination at the site). Groundwater collected from downgradient monitoring wells 65MW-02, -05 and 65DW-02, and spent decontamination fluids were combined with groundwater from Site 73 and temporarily contained in two, 5,000-gallon, stainless-steel tankers and a 1,000-gallon polytank. A sample was collected from each of the storage containers and analyzed for TCL organics, TAL metals, and RCRA hazardous waste characteristics. A correspondence letter is included in Appendix F which discusses the results of the analyses and the fate of groundwater contained in each one of the storage tankers.

Used personal protective equipment (e.g., nitrile gloves, tyvek, etc.) were double bagged, labeled and disposed as solid waste in an on-site refuse container which subsequently was emptied at a sanitary landfill. If the equipment would have been exposed to potentially hazardous substances or excessively contaminated soil or groundwater, the equipment would have been placed in a drum and disposed at a hazardous waste landfill.

2.6 References

Baker, 1995. Baker Environmental, Inc. Remedial Investigation/Feasibility Study Project Plans: Operable Unit No. 9 (Sites 65 and 73), Camp Lejeune, North Carolina. Final. Prepared for the Department of the Navy, Naval Facilities Engineering Command, Atlantic Division, Norfolk, Virginia, March 1995.

Faizelle, Mac. Personal Communication. General Foreman, Water Treatment, MCB, Camp Lejeune, September and October, 1995.

TABLES

TABLE 2-1

SUMMARY OF GROUNDWATER MONITORING WELL CONSTRUCTION DETAILS
SITE 65 - ENGINEER AREA DUMP
REMEDIAL INVESTIGATION, CTO-0312
MCB, CAMP LEJEUNE, NORTH CAROLINA

Well No.	Date Installed	Consultant Supervising Well Installation	Top of PVC Casing Elevation (feet, above msl)	Ground Surface Elevation (feet, above msl)	Stick-Up (feet, above ground surface)	Boring Depth (feet, bgs)	Well Depth (feet, bgs)	Steel Casing Depth (feet, bgs)	Screen Interval Depth (feet, bgs)	Depth to Sand Pack (feet, bgs)	Depth to Bentonite (feet, bgs)
65-MW04	04-07-95	Baker	44.84	42.90	1.94	23	23	NA	6.0-23.0	6.0	4.0
65-MW05	04-05-95	Baker	30.26	28.00	2.28	23	22	NA	7.0-22.0	5.0	3.0
65-MW06	04-05-95	Baker	34.71	32.55	2.16	21	20	NA	5.0-20.0	3.0	2.0
65-MW07	04-04-95	Baker	36.74	34.47	2.27	23	23	NA	8.0-23.0	6.0	4.0
65-DW01	04-10-95	Baker	32.07	30.00	2.07	66.0	66.0	42.0	56.0-66.0	54.0	39.0
65-DW02	04-11-95	Baker	25.40	23.50	1.90	56.0	54.0	39.0	44.0-54.0	42.0	37.5
65-DW04	04-07-95	Baker	44.49	42.43	2.06	70.0	68.0	50.0	58.0-68.0	56.0	44.0

Notes:

msl = Mean Sea Level
bgs = Below Ground Surface
NA = Not Applicable

TABLE 2-2

SUMMARY OF GROUNDWATER LEVEL MEASUREMENTS
SITE 65 - ENGINEER AREA DUMP
REMEDIAL INVESTIGATION, CTO-0312
MCB, CAMP LEJEUNE, NORTH CAROLINA

Well No.	Top of PVC Casing Elevation (feet, above msl)	Depth to Groundwater (feet, below top of casing) April 20, 1995	Depth to Groundwater (feet, below top of casing) April 23, 1995	Depth to Groundwater (feet, below top of casing) August 21, 1995	Groundwater Elevation (feet, above msl) April 20, 1995	Groundwater Elevation (feet, above msl) April 23, 1995	Groundwater Elevation (feet, above msl) August 21, 1995
65-MW01	34.64	12.95	11.58	13.07	21.69	23.06	21.57
65-MW02	25.21	7.43	6.53	8.09	17.78	18.68	17.12
65-MW03	39.61	13.05	12.19	14.01	26.56	27.42	25.60
65-MW04	44.84	15.44	14.54	16.75	29.40	30.30	28.09
65-MW05	30.28	11.70	10.82	12.29	18.58	19.46	17.99
65-MW06	34.71	9.33	8.42	10.34	25.38	26.29	24.37
65-MW07	36.74	13.29	12.38	13.85	23.45	24.36	22.89
65-DW01	32.07	24.11	22.83	24.01	7.96	9.24	8.06
65-DW02	25.40	17.65	16.97	18.33	7.75	8.43	7.07
65-DW04	44.49	34.10	33.28	34.82	10.39	11.21	9.67

Notes:

msl = Mean Sea Level

TABLE 2-3

SUMMARY OF GROUNDWATER SAMPLING FIELD PARAMETERS
SITE 65 - ENGINEER AREA DUMP
REMEDIAL INVESTIGATION, CTO-0312
MCB, CAMP LEJEUNE, NORTH CAROLINA

Well Number	Sampling Date	Well Depth (ft)(1)	Purge Volume (gal)	Field Parameters					
				Well Volume	Specific Cond.(2) (umhos/cm)	pH (SU)(3)	Cond. Temp.(4) (deg. C)	pH Temp.(5) (deg. C)	Turbidity (NTU)(6)
65-MW01	5/8/95	21.48	1.5	0	820	6.87	22.0	20.0	NA
				1	820	6.94	19.0	21.0	NA
				2	820	6.90	21.0	20.0	11.09
				3	***820***	***6.83***	***21.0***	***20.0***	***1.52***
65-MW02	5/9/95	15.87	1.4	0	385	6.35	20.0	19.0	5.80
				1.5	330	6.15	19.0	19.0	6.73
				3	310	6.09	19.0	19.0	4.73
				4.5	***300***	***6.10***	***19.0***	***19.0***	***2.63***
65-MW03	5/9/95	22.11	1.6	0	170	5.67	18.0	17.0	6.33
				1	270	6.09	18.5	18.0	2.05
				2	265	6.06	19.5	18.0	1.67
				3	***260***	***6.08***	***19.5***	***18.0***	***1.10***
65-MW04	5/17/95	24.57	1.6	0	73.8	5.55	18.1	19.0	6.7
				1	76.7	5.76	18.1	17.6	1.9
				2	76.5	5.65	17.9	17.9	1.2
				3	75.3	5.60	17.8	17.4	0.3
				4	73.6	5.45	17.7	17.1	0.2
				5	73.8	5.48	17.7	17.0	0.2
				6	***73.8***	***5.47***	***17.8***	***17.1***	***0.2***

Notes:

(1) - Measured from top of PVC Casing

(2) - Specific Conductance at 25 deg. C

(3) - SU = Standard Units

(4) - Temperature Measured with Cond. Meter

(5) - Temperature Measured with pH Meter

(6) - NTU = Nephelometric Turbidity Units

The bold and italicized parameters where taken immediately prior to sampling the well.

TABLE 2-3 (Continued)

SUMMARY OF GROUNDWATER SAMPLING FIELD PARAMETERS
SITE 65 - ENGINEER AREA DUMP
REMEDIAL INVESTIGATION, CTO-0312
MCB, CAMP LEJEUNE, NORTH CAROLINA

Well Number	Sampling Date	Well Depth (ft)(1)	Purge Volume (gal)	Field Parameters					
				Well Volume	Specific Cond.(2) (umhos/cm)	pH (SU)(3)	Cond. Temp.(4) (deg. C)	pH Temp.(5) (deg. C)	Turbidity (NTU)(6)
65-MW05	5/9/95	24.82	2.2	0	227	5.75	20.0	18.0	4.82
				1	220	5.73	19.0	18.0	13.38
				2	237	5.75	19.0	18.0	10.12
				3	***240***	***5.78***	***19.0***	***18.0***	***6.04***
65-MW06	5/9/95	21.36	1.8	0	190	5.01	18.5	17.0	32.90
				1	135	4.99	19.0	16.5	38.60
				2	130	4.93	18.5	17.0	18.30
				3	130	4.94	18.5	17.0	10.12
				4	***135***	***4.96***	***18.0***	***17.0***	***8.18***
65-MW07	5/9/95	24.72	1.9	0	245	5.67	19.0	19.0	6.39
				1.25	262	5.85	19.0	18.0	3.99
				2	260	5.74	19.0	20.0	3.07
				3	***260***	***5.72***	***19.0***	***19.0***	***2.49***
65-DW01	5/8/95	67.88	7.3	0	700	8.53	22.5	19.0	10.59
				1	270	8.45	20.0	18.0	5.52
				2	275	8.37	19.5	18.0	3.81
				3	***275***	***8.42***	***19.0***	***18.0***	***2.93***
65-DW02	5/9/95	55.49	6.2	0	440	6.61	19.5	18.0	11.28
				1	550	6.38	19.5	17.5	3.28
				2	550	6.48	19.5	17.5	1.19
				3	***500***	***6.44***	***19.5***	***17.5***	***1.22***

Notes:

(1) - Measured from top of PVC Casing

(2) - Specific Conductance at 25 deg. C

(3) - SU = Standard Units

(4) - Temperature Measured with Cond. Meter

(5) - Temperature Measured with pH Meter

(6) - NTU = Nephelometric Turbidity Units

The bold and italicized parameters where taken immediately prior to sampling the well.

TABLE 2-3 (Continued)

SUMMARY OF GROUNDWATER SAMPLING FIELD PARAMETERS
SITE 65 - ENGINEER AREA DUMP
REMEDIAL INVESTIGATION, CTO-0312
MCB, CAMP LEJEUNE, NORTH CAROLINA

Well Number	Sampling Date	Well Depth (ft)(1)	Purge Volume (gal)	Field Parameters					
				Well Volume	Specific Cond.(2) (umhos/cm)	pH (SU)(3)	Cond. Temp.(4) (deg. C)	pH Temp.(5) (deg. C)	Turbidity (NTU)(6)
65-DW02	5/18/95	55.60	6.3	1	620	6.95	19.1	21.3	1.98
				2	605	7.10	18.9	20.2	2.08
				3	***600***	***7.12***	***19.0***	***20.2***	***1.21***
65-DW04	5/16/95	69.71	6	0	226.3	8.76	20.4	21.6	6.9
				1	223.2	8.87	19.9	20.2	3.5
				2	221.4	8.89	20.2	20.4	2.8
				3	221.6	8.94	19.5	20.0	3.0
				4	219.5	8.99	19.2	19.2	1.5
				5	219.5	8.98	19.3	19.2	1.9
				6	***219.4***	***8.98***	***19.4***	***19.4***	***2.1***

Notes:

(1) - Measured from top of PVC Casing

(2) - Specific Conductance at 25 deg. C

(3) - SU = Standard Units

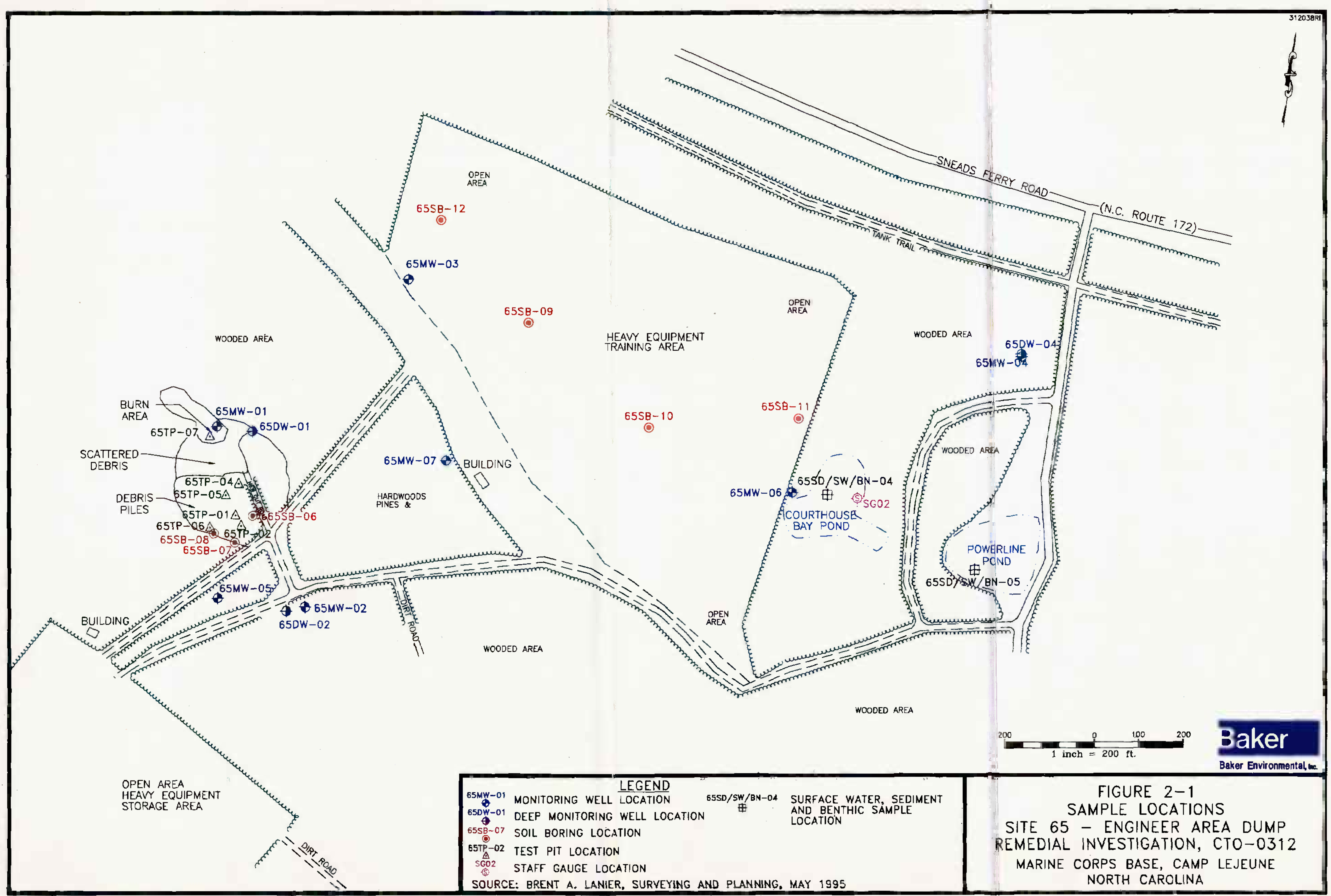
(4) - Temperature Measured with Cond. Meter

(5) - Temperature Measured with pH Meter

(6) - NTU = Nephelometric Turbidity Units

The bold and italicized parameters where taken immediately prior to sampling the well.

FIGURES



LEGEND

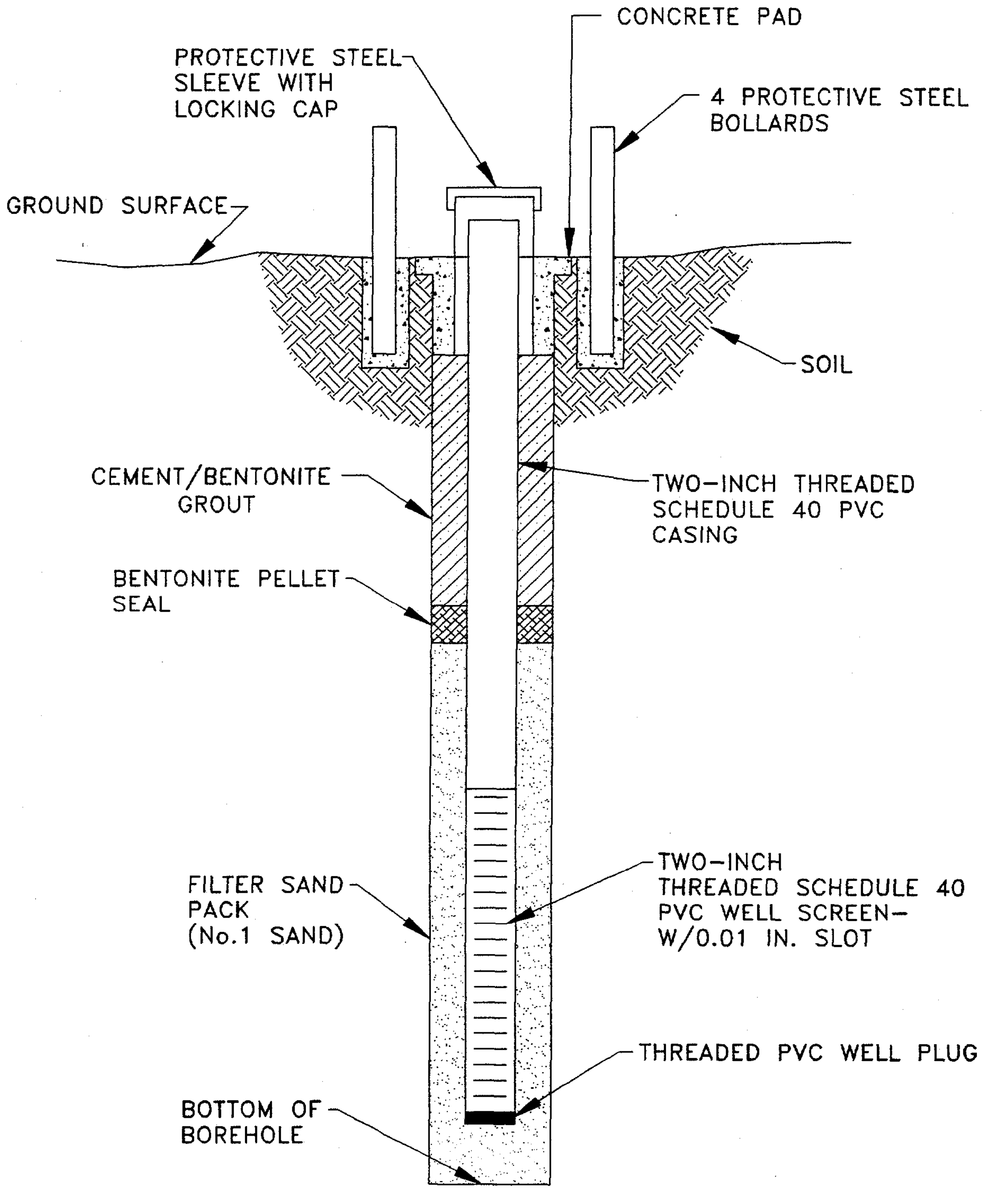
65MW-01 ⊕	MONITORING WELL LOCATION
65DW-01 ⊕	DEEP MONITORING WELL LOCATION
65SB-07 ◉	SOIL BORING LOCATION
65TP-02 △	TEST PIT LOCATION
SG02 ⓢ	STAFF GAUGE LOCATION
65SD/SW/BN-04 ⊞	SURFACE WATER, SEDIMENT AND BENTHIC SAMPLE LOCATION

SOURCE: BRENT A. LANIER, SURVEYING AND PLANNING, MAY 1995

Baker
Baker Environmental, Inc.

FIGURE 2-1
SAMPLE LOCATIONS
SITE 65 – ENGINEER AREA DUMP
REMEDIAL INVESTIGATION, CTO-0312
MARINE CORPS BASE, CAMP LEJEUNE
NORTH CAROLINA

00145007Y

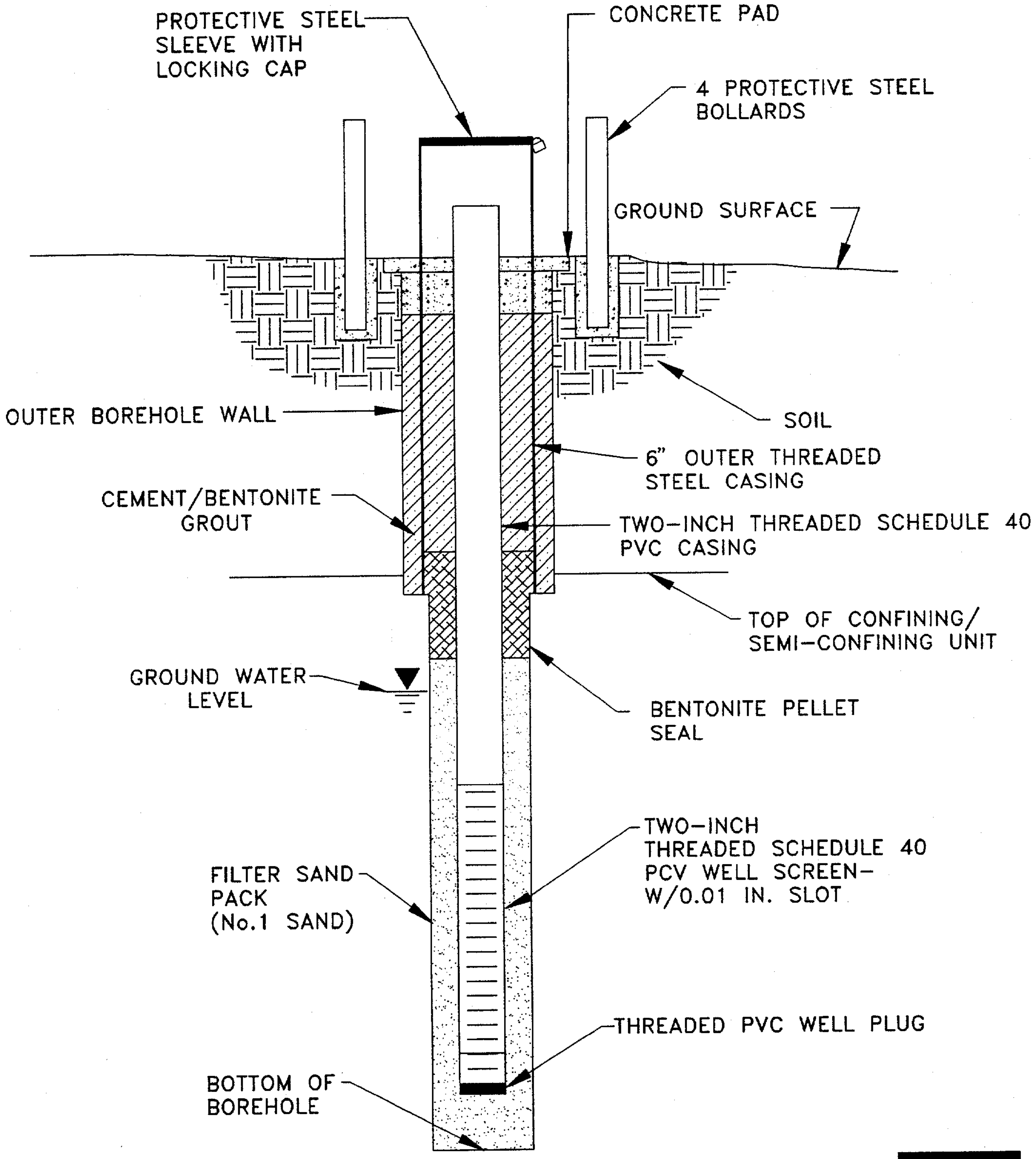


NOT TO SCALE

Baker
Baker Environmental, Inc.

FIGURE 2-2
TYPICAL TYPE II GROUNDWATER MONITORING WELL CONSTRUCTION DIAGRAM
SITE 65 - ENGINEER AREA DUMP
REMEDIAL INVESTIGATION, CTO-0312
MARINE CORPS BASE, CAMP LEJEUNE
NORTH CAROLINA

312035RI



NOT TO SCALE

Baker Environmental, Inc.

FIGURE 2-3
TYPICAL TYPE III GROUNDWATER MONITORING WELL
CONSTRUCTION DIAGRAM
SITE 65 - ENGINEER AREA DUMP
REMEDIAL INVESTIGATION, CTO-0312
MARINE CORPS BASE, CAMP LEJEUNE
NORTH CAROLINA

3.0 PHYSICAL CHARACTERISTICS OF THE STUDY AREA

This section presents a discussion of the physical characteristics of Site 65, Engineer Area Dump including: surface features, climatology and meteorology, hydrology, geology (regional and site), soils, hydrogeology (regional and site), land usage, ecology (regional and site), and a water supply well inventory of the area. This information was obtained from available literature pertaining to MCB, Camp Lejeune and from the RI field activities.

3.1 Topography and Surface Features

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

Drainage at Camp Lejeune is generally toward the New River, except in areas near the coast which drain through the Intracoastal Waterway. In developed areas, natural drainage has been altered by asphalt cover, storm sewers, and drainage ditches. Approximately 70 percent of Camp Lejeune is in broad, flat interstream areas. Drainage is poor in these areas and the soils are often wet (WAR, 1983).

The U.S. Army, Corps of Engineers has mapped the limits of 100-year floodplain at Camp Lejeune at 7.0 feet above msl in the upper reaches of the New River; this increases downstream to 11 feet above msl near the coastal area (WAR, 1983). Since Site 65 elevations range between 20 and 40 feet msl, it does not lie within the 100-year floodplain of the New River.

The surface of the study area is primarily covered with vegetation except for the heavy equipment training area and vehicular trails that bisect the site. Two ponds (Courthouse Bay and Powerline Ponds) are located east of the Heavy Equipment Training Area.

The topography of Site 65 is gently pitched to the southeast. The site has numerous areas where the natural topography has been modified by the removal and redistribution of earth materials (i.e., training exercises) or by past dumping practices. A 4.5-percent grade exists between monitoring wells 65DW-04 (located near the ponds east of the site) and 65DW-02 (located on the southeastern edge of the site). Infiltration is high at the site due to the lack of man-made drainage ditches and impervious surfaces such as paved roads, parking lots or buildings.

3.2 Surface Water Hydrology

The following summary of surface water hydrology was originally presented in the IAS report (WAR, 1983). The dominant surface water at MCB, Camp Lejeune is the New River. It receives drainage from most of the base. The river is short, with a course of approximately 50 miles on the central Coastal Plain of North Carolina. Over most of its course, the New River is confined to a relatively narrow channel entrenched in Eocene and Oligocene limestones. South of Jacksonville, the river widens as it flows across less resistant sands, clays, and marls. At MCB, Camp Lejeune, the New River flows in a southerly direction into the Atlantic Ocean through the New River Inlet. Several small coastal creeks drain into the area of MCB, Camp Lejeune not associated with the New River and its tributaries. The New River, the Intracoastal Waterway and the Atlantic Ocean converge at the New River Inlet.

Water quality criteria for surface waters in North Carolina have been published under Title 15 of the North Carolina Administration Code. The following classifications were assigned to the New River, Courthouse Bay and the two ponds located east of Site 65.

At MCB, Camp Lejeune, the New River falls into two classifications: estuarine waters not suited for body-contact sports or commercial shell fishing (SC) and estuarine water suited for commercial shellfishing primary recreation, aquatic life propagation and survival, fishing, wildlife, and secondary recreation (SA). The portion of the river that is nearest to the site, as well as Courthouse Bay are classified as Class SA.

The ponds located east of the site have not been classified by NC DEHNR. Therefore, the ponds were assigned a classification by a process of elimination. The ponds are freshwater ponds not used for consumptive purposes, and are not used for primary recreation. Therefore, they were assigned a Class C classification. This classification is reserved for freshwater bodies in which aquatic life propagation and survival, fishing, wildlife, secondary recreation and agricultural uses may occur.

3.3 Geology and Soil

3.3.1 Regional

MCB, Camp Lejeune is situated within the Tidewater region of the Atlantic Coastal Plain physiographic province. The sediments of the Atlantic Coastal Plain consist mostly of interbedded sands, silts, clays, calcareous clays, shell beds, sandstone and limestone. These sediments are layered in interfingering beds and lenses that gently dip and thicken to the southeast to a combined thickness of approximately 1,500 feet. These sediments were deposited in marine or near-shore environments and range in age from early Cretaceous to Quaternary time. Regionally, they comprise 10 aquifers and 9 confining units which overlie igneous and metamorphic basement rocks of the pre-Cretaceous age. Seven of these aquifers and their associated confining units are present in the MCB, Camp Lejeune area. Table 3-1 presents a generalized stratigraphic column for Jones and Onslow Counties, North Carolina, and geologic cross sections of the MCB, Camp Lejeune area are presented on Figures 3-1 and 3-2.

3.3.2 Site-Specific

Information regarding surface soil classifications was obtained from a study entitled Soil Survey, Camp Lejeune, North Carolina (Barnhill, 1984). The soils at the site fall into three different classifications: Baymeade fine sand (BmB), Pits (Pt) and Leon fine sand (Ln).

The soils located north of the site (i.e., north of the Heavy Equipment Training Area) and west of the site are classified as Baymeade fine sand. This soil is well drained and occurs in large areas with moderately convex slopes near major drainageways. Typically ranging from 25 to 300 acres in size, most of the acreage is woodland. Infiltration is rapid and surface runoff slow while permeability is moderately rapid with low water capacity. In the absence of ground cover, the soil is susceptible to accelerated erosion.

The portions of the site used for Heavy Equipment Training and past dumping (i.e., the area where the debris piles are located) are classified as Pits (Pt). These soils are defined as units consisting of areas where the soils have been excavated, commonly to a depth of five to 15 feet bgs.

The remaining soils located to the south of the site are classified as Leon fine sands. These nearly level, poorly drained soils are primarily located in upland areas, occurring on broad interstream divides. These soils range from 20 to 800 acres in size and are nearly all in woodland areas. Infiltration is rapid and surface run-off slow. Permeability of the surface soils is typically rapid but only moderate in the subsurface soils. The humus-coated sand particles are weakly cemented when wet and become hard and brittle upon drying.

Subsurface soils encountered during drilling at Site 65 are representative of undifferentiated and River Bend Formations. Geologic cross sections for Site 65 are presented on Figures 3-3, 3-4, and 3-5.

Numerous borings were advanced within the study area during the field investigations conducted by Baker. Subsurface soil descriptions are provided in the Test Boring and Well Construction Records in Appendix A. Additional information regarding the soils were obtained from the previous investigations. The following provides a detailed description of the stratigraphy underlying the study area.

Soil conditions are generally uniform throughout the study area. In general, the shallow soils consist of unconsolidated deposits of sand and silty sand. These soils represent the Quaternary age "undifferentiated" deposits which overlay the River Bend Formation. Sands are primarily very fine to fine grained and contain varied amounts of silt and clay. Results of the standard penetrations tests indicate that the sands have a relative density of loose to dense. Based on field observations, the sands classify as silty sand (SM) and/or poorly graded sand (SP) according to the Unified Soil Classification System (USCS).

Geologic cross-sections were constructed to illustrate subsurface soil beneath the study area. As shown on Figure 3-3, the site was traversed to provide a cross-sectional view of the study area. Two cross-sections were constructed: A-A' crosses the site north to south; B-B' crosses west to east.

Cross-section A-A' depicts subsurface soils to an elevation of -42.5 feet msl from the northern portion of the site to the southern. As illustrated on Figure 3-4, the soil underlying this portion of the area consists of very fine to fine sands with trace amounts of silt and clay.

Underlying the previously described soils is a loose to medium dense, greenish gray, fine sand containing little clay (approximately 10-35%) and trace silt. This soil unit constitutes the Belgrade Formation in the semi-confining unit separating the Quaternary sediments from the Castle Hayne aquifer. The semi-confining unit appears to be approximately 7.5 to 15 feet thick, generally thickening toward the north. Beneath this unit resides the River Bend Formation. Borings were only advanced 10 to 15 feet into this formation during the RI, therefore providing limited knowledge of specific details regarding the condition of the River Bend beneath the study area. The upper portion of the River Bend was described as a partially cemented, gray, fine sand with some shell fragment and limestone fragments encountered periodically.

Cross-section B-B' depicts the subsurface soil conditions to an elevation of -35.1 feet msl (Figure 3-5). Overall the soils did not differ substantially from those encountered in the A-A' cross section. In general, a very fine to fine sand with little clay and trace silt to an elevation of 3 to - 11 feet msl. The semi-confining unit underlies this unit followed by the River Bend Formation.

Overall, the soils encountered during investigations within the study area are fairly consistent throughout. Note that within the study area, a laterally continuous semi-confining unit was present and between 3 and -11 feet msl. The location of the semi-confining unit separating the surficial from the Castle Hayne aquifer was encountered approximately 40 feet bgs. This is consistent with the range reported by the USGS, but exceeds the reported average of 25 feet bgs (Cardinell et al., 1993).

3.4 Hydrogeology

3.4.1 Regional

The following sections discuss the regional and site-specific hydrogeologic conditions. The information presented on the regional hydrogeology is from literature (Harned, et al., 1989 and Cardinell, et al., 1993). Site-specific, hydrogeologic information presented is from data collected during field investigations. Additional information was collected from a technical memorandum prepared by Baker which summarizes groundwater data and aquifer characteristics for MCB, Camp Lejeune (see Appendix G).

United States Geological Survey (USGS) studies at MCB, Camp Lejeune indicate that the area is underlain by sand and limestone aquifers separated by confining units of silt and clay. These aquifers include the surficial (water table), Castle Hayne, Beaufort, Peedee, Black Creek, and upper and lower Cape Fear. Less permeable clay and silt beds function as confining units or semi-confining units which separate the aquifers and impede the flow of groundwater between aquifers.

The surficial aquifer consist of interfingering beds of sand, clay, sandy clay and silt that contain some peat and shells of Quaternary and Miocene age. These sediments commonly extend to depths of 50 to 100 feet bgs. Thickness of the surficial aquifer in MCB, Camp Lejeune area range from 0 to 73 feet, and typically average 25 feet. The aquifer is generally thickest in the interstream divide areas and may be absent where it is cut by the New River and its tributaries. The clay, sandy clay, and silt beds that occur in the surficial aquifer are thin and discontinuous throughout. A semi-confining unit is found in the surficial aquifer within some portions of MCB, Camp Lejeune.

Recharge to the surficial aquifer is by rainfall. The aquifer receives more recharge in the winter than in the summer when much of the water evaporates or is transpired by plants before it can reach the water table. Most of the surficial groundwater is discharged to local streams, but some water passes through the underlying semi-confining unit. Recharge for the surficial aquifer is based on an average rainfall of 52 inches per year and an average recharge of 30 percent, or an annual recharge of approximately 16 inches per year. The remaining 70 percent of the rainfall is lost as surface runoff or evapotranspiration. Sixteen inches of recharge equates to 7,600,000 gallons per day (gpd) per square mile or approximately 114,000,000 gpd for all of MCB, Camp Lejeune (based on 150 square miles of recharge area). Water levels in the wells tapping the surficial aquifer vary seasonally. The water table is generally highest in the winter and spring, and lowest in the summer and early fall. The estimated lateral hydraulic conductivity for the surficial aquifer is 50 feet per day (ft/d) and is based on a general composition of fine sand mixed with some silt and clay (Cardinal, et al., 1993).

Although the aquifer is classified as GA (i.e., existing or potential source of drinking water supply for humans), it is not used as a potable water source at MCB, Camp Lejeune because of its low yielding production rates (typically less than 3 gpm).

The Castle Hayne semi-confining unit in the MCB, Camp Lejeune area is characterized as less permeability beds overlying the Castle Hayne aquifer that have been partly eroded or incised in places. This unit is composed of clay, silt, and sandy clay, with vertical hydraulic conductivity estimates of 1.4×10^{-3} to 0.41 feet/day. The range in vertical hydraulic conductivity of the semi-confining layers determines the degree to which the semi-confining unit transmits flow. The thickness of the semi-confining unit ranges from zero to 26 feet and averages about nine feet where present.

The principal water supply aquifer for MCB, Camp Lejeune is the Castle Hayne aquifer. This aquifer primarily resides within the River Bend Formation which consists of sand, cemented shells and limestone. The upper portion of the aquifer is primarily comprised of calcareous sands with some thin clay and silt beds. The sand becomes increasingly more limy with depth. The lower portion of the aquifer is comprised of partially unconsolidated limestone and sandy limestone interbedded with clay and sand. Also, buried paleostream channels containing various deposits exist within the aquifer. The top of the aquifer ranges from 10 feet above sea level to 70 feet below sea level and is irregular over most of the northern portion of MCB, Camp Lejeune. The aquifer is more regular in areas southeast of the New River, where it slopes southeastward. The Castle Hayne thickens to the east, from 160 feet in the Camp Geiger area to over 400 feet at the eastern boundary of MCB, Camp Lejeune.

Estimated transmissivity, hydraulic conductivity and storage coefficient values for the Castle Hayne aquifer range from 6,100 to 183,300 gpd/ft, 14 to 91 feet/day and $2x10^{-4}$ to $1x10^{-3}$, respectively. An aquifer pump test conducted by ESE (1988) in the Hadnot Point Industrial Area, using an existing water supply well (HP-642), indicates an average transmissivity and storage coefficient of 9,600 gpd/ft and $8.8x10^{-4}$, respectively (ESE, 1988).

Recharge of the Castle Hayne aquifer at MCB, Camp Lejeune is primarily received from the surficial aquifer. Natural discharge is to the New River and its major tributaries. The Castle Hayne aquifer provides roughly seven million gallons of water to MCB, Camp Lejeune. Groundwater pumping has not significantly affected natural head gradients in the aquifer.

MCB, Camp Lejeune lies in an area where the upper part of the Castle Hayne aquifer contains freshwater. Saltwater is found in the bottom of the aquifer in the region and in the New River estuary; both are of concern in managing water withdrawals from the aquifer. Overpumping of the deeper parts of the aquifer or in areas hydraulically connected to estuarine streams could cause saltwater intrusions. The aquifer underlying most of the area contains water having less than 120 milligrams per liter (mg/L) of chloride.

3.4.2 Site-Specific

The following sections describe the site hydrogeologic conditions for the surficial (water table) aquifer and the Castle Hayne aquifer at Site 65. Hydrogeologic characteristics in the vicinity of the site were evaluated by reviewing existing information and installing a network of shallow and deep monitoring wells.

Groundwater was encountered at varying depths during the drilling program. This variation is primarily attributed to topographical changes. In general, the groundwater was encountered between 7.5 and 11 bgs feet during field activities performed at the site.

Three rounds of groundwater level measurements were obtained on April 20, 23 and August 21, 1995, from the shallow and deep monitoring wells within the study area. The measurements are recorded on Table 2-2 and groundwater contours for the surficial aquifer are depicted on Figure 3-6.

Shallow groundwater elevations exhibited some fluctuation over the four-month period. The water table increased an average of 0.97 feet in elevation between April 20 and 23, 1995. Conversely, between April 23 and August 21, 1995, the water table decreased an average of 1.71 feet in elevation. Typically at MCB, Camp Lejeune, a higher water table is observed in the winter and spring and a lower water table is noted in the summer and fall. According to historical rainfall data provided by the Naval Oceanography Command Detachment, rainfall increases throughout the summer with July recording the largest quantity per year on average. A decrease in amount of rain is usually observed in August; however, the month of August historically records the second highest quantity of rain for the entire year with the month of June recording the third highest amount (see Table 3-2). However, according to Headquarters and Headquarters Squadron Station Weather located at the Marine Corps Air Station, New River, considerably less rain was received during the summer months (Appendix H). During 1995, the following quantities of rain were received by month:

- April - 0.14 inches
- May - 3.66 inches
- June - 9.54 inches
- July - 2.37 inches
- August - 7.49 inches

These actual quantities are well below the historical average.

Shallow groundwater elevations and flow patterns observed on August 21, 1995 are depicted on Figure 3-6. Calculations for hydraulic gradient were completed using the three point method described in USGS Water Supply Paper No. 2220, entitled "Basic Groundwater Hydrology". The data indicates that the groundwater flow is toward the south-southwest, with an average gradient of 9.7×10^{-3} ft/ft. The southwestern portion of the site has a steeper gradient (an average of 1.2×10^{-2} ft/ft) than the rest of the site (an average of 8.2×10^{-3} ft/ft).

Hydraulic conductivity tests were performed at the site on May 22, 1995. The average conductivity for the surficial aquifer is 0.722 ft/day (2.55×10^{-4} cm/sec). These values were calculated using the Geraghty and Miller, Aquifer Test Solver (AQTESOLV) program which uses the Bouwer and Rice (1976) method for unconfined aquifers. The average values are consistent with expected values of hydraulic conductivity for the fine sands observed at the site (Fetter, 1980). The copies of the AQTESOLV printouts are located in Appendix I and the results are summarized on Table 3-3.

A study of data from other aquifer tests (pump tests) performed at MCB, Camp Lejeune was conducted by Baker to further evaluate aquifer characteristics and production capacities. The technical memorandum is provided in Appendix G. The information contained in this memorandum pertains primarily to the surficial aquifer. Average pumping rates range from 0.5 to 3 gpm.

Transmissivity ranges from 7.17 to 7,100 ft^2/day; storativity ranges from 1.51 x 10^{-3} to 7.48 x 10^{-2}; and hydraulic conductivity ranged from 0.48 to 1.42 ft/day.

Fluctuation of the groundwater elevations within the deep wells was observed over the three months; however, the change was not as significant as in the shallow wells. An average increase of 0.93 feet was observed between April 20 and 23, and a decrease of 1.36 feet in the groundwater elevation was observed between April 23 and August 21, 1995. It is not uncommon for a semi-confined aquifer to not respond to precipitation or seasonal fluctuation with the same magnitude as an unconfined aquifer. The presence of the semi-confining unit serves to impede the vertical migration of precipitation causing a delayed and minimized effect on the head of the semi-confined aquifer.

Groundwater elevations and flow patterns for the upper portion of the Castle Hayne aquifer are depicted on Figure 3-7. Given the limited number of points, groundwater flow direction and gradient is estimated to flow in a southern to southwestern direction with a gradient of 2.3 x 10^{-03} to 2.7 x 10^{-03} ft/ft.

3.6 Land Use and Demographics

MCB, Camp Lejeune presently covers an area of approximately 236 square miles. Currently, the military population of MCB, Camp Lejeune is approximately 41,000 active duty personnel. The military dependent community is in excess of 32,000 civilian employees perform facilities management and support functions. The population of Onslow County has grown from 17,738 in 1940, prior to the formation of the base, to its present population of 121,350.

During World War II, MCB, Camp Lejeune was used as a training area to prepare Marines for combat. This has been a continuing function of the facility during the Korean and Vietnam Conflicts and the recent Gulf War (i.e., Desert Storm). Toward the end of World War II, the base was designated as home for the Second Marine Division. Since that time, Fleet Marine Forces units also have been stationed here as tenant commands.

The existing land use patterns in the various geographic areas within the MCB are described in this section and listed, per geographic area, on Table 3-4. In addition, the number of acres comprising each land use category has been estimated and provided on the table. The areas described below are depicted on Figure 1-2.

The Engineer Area Dump (Site 65) refers to a four- to five-acre former land disposal site situated in the Courthouse Bay section of MCB, Camp Lejeune. Courthouse Bay is located on the south side of state road 172 along the eastern shore of the New River. It is one of a series of small bays which are formed by the New River.

Site 65 is a primarily wooded area located immediately east of the Marine Corps Engineer School which occupies property between Site 65 and the bay. The school is used for maintenance, storage, and operator training of amphibious vehicles and heavy construction equipment. The school also utilizes a several acre parcel located just east of Site 65 to conduct heavy equipment training activities. Two surface ponds are located immediately east of the training facilities that have recreational fishing available, and is stocked by the base fishery commission. Also, there are some physical fitness trails and exercise stops that run throughout the site and surrounding areas. Several wide, cleared trails for tanks and heavy equipment cross the site.

3.7 Climatology and Meteorology

Although coastal North Carolina lacks distinct wet and dry seasons, there is some seasonal variation in average precipitation (See Table 3-2). July tends to receive the most precipitation and rainfall amounts during summer are generally the greatest. Daily showers during the summer are not uncommon, nor are periods of one or two weeks without rain. Convective showers and thunderstorms contribute to the variability of precipitation during the summer months. October tends to receive the least amount of precipitation, on average. Throughout the winter and spring months precipitation occurs primarily in the form of migratory low pressure storms. MCB, Camp Lejeune's average yearly rainfall is approximately 52 inches. Table 3-2 presents a climatic summary of data collected during 35 years (January 1955 to December 1990) of observations at Marine Corps Air Station New River.

Coastal plain temperatures are moderated by the proximity of the Atlantic Ocean. The ocean effectively reduces the average daily fluctuation of temperature. Lying 50 miles offshore at its nearest point, the Gulf Stream tends to have little direct effect on coastal temperatures. The southern reaches of the cold Labrador Current offsets any warming effect the Gulf Stream might otherwise provide.

MCB, Camp Lejeune experiences hot and humid summers; however, ocean breezes frequently produce a cooling effect. The winter months tend to be mild, with occasional brief cold spells. Average daily temperatures range from 38°F to 58°F in January and 72°F to 86°F in July. The average relative humidity, between 75 and 85 percent, does not vary greatly from season to season.

Observations of sky conditions indicate yearly averages of approximately 112 days clear, 105 partly cloudy, and 148 cloudy. Measurable amounts of rainfall occur 120 days per year, on the average. Prevailing winds are generally from the south-southwest 10 months of the year, and from the north-northwest during September and October at an average speed of 6.9 miles per hour.

3.8 Water Supply

Potable water for MCB, Camp Lejeune is supplied entirely by groundwater. The base has no formally established groundwater preservation areas; however, because the base controls more than 110,000 acres of land, and because much of this land has remained undeveloped, the undeveloped areas serve the function of groundwater preserves. Groundwater usage is roughly seven million gallons per day (Cardinell, et al., 1993). Groundwater is pumped from approximately 77 of 90 water supply wells located within the boundaries of MCB, Camp Lejeune. Water is treated at eight plants which have a total capacity of 15.8 million gallons per day.

All of the water supply wells utilize the Castle Hayne aquifer. The Castle Hayne aquifer is highly permeable, semi-confined aquifer that is capable of yielding several hundred to 1,000 gpm in municipal and industrial wells in the MCB, Camp Lejeune area. The water supply wells at the base average 162 feet in depth; eight inches in diameter (casing); and yield 174 gpm (Harned, et al., 1989). The water is typically a hard, calcium bicarbonate type. Table 3-5 provides a summary of the supply wells within a one-mile radius of Site 65. The locations of these supply wells are depicted in Figure 3-8. Information pertaining to the supply wells was gathered from the Wellhead Management Program Engineering Study 91-36 (Geoplex, 1991), the Preliminary Draft Report Wellhead Monitoring Study 92-34 (Greenhorne and O'Mara, Inc., 1992), and interviews with base personnel.

Five active wells are located within a one-mile radius of Site 65 (BB44, BB47, BB218, BB220, and BB221). Production well BB44 is located approximately 1,200 feet from the site. The total depth of this well is 62 feet bgs and is screened from 32 to 62 feet bgs. This well is suspected to have been impacted by surficial groundwater infiltration due to its relatively shallow screen.

Production wells BB47, BB218, BB220, and BB221 have total depths of 150, 185, 150, and 200 feet, respectively. The screen intervals for the wells (measured in feet bgs) are as follows:

- BB 47 - <40-53 feet and 102-125 feet
- BB 218 - <64-94 feet and 148-168 feet
- BB 220 - 55-70 feet; 85-95 feet; and 130-145 feet
- BB 221 - 60-80 feet; and 135-155 feet

3.9 Ecological Characteristics

3.9.1 Regional Ecology

Camp Lejeune covers approximately 108,800 acres, 84 percent of which is forested (USMC, 1987). Approximately 45 percent of this is pine forest, 22 percent is mixed pine/hardwood forest, and 17 percent is hardwood forest. Nine percent of the base, a total of 3,587 acres, is wetland and includes pure pond pine stands, mixed pond pine/hardwood stands, marshes, pocosins, and wooded swamps. The base also contains 80 miles of tidal streams, 21 miles of marine shoreline, and 12 freshwater ponds.

The base drains primarily to the New River or its tributaries. These tributaries include Northeast Creek, Southwest Creek, Wallace Creek, French's Creek, Bear Head Creek, and Duck Creek.

Because of the natural resources on the base, forested areas are actively managed for timber. Game species are also managed for hunting, and ponds are maintained for fishing. Game species managed include wild turkey, white-tailed deer, black bear, grey and fox squirrels, bobwhite quail, eastern cottontail and marsh rabbits, racoons, and wood ducks.

A number of natural communities are present in the coastal plain. Subcommunities and variations of these major community types are also present and alterations of natural communities have occurred in response to disturbance and intervention (i.e., forest cleared to become pasture). The natural communities found in the Camp Lejeune area are summarized as follows:

- Mixed Hardwood Forest - Found generally on slopes of ravines. Beech is an indicator species with white oak, tulip, sweetgum, and holly.

- Southern Evergreen Forest - Dominated by pines, especially longleaf pine.

- Loblolly Pine/Hardwoods Community - Second growth forest that includes loblolly pine with a mix of hardwoods - oak, hickory, sweetgum, sour gum, red maple, and holly.

- Southern Floodplain Forest - Occurs on the floodplains of rivers. Hardwoods dominate with a variety of species present. Composition of species varies with the amount of moisture present.

- Maritime Forest - Develop on the lee side of stables and dunes protected from the ocean. Live oak is an indicator species with pine, cedar, yaupon, holly, and laurel oak. Deciduous hardwoods may be present where forest is mature.

- Pocosin - Lowland forest community that develop on highly organic soils that are seasonally flooded. Characterized by plants adapted to drought and acidic soils low in nutrients. Pond pine is dominant tree with dense layer of evergreen shrubs. Strongly influenced by fire.

- Cypress Tupelo Swamp Forest - Occurs in the lowest and wettest areas of floodplains. Dominated by bald cypress and tupelo.

- Freshwater Marsh - Occurs upstream from tidal marshes and downstream from non-tidal freshwater wetlands. Cattails, sedges, and rushes are present. On the coast of North Carolina swamps are more common than marshes.

- Salt Marsh - Regularly flooded, tidally influenced areas dominated by salt-tolerant grasses. Saltwater cordgrass is a characteristic species. Tidal mud flats may be present during low tide.

- Salt Shrub Thicket - High areas of salt marshes and beach areas behind dunes. Subjected to salt spray and periodic saltwater flooding. Dominated by salt resistant shrubs.

- Dunes/Beaches - Zones from the ocean shore to the maritime forest. Subjected to sand, salt, wind, and water.

- Ponds and Lakes - Low depressional areas where water table reaches the surface or where ground is impermeable. In ponds rooted plants can grow across the bottom, Fish populations managed in these ponds include redear, bluegill, largemouth bass, and channel catfish (USMC, 1987).

- Open Water - Marine and estuarine waters as well as all underlying bottoms below the intertidal zone.

3.9.2 Site-Specific Ecology

During May 15 to 24, 1995, Baker conducted a qualitative habitat evaluation of the terrestrial environment at Site 65. The site and surrounding areas are dominated by a mixed forest composed of pine and deciduous trees. Cleared, sandy areas are located to the south and southeast of the site. Buildings, mowed grass, and paved surfaces are located to the west, and an earth moving training area is located east of Site 65. Mixed forest extends across Site 65, and is interspersed around the aforementioned zones. Topography is primarily broad and flat with scattered depressions.

Four habitat types are present at Site 65. These include forested areas, two separate wetland areas, and a low-lying drainage area. These areas are depicted on Figure 3-9, and are demarcated by an abbreviation (i.e., the forested areas are identified as F1). In addition to the aforementioned habitat types, two heavy equipment areas with close proximity to Site 65 are also identified on Figure 1-2.

Areas identified by F1, encompass the majority of land at Site 65. These areas are found within the site boundary, and are located in all directions away from Site 65. The following is a listing of the tree and shrub species identified within the F1 area:

- Loblolly Pine-Pinus taeda
- Red Maple-Acer rubrum
- Sweetgum-Liquidambar styraciflua
- Southern Red Oak-Quercus falcata
- Water Oak-Quercus nigra
- Sumac-Rhus spp.
- Tulip Poplar-Liriodendron tulipifera
- Green Ash-Fraxinus pennsylvanica
- Redbay-Persea borbonia
- Sweetbay-Magnolia virginiana
- American Holly-Ilex opaca
- Yaupon Holly-Ilex vomitoria
- Inkberry-Ilex glabra
- Privet-Ligustrum sinense
- Wild Grape-Vitis sp.
- Fetterbush-Lyonia lucida
- Blueberry-Vaccinium sp.
- Briar (various)-Smilax spp.

Because of the large wooded area surrounding Site 65, the following birds were observed or expected to occur at Site 65:

- Robin-Turdus migratorious
- Carolina Wren-Thryrothorus ludovicianus
- Red-bellied Woodpecker-Melanerpes carolinus
- Blue-gray Gnatcatcher-Polioptila caerulea
- Morning Dove-Zenaida macroura
- Summer Tanager-Piranga rubra
- Northern Mockingbird-Mimus polyglottas
- Saw Grey Heron or King Fisher (observed)

Five mammal species were identified at Site 65 based upon field signs, and are listed below:

- Raccoon-Procyon lotor
- Whitetail Deer-Odocoileus virginianus
- Gray Squirrel-Sciurus carolinensis
- Opossum-Didelphis marsupialis
- Striped Skunk-Mephitis mephitis

Six reptile and one amphibian species were identified at Site 65 based on observations, and are listed below:

- Snapping Turtle-Chelydra serpentina
- Eastern Painted Turtle-Chrysemys picta picta
- Eastern Box Turtle-Terrapene carolina carolina

- Five-lined Skink-Eumeces fasciatus
- Green Anole-Anolis carolinensis carolinensis
- Water Snake-specie unidentified
- Copperhead Snake - Agkistrodon contortrix
- Frogs-species unidentified

Two wetland areas (i.e., freshwater ponds), located several hundred feet to the east of Site 65 are shown on Figure 3-9. These areas are identified as W1 and W2. Wetland area W1, is known as Courthouse Bay Pond and wetland area W2, as Powerline Pond.

Area W1 is surrounded by a forest mixture similar to that described above. On the western side of area W1, vegetation forms a narrow (approximately 25 feet) forested buffer between the heavy equipment training area, used for earthmoving exercises and the water. The water within area W1 is very silty, and visibility is less than one inch. The source of the silt is believed to be from the earth moving exercises that take place on the western edge of area W1. In addition, area W1 is located within a depression area with slopes to the south, east, west, and north. Furthermore, an F1 area surrounds area W1 on the northern, eastern, and southern sides. The following is a listing of the tree and shrub species identified within the W1 area:

- Loblolly Pine-Pinus taeda
- Sweetgum-Liquidambar styraciflua
- Black Willow-Salix nigra
- Southern (Wax) Myrtle-Myrica cerifera
- Watershield-Brasenia schreberi

During the time of the ecological and habitat investigations, a fish investigation was conducted in Courthouse Bay Pond. Hoop nets were deployed in four different areas of the pond to assist in capturing fish. These nets were checked at least once daily. Blue gill (6 ponius macrochirus) and Redear Sunfish (6 ponius microlophus) were the only types of fish captured during the investigation.

Area W2 is located approximately 200 feet to the east of area W1. Similar to area W1, area W2 is also located within a depressional area. Large amounts of fragrant water lilly (Nymphaea odorata) and miscellaneous algae and grasses were present in Powerline Pond during sampling activities. Furthermore, an F1 area surrounds area W2 in all directions. The following is a listing of the tree and shrub species identified within the W2 area:

- Sweetgum-Liguidambar styraciflua
- Water Oak-Quercus nigra
- Black Willow-Salix nigra
- Cordgrass-Spartina sp.
- Briars (various)-Smilax spp.
- Fragrant Water Lilly-Nymphaea odorata
- Water Pennywort-Hydrocotyle umbellata
- Misc. algae and grasses

As with area W1, a fish investigation was also conducted. Hoop nets were deployed in three different areas of Powerline pond to assist in capturing fish. These nets were checked at least once daily. The following is a list of the fish species that were captured during the investigation:

- Bluegill-Lepomis macrochirus
- Redear sunfish-Lepomis microlophus
- Largemouth bass-Micropterus salmoides

The last area, is the low lying drainage area (D1). This area is adjacent to and is located to the southwest of area W1 (Courthouse Bay Pond). Area D1 appears to accept run-off from the pond during periods of heavy rainfall. Although D1 was dry during surface water and sediment sampling activities, an earlier site visit did confirm the presence of pond-overflow water within this area. Also, water marks left on trees within D1 was another contributing fact that this area becomes flooded during rain events throughout the year. The western side of D1 is bordered by the engineer training area, and the eastern and southern sides are bordered by F1 forest. The following is a listing of the tree and shrub species identified within the D1 area:

- Loblolly Pine-Pinus taeda
- Sweetgum-Liguidambar styraciflua
- Red Maple-Acer rubrum
- Southern Red Oak-Quercus falcata
- Black Willow-Salix nigra

3.10 Water Body Description

Both Courthouse Bay Pond and Powerline Pond are designated by the NC DEHNR as "C" (NC DEHNR, 1993). The C classifies the water bodies as fresh water, which allows for aquatic life propagation and survival, fishing, wildlife, secondary recreation, and agriculture (NC DEHNR, 1993).

3.11 Sensitive Environments

This section describes the sensitive environments that were evaluated at Site 65. These include wetlands, threatened and endangered species, and other potentially sensitive environments.

3.11.1 Wetlands

The NC DEHNR's Division of Environmental Management (DEM) has developed guidance pertaining to activities that may impact wetlands (NC DEHNR, 1992). In addition, certain activities affecting wetlands also are regulated by the U.S. Corps of Engineers. The U.S. Fish and Wildlife Service has prepared National Wetlands Inventory (NWI) maps for the Camp Lejeune, North Carolina area by stereoscopic analysis of high altitude aerial photographs (USDI, 1982).

Wetland areas W1 and W2 are included on the NWI maps. According to the NWI maps, both wetland areas have been identified as a Palustrine system, with an unconsolidated bottom class, and a permanently flooded water regime. Information from the NWI maps was transferred to site-specific biohabitat map (Figure 3-9).

3.11.2 Other Sensitive Environments

In addition to wetlands and protected species, other sensitive environments, including those listed in 40 CFR Part 300, were evaluated during Hazard Ranking System evaluations. These sensitive environments and their presence or absence at Site 65 are discussed below.

- Marine Sanctuary - Site 65 is not located within a Marine Sanctuary (NCMFC, 1994).

- National Park - Site 65 is not located within a National Park (NPS, 1993a).

- Designated Federal Wilderness Area - Site 65 is not located within a Designated Federal Wilderness Area (WS, 1989, 1993).

- Areas Identified under the Coastal Zone Management Act - The North Carolina Coastal Area Management Act (CAMA) regulates various types of Areas of Environmental Concern including estuarine waters, coastal wetlands, public trust areas, and estuarine shoreline through the establishment of unified policies, criteria, standards, methods, and processes (CAMA, 1974).

- Sensitive Areas Identified under the National Estuary Program or Near Coastal Waters Program - Site 65 is not located within a Sensitive Area identified under the NEP or NCWP (NCMFC, 1994).

- Critical Areas Identified under the Clean Lakes Program - Site 65 is not located within a Critical Area identified under the Clean Lakes Program (NPS, 1993).

- National Monument - Site 65 is are not located near a National Monument (NPS, 1993).

- National Seashore Recreational Area - Site 65 is not located within a National Seashore Recreational Area (NPS, 1993).

- National Lakeshore Recreational Area - Site 65 is not located within a National Lakeshore Recreational Area (NPS, 1993).

- National Preserve - Site 65 is not located within a National Preserve (NPS, 1991).

- National or State Wildlife Refuge - Site 65 is not located within a National or State Wildlife Refuge (NCWRC, 1992).

- Unit of the Coastal Barrier Resource Program - Site 65 is not located within a unit of the Coastal Barrier Resource Program (USDI, 1993).

- Administratively Proposed Federal Wilderness Area - Site 65 is not located within an Administratively Proposed Federal Wilderness Area (WS, 1989, 1993).

- Spawning Areas Critical for the maintenance of fish/shellfish species within river, lake, or coastal tidal waters (USMC, 1993).

- State land designated for wildlife or game management - Site 65 is are not located within a State game land (NCWRC, 1992).

- State designated Natural Area - Site 65 is not located within a State designated Natural Area or Area of Significant Value (LeBlond, 1991).

- State designated areas for protection or maintenance of aquatic life - No areas within the boundaries of Site 65 are designated as primary nursery areas or are unique or special waters of exceptional state or national recreational or ecological significance which require special protection to maintain existing uses (NC DEHNR, 1994).

- Areas of Significant Value - Site 65 is not located within a State Area of Significant Value (LeBlond, 1991).

- State Registered Natural Resource Area - Site 65 is not located within a State Registered Natural Resource Area (LeBlond, 1991).

3.11.3 Threatened and Endangered Species

Certain species have been granted protection by the U.S. Fish and Wildlife Service under the Federal Endangered Species Act (16 U.S.C. 1531-1543), and/or by the North Carolina Wildlife Resources Commission, under the North Carolina Endangered Species Act (G.S. 113-331 to 113-337). The protected species fall into one of the following status classifications: Federal or State endangered, threatened, or candidate species; State special concern; State significantly rare; or State watch list. While only the Federal or State threatened or endangered and State special concern species are protected from certain actions, the other classified species have the potential for protection in the future.

Surveys have been conducted to identify threatened or endangered species at Camp Lejeune and several programs are underway to manage and protect them. Table 3-6 lists protected species present at the base and their protected classifications. Of these species, the red-cockaded woodpecker, American alligator, and sea turtles are covered by specific protection programs.

The red-cockaded woodpecker is classified as being state endangered. This species requires a specific habitat in mature, living longleaf or loblolly pine trees. The birds live in family groups and young are raised cooperatively. At Camp Lejeune, 2,512 acres of habitat have been identified and marked for protection. Research on the bird at Camp Lejeune began in 1985 and information has been collected to determine home ranges, population size and composition, reproductive success, and habitat use. An annual roost survey is conducted and 36 colonies of birds have been located.

The American alligator is considered threatened in the northern-most part of its range, which includes North Carolina. The alligator is found in freshwater, estuarine, and saltwater wetlands in Camp Lejeune. Base wetlands are maintained and protected for the alligator. Signs have been erected where alligators are known to live. Annual surveys of Wallace, Southwest, French, Duck, Mill, and Stone Creeks have been conducted since 1977 to identify alligators and their habitats on base.

Two protected sea turtles species, the Atlantic loggerhead and Atlantic green turtle, nest on Onslow Beach at Camp Lejeune and are both classified as threatened species. The green turtle was found nesting in 1980; the sighting was the first time the species was observed nesting north of Georgia. The turtle returned to nest in 1985. Turtle nests on the beach are surveyed and protected, turtles are tagged, and annual turtle status reports are issued.

Three bird species, piping plover, Bachmans sparrow, and peregrine falcon have also been identified during surveys at Camp Lejeune. The piping plover and peregrine falcon are classified as threatened species. The Bachmans sparrow is classified as special concern (state). The piping plover is a shore bird. Piping plovers prefer beaches with broad open sandy flats above the high tide line. Piping plovers feed along the edge of incoming waves. Bachmans sparrows are very specific in their habitat requirements. They live in open stretches of pines with grasses and scattered shrubs for ground cover. Bachmans sparrows were observed at numerous locations throughout the southern portion of Camp Lejeune.

In addition to the protected species that breed or forage at Camp Lejeune, several protected whales migrate through the coastal waters off the base during the spring and fall. These include the Atlantic right whale, finback whale, sei whale, and sperm whale. Before artillery or bombing practice is conducted in the area, aerial surveys are made to assure that whales are not present in the impact areas.

A natural heritage resources survey was conducted at Camp Lejeune (LeBlond, 1991) to identify threatened or endangered plants and areas of significant natural interest, the results of this survey are included in Appendix J. From this list, the rough-leaf loosestrife was the only plant that is both a Federal and State endangered specie. In addition, one state candidate plant specie was identified at Site 65, from this survey. This specie is the Blackfruit Spikerush (Eleocharis melanocarpa) and is located within the wetland areas of Site 65. However its exact location could not be determined based on the scale of the survey map.

3.12 References

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TABLES

TABLE 3-1

GEOLOGIC AND HYDROGEOLOGIC UNITS IN THE COASTAL PLAIN OF NORTH CAROLINA
SITE 65 - ENGINEER AREA DUMP
REMEDIAL INVESTIGATION, CTO-0312
MCB, CAMP LEJEUNE, NORTH CAROLINA

GEOLOGIC UNITS			HYDROGEOLOGIC UNITS
System	Series	Formation	Aquifer and Confining Unit
Quaternary	Holocene/Pleistocene	Undifferentiated	Surficial Aquifer
Tertiary	Pliocene	Yorktown Formation(1)	Yorktown Confining Unit
			Yorktown Aquifer
	Miocene	Eastover Formation(1)	Pungo River Confining Unit
		Pungo River Formation(1)	Pungo River Aquifer
		Belgrade Formation(2)	Castle Hayne Confining Unit
	Oligocene	River Bend Formation	Castle Hayne Aquifer
	Eocene	Castle Hayne Formation	Beaufort Confining Unit(3)
	Palocene	Beaufort Formation	Beaufort Aquifer
Cretaceous	Upper Cretaceous	Peedee Formation	Peedee Confining Unit
			Peedee Aquifer
		Black Creek and Middendorf Formations	Black Creek Confining Unit
			Black Creek Aquifer
		Cape Fear Formation	Upper Cape Fear Confining Unit
			Upper Cape Fear Aquifer
			Lower Cape Fear Confining Unit
			Lower Cape Fear Aquifer
	Lower Cretaceous(1)	Unnamed Deposits(1)	Lower Cretaceous Confining Unit
			Lower Cretaceous Aquifer(1)
Pre-Cretaceous Basement Rocks		--	--

(1) Geologic and hydrologic units not present beneath Camp Lejeune.
(2) Constitutes part of the surficial aquifer and Castle Hayne confining unit in the study area.
(3) Estimated to be confined to deposits of Paleocene age in the study area.
Source: Cardinell, et al., 1993

TABLE 3-2

CLIMATIC DATA SUMMARY
MARINE CORPS AIR STATION, NEW RIVER
SITE 65 - ENGINEER AREA DUMP
REMEDIAL INVESTIGATION, CTO-0312
MCB, CAMP LEJEUNE, NORTH CAROLINA

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

Note:

* = Mean no. of days less than 0.5 days
Source: Naval Oceanography Command Detachment, Asheville, North Carolina. Measurements obtained from January 1955 to December 1990.

TABLE 3-3

SUMMARY OF HYDRAULIC CONDUCTIVITY TESTS
SITE 65 - ENGINEER AREA DUMP
REMEDIAL INVESTIGATION, CTO-0312
MCB, CAMP LEJEUNE, NORTH CAROLINA

Well No.	Hydraulic Conductivity Failing Head Test		Hydraulic Conductivity Rising Head Test	
	ft/day	cm/sec	ft/day	cm/sec
65-MW04	0.532	1.88×10^{-4}	0.436	1.54×10^{-4}
65-MW05	0.293	1.03×10^{-4}	0.819	2.89×10^{-4}
65-MW07	0.293	1.03×10^{-4}	0.911	3.22×10^{-4}

Average Hydraulic Conductivity for shallow wells:

Entire Site: 0.722 ft/day (2.55×10^{-4} cm/sec)

Notes:

Hydraulic conductivity test results were analyzed using Bouwer and Rice method as presented in the Geraghty and Miller "AQTESOLV" program, version 1.10.

Hydraulic conductivity tests were conducted on May 22 and 23, 1995, using an In-Situ Environmental Data Logger (Model SE-2000C) and pressure transducer.

Falling Head Test data was not used in the calculation of the average hydraulic conductivity for shallow wells. Falling Head Test data are inappropriate for partially penetrating wells. The data is presented for comparison purposes only.

The following formulas were used for calculations and conversions:

- To change ft/min to ft/day, the results were multiplied by 1440 min/day.
- To convert ft/day to cm/sec, the results were multiplied by 3.53×10^{-4}.

TABLE 3-4

LAND UTILIZATION: DEVELOPED AREAS LAND USE(1)
SITE 65 - ENGINEER AREA DUMP
REMEDIAL INVESTIGATION, CTO-0312
MCB, CAMP LEJEUNE, NORTH CAROLINA

Geographic Area	Oper.	Training (Instruc.)	Maint.	Supply/ Storage	Medical	Admin.	Family Housing	Troop Housing	CM	CO	Recreat.	Utility	Total
Hadnot Point	31 (2.9)	15 (1.4)	154 (14.3)	157 (14.4)	10 (0.9)	122 (11.3)	22 (2.0)	196 (18.1)	115 (10.7)	36 (3.3)	182 (16.9)	40 (3.7)	1,080 (100)
Paradise Point	1 (0)		3 (0.4)	1 (0)			343 (34)	19 (1.9)	31 (3.1)		610 (60.4)	2 (0.2)	1,010 (100)
Berkeley Manor/ Watkins Village							406 (80)		41 (8.1)	1 (0.2)	57 (11.2)	2 (0.5)	507 (100)
Midway Park		1 (0.4)		2 (0.7)		2 (0.7)	248 (92.2)		8 (3.0)	3 (1.1)	4 (1.5)	1 (0.4)	269 (100)
Tarawa Terrace I and II			3 (0.5)			1 (0.3)	428 (77.4)		55 (9.9)	11 (2.0)	47 (8.5)	8 (1.4)	553 (100)
Knox Trailer							57 (100)						57 (100)
French Creek	8 (1.4)	1 (0.2)	74 (12.7)	266 (45.6)	3 (0.5)	7 (1.2)		122 (20.9)	22 (3.8)	6 (1.0)	74 (12.7)		583 (100)
Courthouse Bay		**73** **(28.6)**	**28** **(10.9)**	**14** **(5.5)**		**12** **(4.7)**	**12** **(4.7)**	**43** **(16.9)**	**15** **(5.9)**	**4** **(1.6)**	**43** **(16.9)**	**11** **(4.3)**	**255** **(100)**
Onslow Beach	6 (9.8)	1 (1.6)	3 (4.8)	2 (3.2)	1 (1.6)	2 (3.2)		2 (3.2)	12 (19.3)		25 (40.3)	8 (13.0)	62 (100)
Rifle Range		1 (1.3)	1 (1.3)	7 (8.8)	1 (1.3)	5 (6.3)	7 (8.8)	30 (37.5)	5 (6.3)	1 (1.3)	9 (11.3)	13 (16.3)	80 (100)
Camp Geiger	4 (1.9)	15 (6.9)	19 (8.8)	50 (23.1)		23 (10.6)		54 (25.0)	27 (12.5)	2 (1.0)	16 (7.4)	6 (2.8)	216 (100)
Montford Point	6 (2.6)	48 (20.5)	2 (0.9)	4 (1.7)	2 (0.9)	9 (3.9)		82 (35.2)	20 (8.6)	1 (0.4)	49 (21.0)	10 (4.3)	233 (100)
Base-Wide Misc.	1 (0.8)			87 (68.0)		3 (2.3)			19 (14.8)			18 (14.1)	128 (100)
TOTAL	**57** **(1.1)**	**155** **(3.1)**	**287** **(5.7)**	**590** **(11.7)**	**17** **(0.38)**	**186** **(3.7)**	**1,523** **(30.2)**	**548** **(10.8)**	**370** **(7.4)**	**65** **(1.3)**	**1,116** **(22.2)**	**119** **(2.4)**	**5,033** **(100)**

(1) Upper number is acres, lower number is overall percent.

TABLE 3-5

SUMMARY OF SUPPLY WELLS IN THE VICINITY OF SITE 65
SITE 65 - ENGINEER AREA DUMP
REMEDIAL INVESTIGATION, CTO-0312
MCB, CAMP LEJEUNE, NORTH CAROLINA

Well No.	USGS I.D. No.	Approximate Distance/Direction Site to Well	Year Drilled	Depth (feet)	Driller	Screen Interval (feet below surface)	Well Diameter (inches)	Static Water Level (feet below land surface)	Status
BB-43	3434550772148.1	1,630 feet southwest	1942	60	Layne Atlantic Company	30 - 69	8	10.4	deactivated (1991)
BB-44	3435040772143.1	1,200 feet west	1942	62	Layne Atlantic Company	32 - 62	8	13.4	active
BB-47	3434560772148.1	1,630 feet southwest	1982(1)	150	East Coast Construction Company	40 - 55 102 - 125	8(1)	10.1	active
BB-220	3435140772136.1	1,800 feet north	1975	150	Carolina Well and Pump Company	55 - 70 85 - 95 130 - 145	8(1)	10.2	active
BB-221	3435220772122.1	1,500 feet northeast	1974(1)	200	Carolina Well and Pump Company	60 - 80 135 - 155	8(1)	33.5	active
BB-218	3500010772049.1	3,000 feet east	1985	185	Carolina Well and Pump Company	64 - 94 148 - 168	10	approx. 55	active

(1) As per conversations with Mac Farzelle, General Forman, Water Treatment, MCB, Camp Lejeune.

TABLE 3-6

PROTECTED SPECIES WITHIN MCB, CAMP LEJEUNE
SITE 65 - ENGINEER AREA DUMP
REMEDIAL INVESTIGATION, CTO-0312
MCB, CAMP LEJEUNE, NORTH CAROLINA

Species	Protected Classification
Animals:	
American alligator (Alligator mississippienis)	SC
Bachmans sparrow (Aimophilia aestivalis)	FCan, SC
Green (Atlantic) turtle (Chelonia m. mydas)	T(f), T(s)
Loggerhead turtle (Caretta caretta)	T(f), T(s)
Peregrine falcon (Falco peregrinus)	E(f), E(s)
Piping plover (Charadrius melodus)	T(f), T(s)
Red-cockaded woodpecker (Picoides borealis)	E(f), E(s)
Southern Hognose Snake (Heterodon simus)	FCan, SR
Diamondback Terrapin (Malaclemys terrapin)	FCan, SC
Carolina Gopher Frog (Rana capito capito)	FCan, SC
Cooper's Hawk (Accipiter cooperii)	SC
Eastern Diamondback Rattlesnake (Crotalus adamanteus)	SR
Eastern Coral Snake (Micrurus fulvius)	SR
Pigmy Rattlesnake (Sistrurus miliarius)	SR
Black Bear (Ursus americanus)	SR
Plants:	
Rough-leaf loosestrife (Lysimachia asperulifolia)	E(f), E(s)
Seabeach Amaranth (Amaranthus pumilus)	T(f), T(s)
Chapman's Sedge (Carex chapmanii)	FCan
Hirst's Witchgrass (Dichanthelium sp.)	FCan
Pondspice (Litsea aestivalis)	FCan
Boykin's Lobelia (Lobelia boykinii)	FCan
Loose Watermilfoil (Myriophyllum laxum)	FCan,T(s)
Awned Meadowbeauty (Rhexia aristosa)	FCan,T(s)
Carolina Goldenrod (Solidago pulchra)	FCan, E(s)
Carolina Asphodel (Tofieldia glabra)	FCan
Venus Flytrap (Dionaea muscipula)	FCan
Flaxleaf Gerardia (Agalinis linifolia)	SR
Pinebarrens Goober Grass (Amphicarpum purshii)	SR
Longleaf Three-awn (Aristida palustris)	SR
Pinebarrens Sandreed (Calamovilfa brevipilis)	E(s)
Warty Sedge (Carex verrucosa)	SR
Smooth Sawgrass (Cladium mariscoides)	SR
Leconte's Flatsedge (Cyperus lecontei)	SR

TABLE 3-6 (Continued)

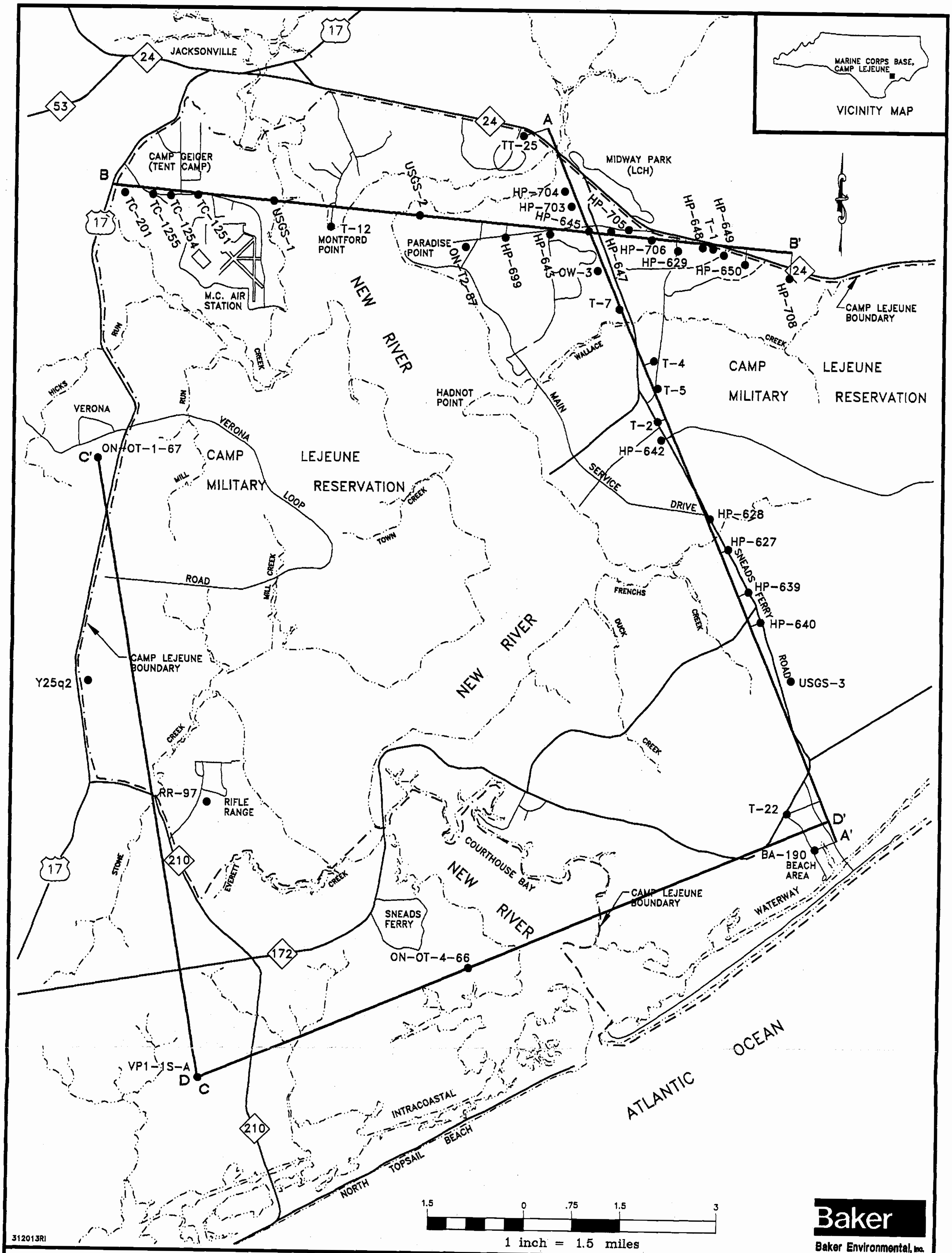
PROTECTED SPECIES WITHIN MCB, CAMP LEJEUNE
SITE 65 - ENGINEER AREA DUMP
REMEDIAL INVESTIGATION, CTO-0312
MCB, CAMP LEJEUNE, NORTH CAROLINA

Species	Protected Classification
Erectleaf Witchgrass (Dichanthelium erectifolium)	SR
Horsetail Spikerush (Eleocharis equisetoides)	SR
Sand Spikerush (Eleocharis montevidensis)	SR
Flaxleaf Seedbox (Ludwigia linifolia)	SR
Torrey's Muhley (Muhlenbergia torreyana)	E(s)
Southeastern Panic Grass (Panicum tenerum)	SR
Spoonflower (Peltandra sagittifolia)	SR
Shadow-witch (Ponthieva racemosa)	SR
West Indies Meadowbeauty (Rhexia cubensis)	SR
Pale Beakrush (Rhynchospora pallida)	SR
Longbeak Baldsedge (Rhynchospora scirpoides)	SR
Tracy's Beakrush (Rhynchospora tracyi)	SR
Canby's Bulrush (Scirpus etuberculatus)	SR
Slender Nutrush (Scleria minor)	SR
Lejeune Goldenrod (Solidago sp.)	SR
Dwarf Bladderwort (Utricularia olivacea)	T(s)
Elliott's Yellow-eyed Grass (Xyris elliottii)	SR
Carolina Dropseed (Sporobolus sp.)	T(s)

Legend:
E(f) = Federal Endangered
T(f) = Federal Threatened
Fcan = Candidate for Federal Listing
E(s) = State Endangered
T(s) = State Threatened
SC = State Special Concern

Source: LeBlond, 1994

FIGURES



Baker

Baker Environmental, Inc.

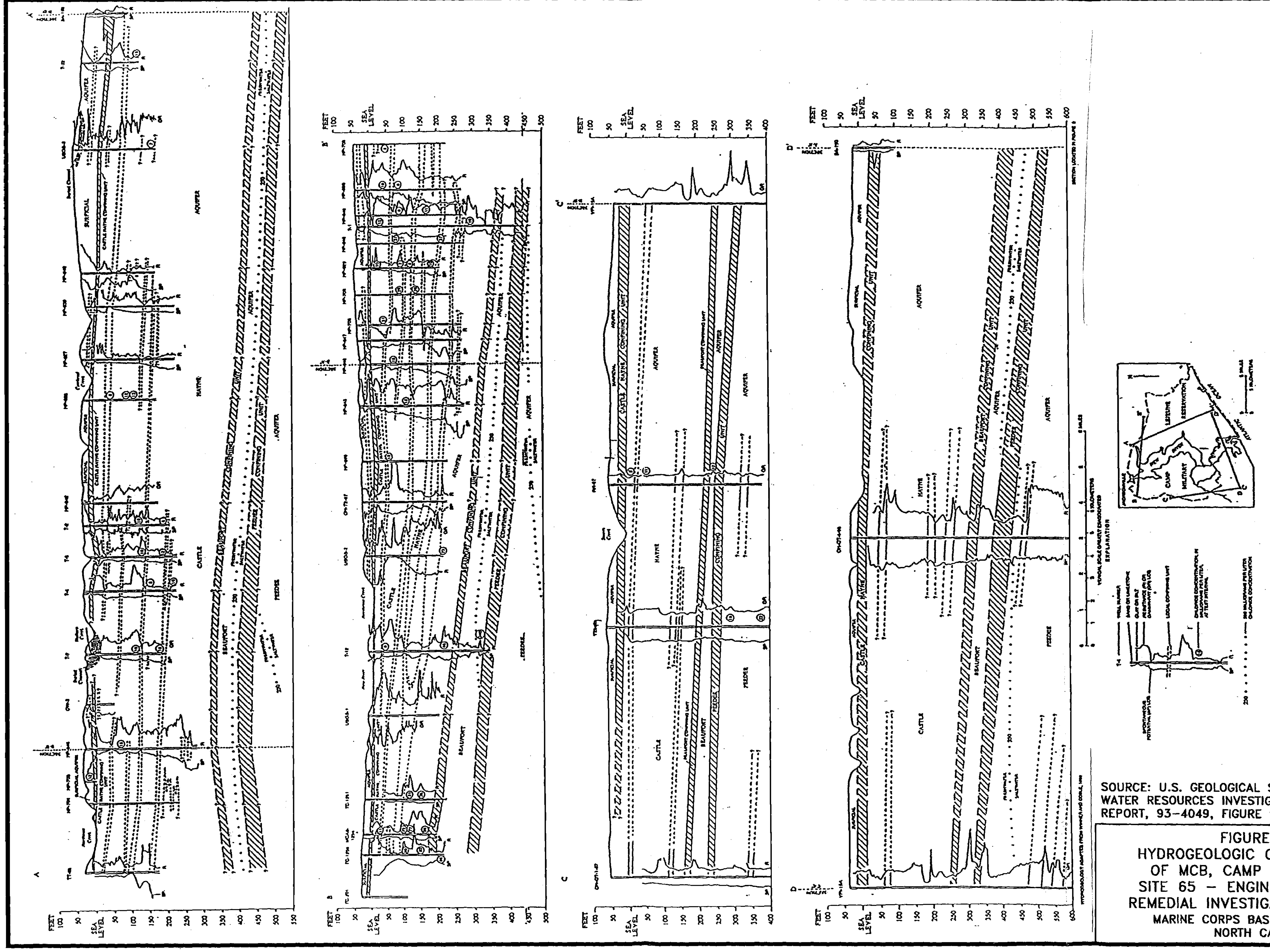
SOURCE: U.S. GEOLOGICAL SURVEY, WATER-RESOURCES INVESTIGATIONS REPORT, 93-4049, FIGURE 9

FIGURE 3-1
LOCATION OF HYDROGEOLOGIC CROSS-SECTIONS
MARINE CORPS BASE, CAMP LEJEUNE
REMEDIAL INVESTIGATION, CTO-0312

MARINE CORPS BASE, CAMP LEJEUNE
NORTH CAROLINA

312014RI

001450092



SOURCE: U.S. GEOLOGICAL SURVEY, WATER RESOURCES INVESTIGATIONS REPORT, 93-4049, FIGURE 9

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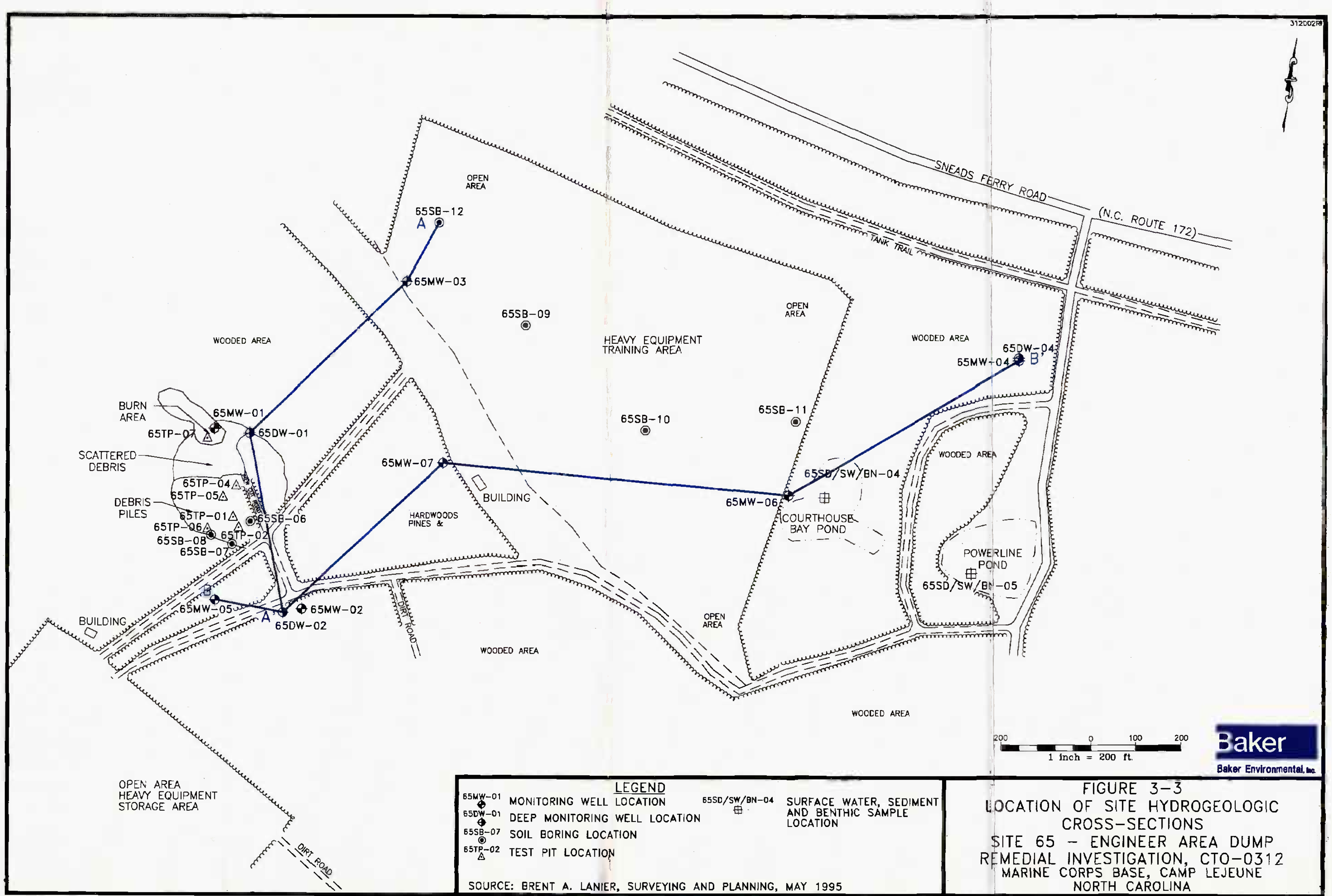
FIGURE 3-2
HYDROGEOLOGIC CROSS-SECTIONS
OF MCB, CAMP LEJEUNE AREA
SITE 65 – ENGINEER AREA DUMP
REMEDIAL INVESTIGATION, CTO-0312
MARINE CORPS BASE, CAMP LEJEUNE
NORTH CAROLINA



Baker
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LEGEND

65MW-01 ⊕ MONITORING WELL LOCATION

65DW-01 ⊕ DEEP MONITORING WELL LOCATION

65SB-07 ◉ SOIL BORING LOCATION

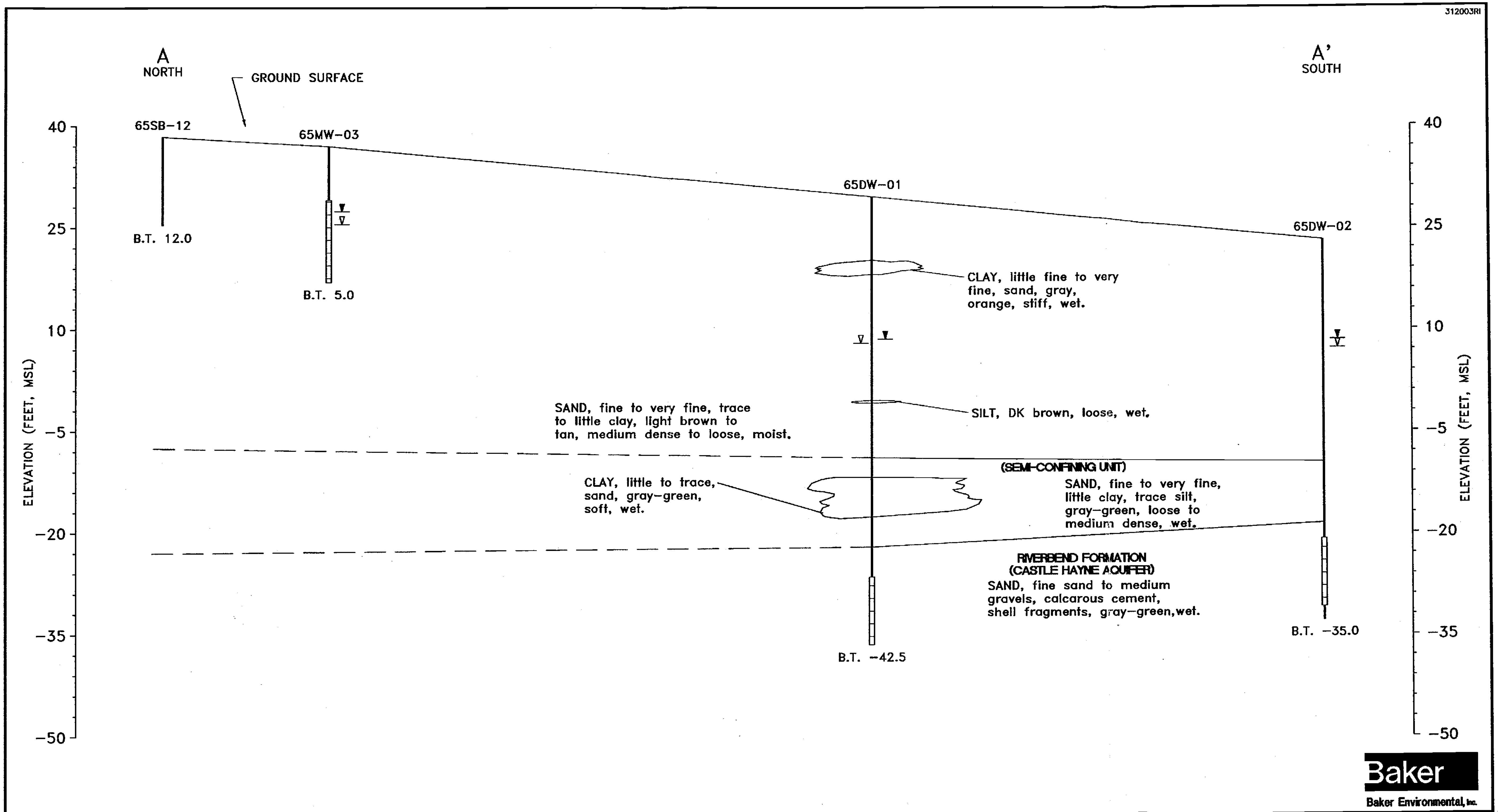
65TP-02 △ TEST PIT LOCATION

65SD/SW/BN-04 ⊞ SURFACE WATER, SEDIMENT AND BENTHIC SAMPLE LOCATION

SOURCE: BRENT A. LANIER, SURVEYING AND PLANNING, MAY 1995

FIGURE 3-3
LOCATION OF SITE HYDROGEOLOGIC CROSS-SECTIONS
SITE 65 - ENGINEER AREA DUMP
REMEDIAL INVESTIGATION, CTO-0312
MARINE CORPS BASE, CAMP LEJEUNE
NORTH CAROLINA

00145010X



LEGEND

▼	GROUNDWATER ELEVATION (4/23/95)
▽	GROUNDWATER ELEVATION (8/21/95)
B.T. 5.0	BORING TERMINATED, ELEVATION MSL
▯	WELL SCREEN INTERVAL
———	ESTIMATED
— — —	PROJECTED

90 0 45 90 180

Horizontal Scale: 1 inch = 90 ft.

15 0 7.5 15 30

Vertical Scale: 1 inch = 15 ft.

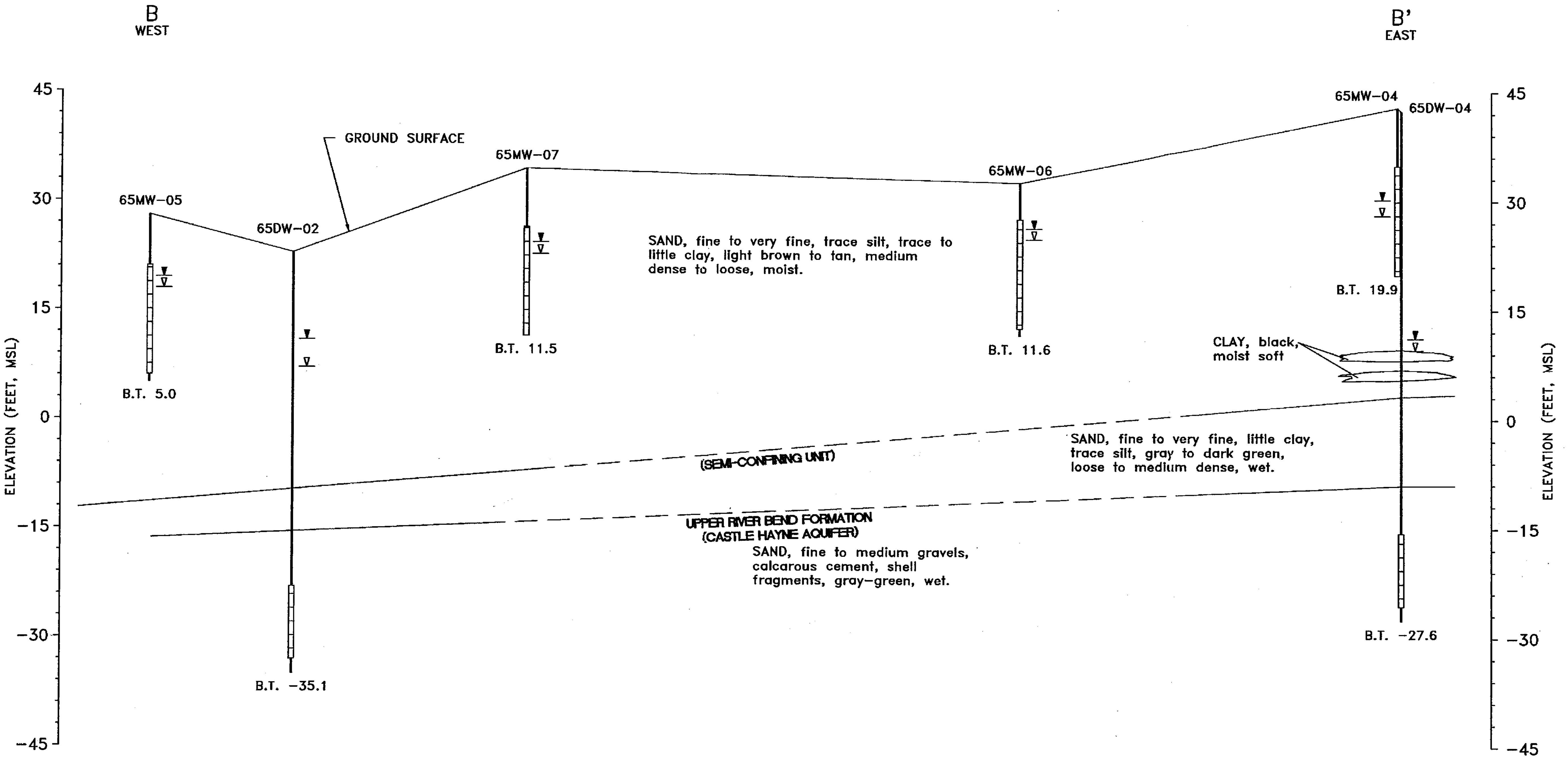
THE SOIL BORING INFORMATION IS CONSIDERED TO BE REPRESENTATIVE OF SUBSURFACE CONDITIONS AT THE RESPECTIVE BORING LOCATIONS. SUBSURFACE CONDITIONS INTERPOLATED BETWEEN BORINGS ARE ESTIMATED BASED ON ACCEPTED SOIL ENGINEERING PRINCIPLES AND GEOLOGIC JUDGEMENT.

FIGURE 3-4
HYDROGEOLOGIC CROSS-SECTION A-A'
SITE 65 - ENGINEER AREA DUMP
REMEDIAL INVESTIGATION, CTO-0312

MARINE CORPS BASE, CAMP LEJEUNE
NORTH CAROLINA

00145011Z

312004RI



Baker
Baker Environmental, Inc.

LEGEND

▼	GROUNDWATER ELEVATION (4/23/95)
▽	GROUNDWATER ELEVATION (8/21/95)
B.T. 5.0	BORING TERMINATED, ELEVATION MSL
▯	WELL SCREEN INTERVAL
——	ESTIMATED
– – –	PROJECTED

170 0 85 170 340

Horizontal Scale: 1 inch = 170 ft.

15 0 7.5 15 30

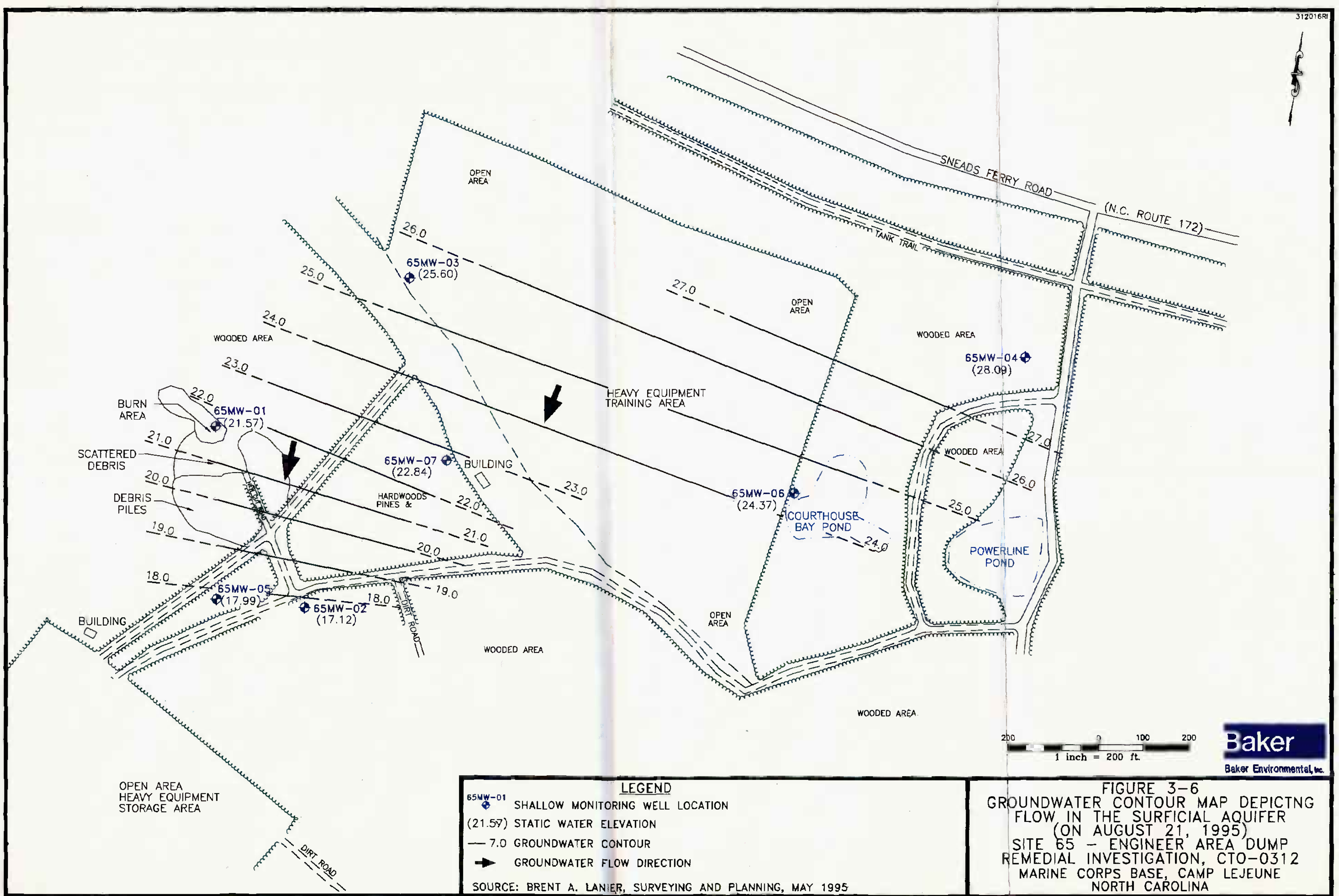
Vertical Scale: 1 inch = 15 ft.

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

FIGURE 3-5
HYDROGEOLOGIC CROSS-SECTION B-B'
SITE 65 - ENGINEER AREA DUMP
REMEDIAL INVESTIGATION, CTO-0312

MARINE CORPS BASE, CAMP LEJEUNE
NORTH CAROLINA

312016RI



Baker

Baker Environmental, Inc.

LEGEND

65MW-01 ⊕ SHALLOW MONITORING WELL LOCATION

(21.57) STATIC WATER ELEVATION

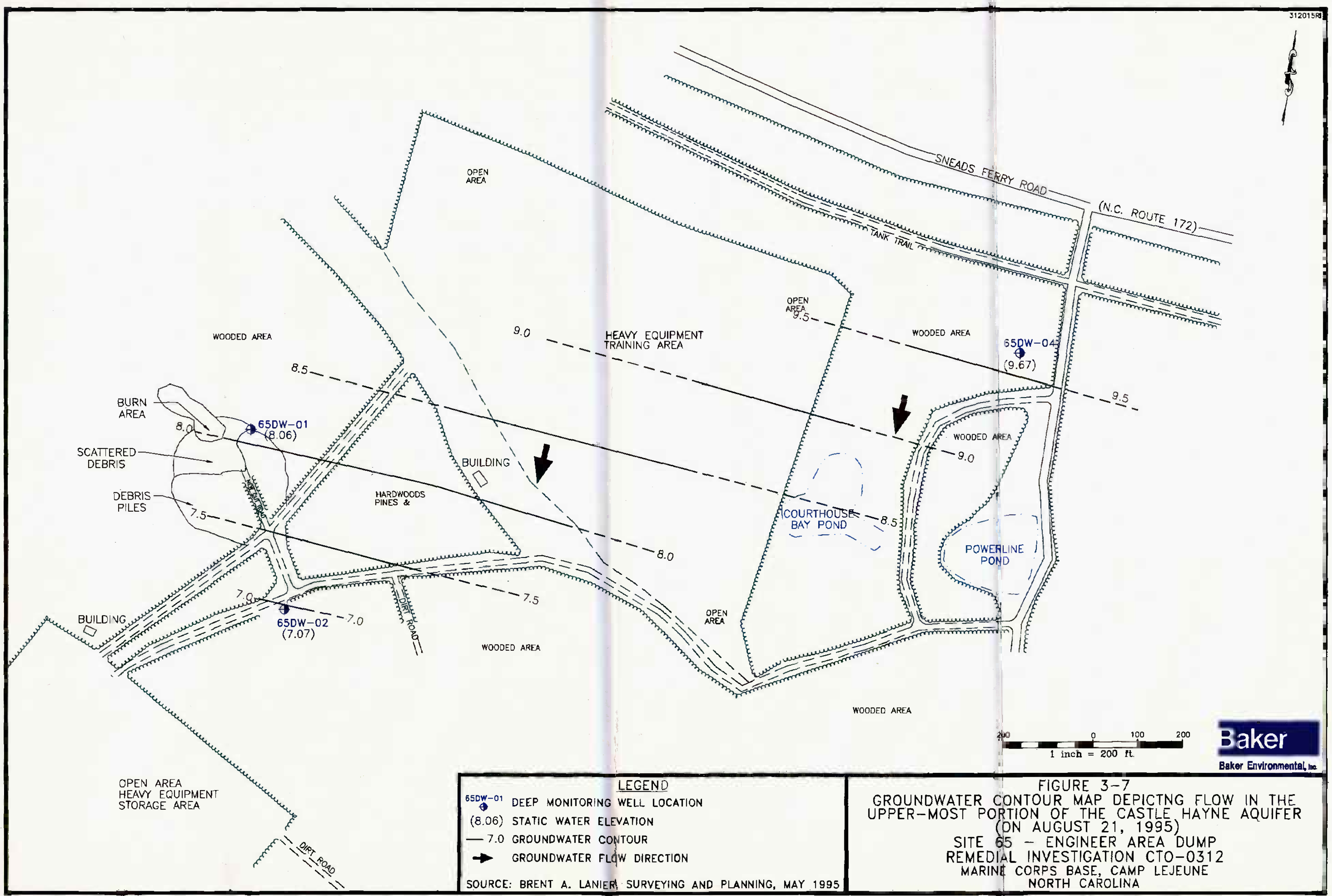
— 7.0 GROUNDWATER CONTOUR

➔ GROUNDWATER FLOW DIRECTION

SOURCE: BRENT A. LANIER, SURVEYING AND PLANNING, MAY 1995

FIGURE 3-6
GROUNDWATER CONTOUR MAP DEPICTNG
FLOW IN THE SURFICIAL AQUIFER
(ON AUGUST 21, 1995)
SITE 65 – ENGINEER AREA DUMP
REMEDIAL INVESTIGATION, CTO-0312
MARINE CORPS BASE, CAMP LEJEUNE
NORTH CAROLINA

00145013Y



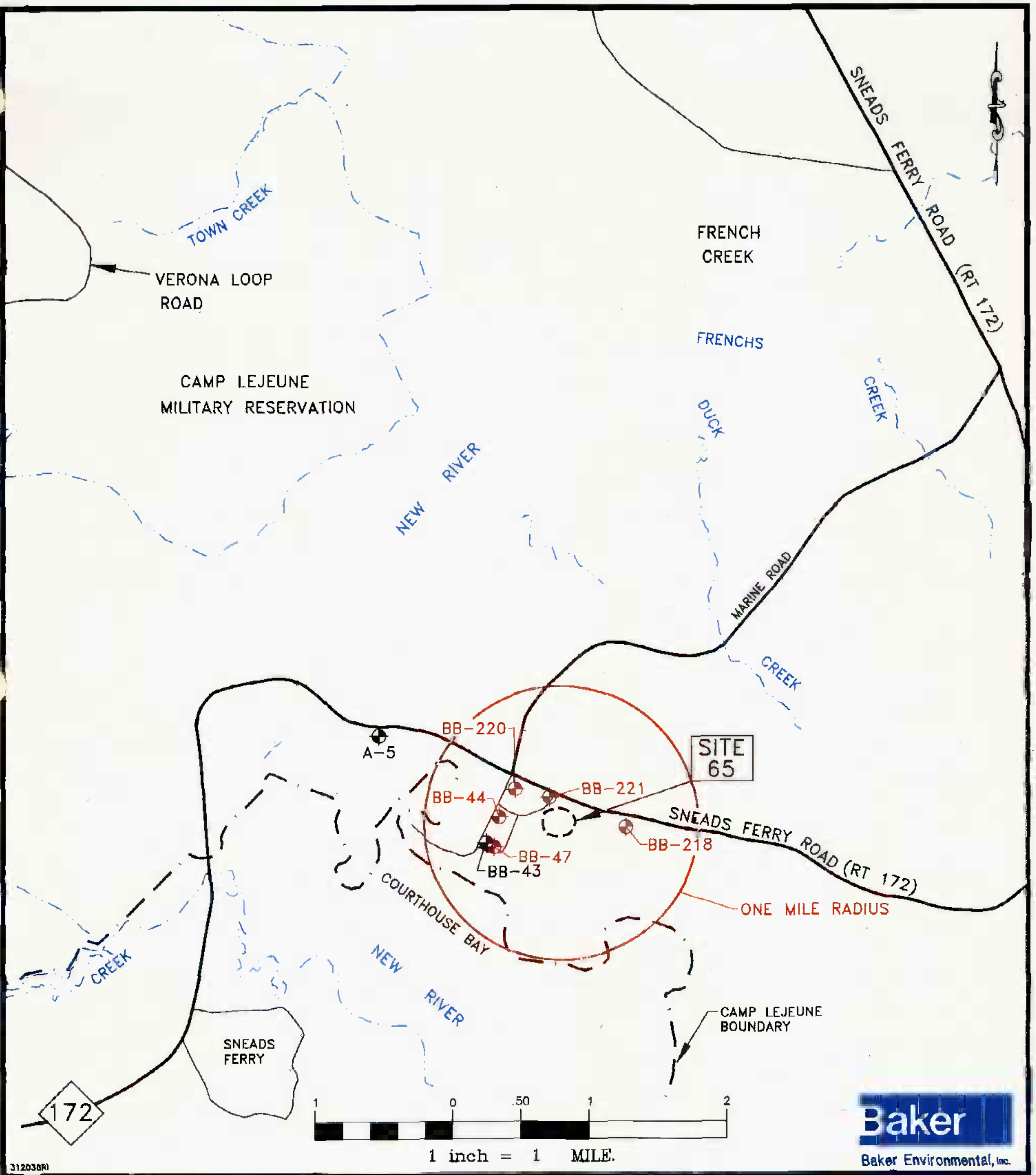
LEGEND

65DW-01 ⊕	DEEP MONITORING WELL LOCATION
(8.06)	STATIC WATER ELEVATION
— 7.0	GROUNDWATER CONTOUR
➔	GROUNDWATER FLOW DIRECTION

SOURCE: BRENT A. LANIER SURVEYING AND PLANNING, MAY 1995

FIGURE 3-7
GROUNDWATER CONTOUR MAP DEPICTNG FLOW IN THE UPPER-MOST PORTION OF THE CASTLE HAYNE AQUIFER (ON AUGUST 21, 1995)
SITE 65 – ENGINEER AREA DUMP
REMEDIAL INVESTIGATION CTO-0312
MARINE CORPS BASE, CAMP LEJEUNE
NORTH CAROLINA

00145014Y



LEGEND

- SITE

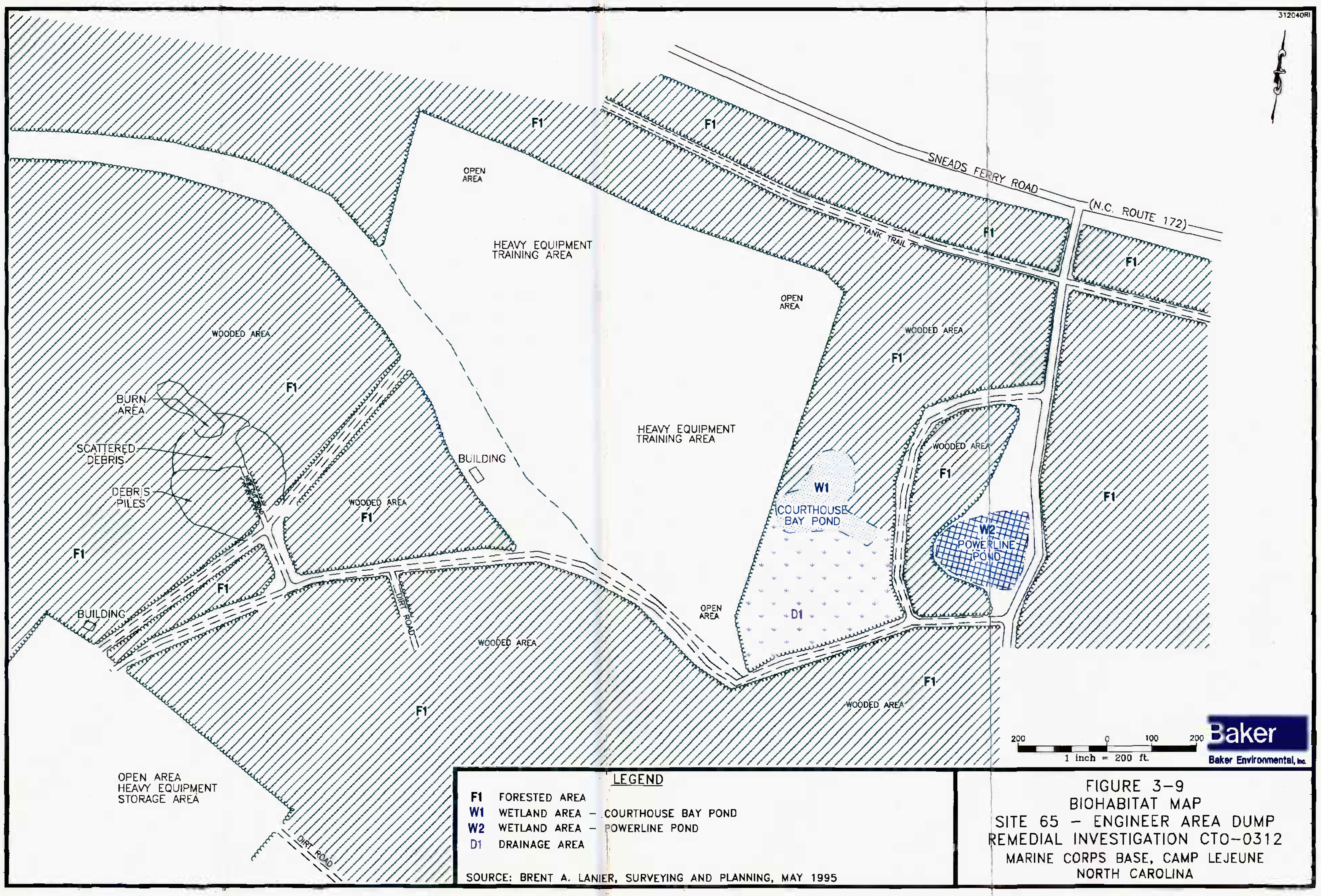
BB-221 - ACTIVE SUPPLY WELL

BB-43 - DEACTIVATED SUPPLY WELL (1991)

SOURCE: GEOPHEX, 1983.

FIGURE 3-8
SUPPLY WELL LOCATION MAP
SITE 65 - ENGINEER AREA DUMP
REMEDIAL INVESTIGATION, CTO-0312

MARINE CORPS BASE, CAMP LEJEUNE
NORTH CAROLINA



LEGEND

F1	FORESTED AREA
W1	WETLAND AREA – COURTHOUSE BAY POND
W2	WETLAND AREA – POWERLINE POND
D1	DRAINAGE AREA

SOURCE: BRENT A. LANIER, SURVEYING AND PLANNING, MAY 1995

FIGURE 3-9
BIOHABITAT MAP
SITE 65 – ENGINEER AREA DUMP
REMEDIAL INVESTIGATION CTO-0312
MARINE CORPS BASE, CAMP LEJEUNE
NORTH CAROLINA

00145016Y

4.0 NATURE AND EXTENT OF CONTAMINATION

This section presents and evaluates the results of the RI conducted at Site 65. The objectives of the section are to characterize the nature and extent of contamination at the site. The characterization was accomplished through environmental sample collection and laboratory analysis of soil, groundwater, surface water and sediments. The detection summary tables and figures referenced in the text are located at the end of Section 4.

Analytical parameters can be segregated into two broad categories: organic compounds and inorganic elements. Most of the organic parameters included in the analytical program do not occur naturally. Therefore, any organic compounds detected in the samples collected from the site may be attributed to either site or sampling/laboratory contamination. However, many of the inorganic elements included in the analytical program occur naturally. In order to accurately present the nature and extent of contamination, the detected parameters that are either common laboratory contaminants or are naturally occurring on site must be segregated from those that may be attributed to site or off-site activities.

4.1 Data Management and Tracking

Analytical data generated during the RI was submitted for third-party validation to Heartland Environmental Services, Inc. Procedures established by the National Functional Guidelines for Organic (USEPA, 1991) 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 usable by the USEPA. Data may be qualified as estimated for several reasons including: an exceedence of holding times; high or low surrogate recovery; intra-sample variability; or the reported value is below the Contract Required Detection Limit (CRDL) or the Contract Required Quantitation Limit (CRQL).

Additional data qualifiers were employed during the data validation (see Appendix K). The "NJ" qualifier denotes that a compound was tentatively identified, but the reported value may not be accurate or precise. Compounds which were not detected and had inaccurate or imprecise quantitation limits were assigned the "UJ" qualifier. The "B" qualifier identifies a compound that was detected in the method blank associated with the sample. If the sample result has serious deficiencies with regard to the ability to analyze the sample and meet quality control criteria, the compound is assigned the "R" qualifier and the data is rejected. No data acquired during this RI was rejected.

The management and tracking of data from the time of field collection to receipt of the validated electronic analytical results is of primary importance and reflects the overall quality of the analytical results. Field samples and their corresponding analytical tests were recorded on the chain-of-custody sheets, included as Appendix D. The chain-of-custody forms were checked against the FSAP (Baker, 1995) to determine if all designated samples were collected for the appropriate parameters. Similarly, the validated information was compared to laboratory information as a final check. In summary, the tracking information was used to identify the following items:

- Identify sample discrepancies between the analysis plan and the field investigation.
- Verify that the laboratory received all samples and analyzed for the correct parameters.

- Verify that the data validator received a complete data set.
- Ensure that a complete data set was available for each media of concern prior to entering results into the database.

4.2 Non-Site Related Analytical Results

Many of the organic and inorganic constituents detected in soil, groundwater, surface water and sediments at Site 65 are attributable to non-site related conditions or activities. Two primary sources of non-site related results include laboratory contaminants and naturally-occurring inorganic elements. In addition, non-site related operational activities and conditions may contribute to "on-site" contamination. A discussion of non-site related analytical results for the site is provided in the following subsections.

4.2.1 Laboratory Contaminants

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

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

acetone	93J μg/L
methylene chloride	1J μg/L
2-butanone	7J μg/L
toluene	4J μg/L
bis(2-ethylhexyl)phthalate	2J μg/L
di-n-butyl phthalate	1J μg/L

Chloroform was detected at 30 μg/L in a potable water field blank (73-FB-03), but is probably not due to laboratory contamination.

Organic constituents contained in blanks that were not considered common laboratory contaminants were considered as positive results only when observed concentrations exceeded five times the maximum concentration detected in any blank (USEPA, 1989b). All TCL compounds 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:

1,1-dichloroethene	2J μg/L
1,2-dichloroethane	2J μg/L
trichloroethene	2J μg/L
4,4-DDT	0.3 μg/L

●	bromodichloromethane	18 µg/L
●	dibromochlorormethane	6J µg/L

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

4.2.2 Naturally-Occurring Inorganic Elements

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

Soil:	MCB, Camp Lejeune Background Soil Samples - Appendix L
Groundwater:	Evaluation of Metals in Groundwater - Appendix M
Surface Water:	Off-Base Reference Stations (White Oak River Basin) - Appendix N
Sediment:	Off-Base Reference Stations (White Oak River Basin) - Appendix N

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 65.

4.2.2.1 Soil

In general, chemical-specific standards and criteria are not available for soil. As a result, base-specific background concentrations have been compiled from a number of locations throughout MCB, Camp Lejeune to evaluate background levels of inorganic elements in the surface and subsurface soil. Organic contaminants, unlike inorganic elements, do not occur naturally. Therefore, it is probable that all organic contaminants detected in the surface and subsurface soil are attributable to activities which have previously occurred or are currently taking place within or surrounding the study area.

Site background and base background concentration values for inorganic elements in surface and subsurface soil at MCB, Camp Lejeune (which includes results from background samples collected at Site 65) are presented in Tables 4-1 and 4-2, respectively. The tables provide a comparison illustrating whether the results from background samples collected at Site 65 are within the range of concentrations collected throughout the base. The base background ranges are based on analytical results of background samples collected in areas not known to have been impacted by site operations or disposal activities at MCB, Camp Lejeune. In subsequent sections, which discuss the analytical results of samples collected during the soil investigation, only those inorganic parameters with concentrations exceeding base background ranges will be considered. Appendix L contains the base soil background database for metals.

4.2.2.2 Groundwater

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

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

Groundwater samples were analyzed for total and dissolved metals parameters. One sample (10%) was analyzed for dissolved metals. The concentrations for the dissolved metals were generally found to be higher than total metals, particularly for metals such as calcium, magnesium and sodium. The only metals which exhibited lower results in the dissolved metals than the total metals were cadmium and iron. A 0.45-micron filter was used in the field to remove small particles of silt and clay that would otherwise be dissolved during sample preservation and generate an unrealistically high apparent value of metals in groundwater. The total metals, or unfiltered samples, thus reflect the concentrations of inorganic in the natural lithology and inorganic elements dissolved in the groundwater.

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

Groundwater in the MCB, Camp Lejeune area is naturally rich in iron and manganese often exceeding the federal Maximum Contaminant Levels (MCLs) and North Carolina Water Quality Standards (NCWQS) of 300 and 50 µg/L, respectively. Elevated levels of iron and manganese, at concentrations above the MCL and NCWQS, were reported in samples collected from a number of the potable water supply wells at the base, which were installed at depths greater than 162 feet bgs (Greenhorne and O'Mara, 1992). Iron and manganese concentrations in several monitoring wells at Site 65 exceeded the MCL and NCWQS, but fell within the range of concentrations for samples collected elsewhere at the base. Based upon the widespread occurrence of iron and manganese at similar levels, it is assumed that these two metals are naturally-occurring in groundwater, and their presence is not attributable to site operations.

4.2.2.3 Surface Water and Sediment

Offsite surface water and sediment samples were collected from three tributaries of the White Oak River as a part of a background investigation, White Oak River Basin Reference Study. These tributaries were generally located between Swansboro and the Croatan National Forest and were believed not to be impacted by previous activities that were conducted at current Base IR sites. As a part of this study a total of ten surface water and 20 sediment samples were collected from nine reference stations and analyzed for TAL metals. A summary of metals results for surface water and sediment are included in Appendix N. Reference stations were located in the following areas of the White Oak River Basin:

- Webb Creek - two reference stations
- Hadnot Creek - four reference stations
- Holland Mill Creek - three reference stations

4.3 State and Federal Criteria and Standards

Contaminant concentrations can be compared to contaminant-specific established federal and state criteria and standards such as federal MCLs or NCWQS.

The only enforceable federal regulatory standards for water are the federal MCLs. In addition to the federal standards, North Carolina developed the NCWQS for groundwater and surface water. Regulatory guidelines were used for comparative purposes to infer the potential health risks and environmental impacts when necessary. Relevant regulatory guidelines include federal Ambient Water Quality Criteria (AWQC) and Health Advisories.

In general, chemical-specific criteria and standards are not available for soil. Therefore, base-specific background concentrations were compiled to evaluate background levels of inorganic constituents in the surface and subsurface soil. Organic contaminants were not detected in the base-specific background samples. Therefore, it is likely that all organic contaminants detected in the surface and subsurface soil, within OU No. 9, Site 65, are attributable to the practices which have or are currently taking place within the areas of concern.

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

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

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

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

USEPA Water Quality Screening Values (WQSV) - WQSVs are non-enforceable regulatory guidelines and are of primary utility in assessing acute and chronic toxic effects in aquatic systems. WQSVs are provided for both freshwater and saltwater aquatic systems, and are reported as acute and/or chronic values (USEPA, 1995a, b). Most of the WQSVs are the same as the USEPA Ambient Water Quality Criteria (AWQC); however, some of the WQSVs are based on more current studies.

Oak Ridge National Laboratory (ORNL) Aquatic Benchmarks - ORNL Aquatic Benchmarks are developed for many contaminants, including those that do not have NCWQS or WQSVs (Suter and Mabrey, 1994). The ORNL aquatic benchmarks include secondary acute values and secondary chronic values that are calculated using the Tier II method describe din the EPA's Proposed Water Quality Guidance for the Great Lakes System (USEPA, 1993b). Tier II values are developed so that aquatic benchmarks could be established with fewer data than are required for the USEPA AWQC. The benchmarks are limited to contaminants in freshwater.

Sediment Screening Levels - Sediment Screening Levels (SSLs) have been compiled to evaluate the potential for contaminants in sediments to cause adverse biological effects (Long, et al., 1995; Long and Morgan 1991; and USEPA, 1995). The lower ten percentile (Effects Range-Low [ER-L]) and the median percentile (Effects Range-Median [ER-M]) of biological effects have been developed for several contaminants. The concentration below the ER-L represents a minimal-effects range (adverse effects would be rarely observed). The concentration above the ER-L but below the ER-M represents a possible-effects range (adverse effects would occasionally occur). Finally, the concentration above the ER-M represents a probable-effects range (adverse effects would probably occur).

In addition to the SSLs, Apparent Effects Threshold Sediment Quality Values have been developed by Tetra Tech Inc., (1986) for the Puget Sound. These values are the concentrations of contaminants above which statistically significant biological effects would always be expected. Finally, the Wisconsin Department of Natural Resources has developed interim criteria for in-water disposal of dredged sediments (Sullivan, et al., 1985). However, these criteria are established using background data and are not based on aquatic toxicity.

Sediment Quality Criteria - Currently, promulgated sediment quality criteria (SQC) only exist for a few contaminants. However, SQC for nonionic organic compounds can be calculated using the procedures in the Technical Basis for Deriving Sediment Quality Criteria for Nonionic Organic Contaminants for the Protection of Benthic Organisms by using Equilibrium Partitioning (USEPA, 1993) as follows:

SQC = (Foc)(Koc)(FCV)/1,000,000

Where:

SQC = sediment quality criteria (μg/kg)
Foc = sediment organic carbon content (mg/kg)
Koc = chemical organic carbon partition coefficient (mL/g)
FCV = final chronic water quality value (μg/L)

4.4 Analytical Results

The analytical results of the surface soil, subsurface soil, test pits, groundwater, surface water, sediment, and fish sampling performed at Site 65 are presented in the following sections. A summary of site contamination, by media, is provided in Table 4-3. The Data Frequency Summaries for all media at Site 65 are presented in Appendix O.

All samples submitted for analysis were analyzed for full TCL organic compounds, including volatiles, semivolatiles and pesticides/PCBs, and TAL inorganics (excluding cyanide), using CLP protocols and Level III data quality.

4.4.1 Surface Soil

A total of 13 surface soil samples were collected from various locations across Site 65. Six of the samples were collected near the waste piles and burn area shown on Figure 4-1. The remaining samples were collected from other locations potentially impacted by historical activities at the site. Surface soil sample detection summaries for organic compounds and inorganic elements are presented in Tables 4-4 and 4-5, respectively. The locations of these samples are shown on Figures 4-1 and 4-2 along with the estimated and positive analytical results.

Six volatile organic compounds (VOCs) were detected in the surface soil samples. Methylene chloride was detected twice at 2J µg/kg; acetone was detected once at 10J µg/kg, trichloroethene was detected once at 1J µg/kg; and toluene was detected three times at concentrations of 1J or 2J µg/kg. All of these compounds were detected at concentrations which are below the levels detected in the QA/QC blanks. These compounds are considered to be sampling or laboratory contaminants, since they are less than 10 times the maximum concentration detected in the QA/QC blanks.

The two remaining VOCs detected in surface soils are ethylbenzene and total xylenes. Ethylbenzene was detected at location 65SB-07 (1J µg/kg) and xylenes were detected at locations 65SB-07 and 65DW-01 (5J and 3J µg/kg, respectively). Both locations are near roads traveled by heavy equipment and both compounds are constituents of petroleum products.

A total of 19 semivolatile organic compounds (SVOCs) were detected in surface soils. The most widespread compound was bis(2-ethylhexyl) phthalate which was detected at nine locations. Bis(2-ethylhexyl)phthalate concentrations ranged from 48J µg/kg (65SB-10) to 87J µg/kg (65MW-06). This phthalate is a common plasticizer in rubber and plastic products, such as tires. All of the sample locations with estimated concentrations of these phthalates are near roads or equipment training areas.

Eleven SVOCs were detected at two or three of the following locations: 65DW-01, 65SB-06 and 65SB-12. These compounds and their respective concentrations are shown on Figure 4-1. These sample locations are near the waste piles and burn area. The compounds are all polyaromatic hydrocarbons (PAHs) which may be generated as products of incomplete combustion.

Di-n-butyl phthalate was detected at two locations (65SB-06 and 65SB-08) at 390J and 260J µg/kg, respectively. Di-n-butyl phthalate is a specialty plasticizer and polymer additive, especially for polyvinyl chloride (PVC) plastics. However, the sample locations are also near the waste piles at Site 65.

The remaining six SVOCs were detected at one location each. Five of the six compounds were detected at only 65DW-01. These PAHs are probably related to the other PAHs detected at 65DW-01. 2,4-dinitrophenol (150J µg/kg) was detected at 65DW-04 near an entrance road to the Engineer Training Area. This compound is probably unrelated to Site 65.

Pesticide results for surface soil samples included detections at 11 of 13 locations. DDT and its by-products were measured at nine locations with a maximum concentration of 83J µg/kg at 65MW-07. Endosulfan II was measured at two locations with a maximum concentration of 3.9NJ µg/kg. Heptachlor epoxide was detected at one location at a concentration of 2.3 µg/kg. PCB Aroclor 1260 was detected at one location at a concentration of 52J µg/kg.

Surface soil sample analytical results for TAL metals were compared to a screening level of two times average background concentrations as listed in Appendix L. Seven of 13 sample locations exceeded two times average base background for one or more elements. Six of the seven samples are near the heavy equipment training area where the soil has been disturbed numerous times by bulldozers, front-end loaders, scrapers and similar equipment. The remaining sample location is 65SB-06, which is near the waste piles. Metals which exceed the screening level at more than one location are barium, chromium, copper, lead, manganese, and zinc. Metals which exceeded the screening level at only one location are iron, nickel, potassium, and thallium.

4.4.2 Subsurface Soil

A total of 13 subsurface soil samples were collected from the same locations within Site 65 as the surface soil samples. Six of the samples were collected near the waste piles and burn area shown on Figure 4-3. The remaining samples were collected from other locations potentially impacted by historical activities at the site. Subsurface soil sample detection summaries for organic compounds and inorganic elements are presented in Tables 4-6 and 4-7, respectively. The locations of these samples are shown on Figures 4-3 and 4-4 along with the estimated and positive analytical results.

Five VOCs were detected in the subsurface soil samples. Acetone was detected seven times with a maximum concentration of 380 µg/kg, 2-butanone was detected twice with a maximum concentration of 4J µg/kg; trichloroethene was detected once at 2J µg/kg; and toluene was detected once at 1J µg/kg. All of these compounds were detected at concentrations which are less than or equal to the levels detected in the QA/QC blanks. These compounds are considered to be sampling or laboratory contaminants, since they are less than 10 times the maximum concentration detected in the QA/QC blanks.

Xylene is the only remaining VOC detected in subsurface soils and it was detected at five locations with a maximum concentration of 3J µg/kg (65SB-10). Three of the locations are within the heavy equipment training area and the other two locations are near roads. Xylenes are a constituent of petroleum products which may have been deposited by heavy equipment.

Sixteen SVOCs were detected in the subsurface soils at 11 locations. The most widespread compound was bis(2-ethylhexyl) phthalate which was detected at all 11 locations. Bis(2-ethylhexyl)phthalate concentrations ranged from 49J µg/kg (65MW-06) to 370 µg/kg (65DW-01). This phthalate is a common plasticizer in rubber and plastic products, such as tires and hoses. Additionally, this compound is commonly a laboratory and field contaminant.

Di-n-butyl phthalate was detected at the same two locations (65SB-06 and 65SB-08) as it was detected in the surface soils at 340J and 240J µg/kg, respectively. Di-n-butyl phthalate is a specialty plasticizer and polymer additive, especially for polyvinyl chloride (PVC) plastics. However, the sample locations are also near the waste piles at Site 65.

The remaining 14 SVOCs were all detected at 65SB-06 at a depth of three to five feet. All of these compounds are PAHs with a total concentration of 1,635 μg/kg. Individual concentrations are shown on Figure 4-3. Twelve of the 16 SVOCs detected in subsurface sample 65SB-06 were also present in the surface soil sample for this location.

Pesticide results for subsurface soil samples included detections at four of 13 locations. DDT and its by-products were measured at the four locations with a maximum concentration of 76J μg/kg of DDD at 65SB-10. Endrin aldehyde (9.4J μg/kg), alpha chlordane (8.3J μg/kg), and gamma chlordane (7.5 μg/kg) were each measured at one location. PCBs were not detected in the subsurface soil samples collected during the field investigation.

Subsurface soil sample analytical results for TAL metals were compared to a screening level of two times average background concentrations as listed in Appendix L. Nine of 13 sample locations exceeded two times average base background for one or more elements. Four of the nine samples are near the heavy equipment training area where the soil has been disturbed numerous times by bulldozers, front-end loaders, scrapers and similar equipment. Another four sample locations are near the waste piles. The final location is near the entrance to the training area. Metals which exceed the screening level at more than one location are arsenic, barium, calcium, copper, iron, lead, manganese, nickel, sodium, and zinc. Metals which exceeded the screening level at only one location are aluminum, chromium, magnesium, potassium, and thallium (see Figure 4-4).

4.4.3 Test Pits

A total of six subsurface soil samples were collected from test pits near the waste piles and burn area as shown on Figure 4-5. Subsurface soil sample detection summaries for organic compounds and inorganic elements are presented in Tables 4-8 and 4-9, respectively. The locations of these samples are shown on Figures 4-5 and 4-6 along with the estimated and positive analytical results.

Three VOCs were detected in the soil samples from the test pits. Acetone was detected four times with a maximum concentration of 210 μg/kg; 2-butanone was detected once with a concentration of 29 μg/kg; and carbon disulfide was detected once at 2J μg/kg. All of these compounds were detected in the QA/QC blanks. These compounds are considered to be sampling or laboratory contaminants, since they are at levels less than 10 times the maximum concentration detected in the QA/QC blanks.

Fifteen SVOCs were detected in the subsurface soil samples from six test pit locations. The most widespread compound was di-n-butyl phthalate which was detected at all six test pit locations. Di-n-butyl phthalate concentrations ranged from 160J μg/kg to 280J μg/kg (65TP-05 and 65TP-07, respectively). Di-n-butyl phthalate is a specialty plasticizer and polymer additive, especially for polyvinyl chloride (PVC) plastics.

Bis(2-ethylhexyl) phthalate was detected at four test pit locations. Bis(2-ethylhexyl) phthalate concentrations ranged from 37J μg/kg (65TP-02) to 230 μg/kg (65TP-07). As discussed previously, this phthalate is a common plasticizer in rubber and plastic products, such as tires.

The remaining 13 SVOCs were all detected at 65TP-07 at a depth of 10 feet. All of these compounds are PAHs with a total concentration of 1,873 μg/kg. Individual concentrations are shown on Figure 4-6. Thirteen of the 15 SVOCs detected in subsurface sample 65TP-07 are also present in the subsurface soil sample 65SB-06. Eleven of these compounds were also detected in surface soil samples 65DW-01 and 65SB-06.

Pesticide results for subsurface test pit soil samples included detections at four of six locations. DDT and its by-products were measured at the four locations with a maximum concentration of 340J µg/kg of DDD at 65TP-05. Gamma chlordane was measured at two locations with a maximum concentration of 3.1J µg/kg. Endosulfan I (3.1J µg/kg) was measured at one location. PCBs were not detected in the subsurface soil test pit samples.

Subsurface, test-pit, soil-sample, analytical results for TAL metals were compared to a screening level of two times average background concentrations as listed in Appendix L. All six sample locations exceeded two times average base background for two or more elements. Metals which exceeded the screening level at more than one location are barium, calcium, copper, lead, manganese, and zinc. Metals which exceeded the screening level at only one location are antimony, arsenic, cadmium, chromium, cobalt, iron, magnesium, nickel, selenium, silver, and sodium.

4.4.4 Groundwater

One round of groundwater samples was collected from the three existing and seven newly installed monitoring wells at the site. The wells were sampled between May 8 through 18, 1995. Detection summary tables for organics and metals are presented in Tables 4-10 and 4-11 and the locations of these samples are shown on Figures 4-7 and 4-8 along with the results.

Five VOCs were detected in the groundwater samples collected at the site. Methylene chloride was detected once at an estimated concentration of 2J µg/L and five times at 1J µg/L; acetone was detected twice at 7J µg/L and four times at 5J µg/L; 2-butanone was detected three times at 1J µg/L. These compounds are common laboratory contaminants and were detected at concentrations less than 10 times the maximum concentration detected in blank samples. Therefore, methylene chloride, acetone and 2-butanone are not considered to be site related contaminants, but rather contamination resulting from laboratory procedures.

1,2-dichloroethane was detected in eight of the ten samples at an estimated concentration of 2J µg/L. Trip blank samples 65-TB-02 and 65-TB-03 contained 1,2-dichloroethane at a concentration of 2J and 1J µg/L, respectively. Contamination in trip blank samples that are prepared by the laboratory typically indicate that either the source of the water used for the trip blanks or the analytical equipment used for analysis, is contaminated with the compound in question. Given the fact that 1,2-dichloroethane was consistently detected at the same concentration, it is prudent to assume that the contamination did not originate from the site, but rather from the laboratory.

Carbon disulfide was the only VOC detected in the groundwater samples that was not detected in any of the blank samples collected during the RI. It was detected in one upgradient sample location (65MW-04) at a concentration of 5J µg/L. Carbon disulfide is not regulated in groundwater by either NCWQS or by federal MCLs. Some of the common uses for carbon disulfide are the manufacture of carbon tetrachloride, flotation agents, soil disinfectants, dyes, electronic vacuum tubes, paints, enamels, paint removers, varnishes, varnish removers, textiles, explosives, and rocket fuels. It is also used as a solvent for waxes, lacquers and cold vulcanized rubber.

Three SVOCs were detected in the samples at very low concentrations. Di-n-butyl phthalate and bis(2-ethylhexyl)phthalate were detected at a maximum concentration of 6J µg/L in sample 65MW-07. These compounds are not considered to be site-related contamination, but rather contamination resulting from the processes involved with sample collection and analysis. However, due to the detection of these compounds in the field blanks, but not in the trip blanks, it is assumed that the contamination was introduced during the collection of the samples or may have originated from the polyethylene storage tank used for transport and temporary storage of potable water. An additional potential source of the contamination is the nitrile gloves used for personal protection during collection and handling of the samples.

The third SVOCs detected in the samples collected at the site was naphthalene. It was detected in a single sample (65DW-04) at an estimated concentration of 3J µg/L. This relatively low concentration is considerably less than the NCWQS of 21µg/L. As with the detection of carbon disulfide, naphthalene was detected in an upgradient location and is suspected to have originated from an off-site source.

Groundwater samples collected from the monitoring wells contained no detectable concentrations of pesticides or PCBs. These results demonstrate that the PCBs, specifically Aroclor - 1254, detected in the subsurface soil sample collected from 65MW-02 as part of a previous investigation (Baker, 1994), have not impacted the groundwater at the site. PCBs have a low solubility and commonly bind to soil matrices. Therefore, PCBs are rarely encountered in groundwater. In addition, the pesticides detected in the soils at the site do not appear to have contaminated the groundwater.

Thirteen metals were detected in groundwater samples including aluminum, barium, calcium, chromium, cobalt, iron, lead, magnesium, manganese, nickel, potassium, sodium and zinc. Metal results were, on average, one or two orders of magnitude below the base background levels (Baker, 1994). Only two of the elements were detected at concentrations that exceed the state and/or federal standards. Iron concentrations in five samples exceeded the NCWQS of 0.3 mg/L with the highest detected level in sample 65-MW02-01 (6,580 µg/L). Manganese values exceeded the NCWQS of 0.05 mg/L in six samples. The highest concentration (186 µg/L) was detected in deep well sample 65-DW02-02, but the adjacent shallow well sample did not exceed the NCWQS. Neither iron nor manganese concentrations exceeded the federal MCL value in any of the samples collected at the site.

A single filtered sample was collected during the RI in order to compare the total metal results with filtered metal results from the same well. Both samples were collected with low-flow sampling techniques and their comparison was used to illustrate the relationship between the total metal and dissolved metal results. The analytical results were within ten percent which is acceptable and can be partially due to laboratory variation.

Groundwater field parameter results for pH, temperature, specific conductance and turbidity are presented in Table 2-3. These values represent all field measurements obtained during groundwater sampling activities. Reviewing the last readings obtained from each well, which are representative of groundwater conditions prior to sampling, pH values ranged from 4.96 to 8.98 standard units, specific conductance values ranged from 73.8 to 820 micromhos/cm, temperature values ranged from 17.1 to 21°C, and turbidity ranged from 0.2 to 8.18 NTUs.

4.4.5 Surface Water

A total of two surface water samples were collected from Powerline Pond and Courthouse Bay Pond during the RI at Site 65. Positive organic and metals results are presented in Tables 4-12 and 4-13, and illustrated on Figures 4-9 and 4-10.

Only two organics (1,2-dichloroethane and acetone) were detected in the samples. 1,2-dichloroethane was detected in both of the samples at a concentration of 1J µg/L and acetone was detected at a concentration of 5J µg/L. Both of these compounds were detected at concentrations less than 10 times the concentration of the compound in the blank samples and therefore not considered to be related to site conditions (see Section 4.2.1).

A total of 13 of the 23 TAL metals were detected in the surface water samples collected at the site. Aluminum, barium, copper, iron, lead, manganese, vanadium and zinc exceeded the lowest Surface Water Screening Value (SWSV) as depicted on Table 4-13. The highest concentrations of aluminum, barium, chromium, copper, iron, manganese, potassium, vanadium and zinc were reported in sample 65-SW04-01 collected from Courthouse Bay Pond (located nearest the heavy equipment training area). All of the detected element concentrations except iron exceeded the average reference station concentration established at Camp Lejeune. Iron exceeded the average reference station concentration only in sample 65-SW04-01.

4.4.6 Sediment

A total of four sediment samples were collected from Courthouse Bay Pond and Powerline Pond during the field investigation at Site 65. One sample was collected from a depth of zero to six inches and another from a depth of six to 12 inches at each of the two sampling stations (65SD-04 and -05). Positive organic and metal results are depicted on Tables 4-14 and 4-15 and illustrated on Figures 4-9 and 4-10.

The VOCs detected were acetone, chloroform, 2-butanone, carbon tetrachloride, tetrachloroethene and toluene. Acetone was detected in each of the four samples at concentrations ranging from 190J to 450J µg/L; chloroform was detected once at a concentration of 79J µg/L; 2-butanone was detected four times at concentrations ranging form 72J to 94J µg/L; carbon tetrachloride was detected twice at 13J and 18J µg/L; tetrachloroethene was detected at concentrations of 6J and 15J µg/L; and toluene was detected three times with concentrations ranging from 3J to 7J µg/L. The concentrations of acetone, chloroform and toluene detected in the samples are below 10 times the maximum concentrations detected in the blanks. Additionally, the concentrations of 2-butanone detected in the samples are slightly higher than 10 times the maximum concentration detected in the blank samples. None of the compounds were detected at concentrations which exceeded the sediment screening values (SSV); however, all of the concentrations exceeded the average reference concentration for each compound.

Only a single SVOC was detected in the sediment samples collected at Site 65. Di-n-butylphthalate was detected in all four samples with concentrations ranging from 940J to 1,600J µg/L. This phthalate ester was detected in blank samples collected during the RI. However, the concentrations within the blanks were substantially lower than the results obtained from the sediment samples. Only one sample contained concentrations of di-n-butylphthalate that exceeded the Lower Effects Range (ER-L) criteria.

Three pesticides were detected during the sediment investigation at the site. The compounds detected were beta-BHC, 4,4'-DDD and 4,4'-DDE. Beta-BHC was detected in only one sample at a concentration of 8.3NJ µg/L; 4,4'-DDD was detected in two samples at concentrations of 76J and 84J µg/L; and 4,4'-DDE was detected twice at concentrations of 18J and 19NJ µg/L. All of these compounds exceeded the lowest SSV and the average reference concentration. These concentrations are similar to the concentrations detected in the surface soils across the site.

Thirteen of 23 TAL metals were detected in the sediment samples collected during the field investigation (see Table 4-15). Copper, lead and zinc were detected at a concentration exceeding the lowest SSV only one time; however, all of the elements exceeded the average reference concentration at least one time.

4.4.7 Ecological

A total of nine fish samples were collected from the two ponds located east of the site. Four samples were collected for fillet analysis and five for whole body analysis. Positive organic and metal results are presented in Tables 4-16, 4-17, 4-18, and 4-19.

The only organics detected in the fillet samples were acetone and 4,4'-DDD. Samples 65-FS05-BG01F and 65-FS05-LB01F contained acetone at concentrations of 5,600J µg/kg and 7,900 µg/kg, respectively. In addition, 4,4'-DDD was detected in sample 65-FS04-BG01F at a concentration of 5.7J µg/kg.

Twelve of the 23 TAL metals were detected in the fish fillet samples collected during the RI. Aluminum, barium, calcium, copper, magnesium, manganese, mercury, potassium, selenium, sodium, thallium, and zinc were the detected inorganic elements.

Four VOCs were detected in the whole body samples collected during the field investigation. Methylene chloride was detected at a concentration of 1,000J µg/kg (65-FS04-RS01W); acetone was detected in three samples with concentrations ranging from 27,000 µg/kg to 1,400,000J µg/kg (65-FS05-BG01W); 2-butanone was detected only in sample 65-FS05-RS01W at a concentration of 560J µg/kg; and toluene was only detected in one sample (65-FS05-BL01W) at a concentration of 5,000J µg/kg.

These contaminants are probably not site-related. The concentrations of VOCs observed in sediment and surface water samples were low and detected infrequently (see Sections 4.4 and 4.5 and Tables 4-10 and 4-12). Typically, VOCs do not bioconcentrate in fish and crab tissues as noted by their relatively low bioconcentration factors (acetone = .69; methylene chloride = 3.75; and toluene = 10.7). Furthermore, all four of the VOCs detected are common laboratory contaminants. Considering these facts, it is highly probable that these VOCs were introduced in the laboratory, although the exact method of introduction cannot be determined.

There were no SVOCs detected in the samples; but there were two pesticides (4,4'-DDE and 4,4'-DDD) detected. 4,4'-DDE was detected in a single sample (65-FS04-BG01W) at a concentration of 15J µg/kg; 4,4'-DDD was detected twice with a maximum concentration of 40J µg/kg detected in sample 65-FS04-BG01W. No PCBs were detected in any of the whole body samples.

Seventeen of the 23 TAL metals were detected in the whole body samples. The elements detected were aluminum, antimony, arsenic, barium, beryllium, calcium, copper, iron, lead, magnesium, manganese, mercury, potassium, selenium, sodium, thallium, and zinc.

4.5 Engineering Results

A total of six samples were collected for engineering parameters during the RI. A subsurface soil sample (65-SB06), groundwater sample (65-MW07A-01), and four sediment samples (65-SD04-06, 65-SD04-06, 65-SD04-612, 65-SD05 and 6505-612) were analyzed. The results are included in Appendix O.

4.6 Quality Assurance/Quality Control

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

Organic compounds detected within the blank samples include methylene chloride, acetone, 1,2-dichloroethane, 2-butanone, chloroform, bromodichloromethane, di-n-butylphthalate, bis(2-ethylhexyl) phthalate, dibromochloromethane, 4,4'-DDT, toluene, trichloroethene and 1,1-dichloroethene. The trip blanks used for the Site 65 RI were prepared by the laboratory, shipped to the field and then returned to the laboratory with the samples. Methylene chloride, acetone, 1,1-dichloroethene, 1-2, dichloroethane, trichloroethene and toluene were detected in the trip blanks at low concentrations. This would tend to indicate that these contaminants originated from the laboratory.

The equipment rinsate blanks were collected in the field from sampling equipment that had recently been cleaned. Methylene chloride, acetone, 1,2-dichloroethane and 2-butanone were detected in the rinseate blanks. With the exception of acetone, the other contaminants were detected at relatively low concentrations. The origin of methylene chloride, 1,2-dichloroethane, and 2-butanone contamination may be related to the laboratory, the deionized water used for the blanks or from the field decontamination process. The methylene chloride and 1,2-dichloroethane was detected in the trip blanks at similar concentrations and, therefore are suspected to be laboratory-related contamination. 2-butanone was not detected in the trip blanks but is a common laboratory contaminant and, therefore is suspected of originating in the laboratory. Acetone was detected at its highest concentration in sample number 65-RB-03. Possible sources for the acetone contamination detected in the blanks include field decontamination and laboratory cleaning/extraction procedures. Acetone is commonly used in laboratories for cleaning glassware and contaminant extractions. However, due to the sharp increase in the concentration of acetone in the equipment rinseate blanks, the suspected source of the contamination is not allowing the isopropanol (which has acetone as a component) to completely air dry after decontamination.

In addition to the organic contamination observed in the blank equipment rinseate blanks, six metals were detected. These analytes include aluminum, barium, calcium, magnesium, sodium and zinc. The origin of these elements is most likely site related.

Field blanks were collected from the three sources of water used at the site. Sample 73-FB-01 was collected from the distilled water used for equipment decontamination (i.e., stainless steel spoons, split spoons, bowls, etc.); sample 73-FB-02 was collected from the deionized water supplied by the laboratory for use in collection of equipment rinseate blanks; and sample 73-FB-03 was collected from the potable water used for decontamination of heavy equipment (i.e., steam cleaning). Sample 73-FB-01 contained acetone, di-n-butylphthalate and bis(2-ethylhexyl) phthalate as contaminants. The water was packaged in plastic bags contained within cardboard boxes and the plastic bags may be the source of the phthalate contamination. The acetone contamination is again suspected to be laboratory related contamination.

Sample 73-FB-02 contained methylene chloride and acetone contamination. The methylene chloride contamination is suspected to have originated in the laboratory; however the acetone is suspected to have had two sources of contamination. Since acetone was detected in the trip blanks, the equipment blanks and the deionized water, it is suspected that the contamination originated from the laboratory (i.e., contaminated deionized water) and the field decontamination procedures (i.e., not allowing the equipment to completely dry prior to use). This would explain the sharp increase in concentration in the rinseate blanks and the high concentration observed in field blank sample 73-FB-02.

Sample 73-FB-03 contained contaminants acetone, chloroform, bromodichloromethane and dibromochloromethane. With the exception of acetone and chloroform, these contaminants are suspected to exist within the potable water supply. The suspected origin of acetone contamination has been discussed in previous paragraphs. Chloroform contamination can come from the use of chlorinated water in the laboratory or if the potable water is chlorinated during its treatment, if any.

Ten of the 23 TAL metals were detected in the field blanks. The analytes include aluminum, barium, calcium, copper, iron, lead, magnesium, potassium, sodium and zinc.

4.7 Extent of Contamination

4.7.1 Surface Soils

Figure 4-1 presents the positive detections of the organic compounds in surface soil samples collected at the site.

As stated previously, a total of six VOCs were detected at Site 65. Acetone, methylene chloride and toluene were detected at concentrations less than 10 times the maximum concentration detected in the blank samples. In addition, the concentration of trichloroethene was less than five times the maximum concentration detected in the blanks, designating them as probable laboratory contaminants and not site-related. The remaining volatiles are considered to be site-related contamination.

Ethylbenzene was detected in surface soil sample 65-SB07-00 and xylene was detected in samples 65-SB07-00 and 65-DW01-00. The occurrence of ethylbenzene and xylene within the surface soils at the site is not a surprise given the vehicular traffic through the site. The relatively low concentrations of these compounds do not indicate a specific source, but may have originated from vehicles and heavy equipment passing through the site.

SVOCs were detected in nearly every surface soil sample collected at the site. The only sample which did not contain any detectable semivolatiles was 65-DW02-00. PAH constituents were detected in only three samples (65-SB06-00, 65-SB12-00 and 65-DW01-00). Samples 65-SB06-00 and 65-DW01-00 were collected near the southern-most debris piles located at the site. In addition, sample 65-SB12-00 was collected in the middle of the area where the northern-most debris pile had existed. The material comprising the northern pile was removed during the field investigation by the engineers that operate the heavy equipment within the training area. All of the locations where PAH compounds were detected are located near an area where construction type materials have been disposed. Sample 65-DW01-00 was near the reported burn area in addition to the debris piles. Due to the types of materials discovered during the test pit excavation and a site reconnaissance, and the reported location of the burn area, the suspected source for the PAH contamination is the debris and the historical burning at the site. The origin of the PAH contamination with regard to burning materials at the site is further corroborated by the substantial increase in PAHs in sample 65-DW01-00 (the sample located closest to the burn area).

PAH constituents were detected during the SI conducted by Baker in 1991. Two samples collected from borings 65-MW03 and 65-SB02 contained the PAHs. Both of these locations were near the debris sites located at the site.

Bis(2-ethylhexyl)phthalate and di-n-butyl phthalate were detected in most of the samples collected across the site. Neither of these compounds was detected at concentrations below 10 times the maximum concentration detected within the blank samples. No specific source can be identified for the phthalate esters.

Pesticides were detected in all areas of the site. The levels detected in the samples are similar to base-wide concentrations from the historical use of pesticides at Camp Lejeune.

PCB compound Aroclor 1260 was detected in one location near the burn area and the southern-most debris piles. The compound was detected in sample 65-DW01-00 at a concentration of 52J µg/kg. Historical records do not indicate the disposal of PCBs, however PCBs were detected in a subsurface soil sample collected from soil boring 65SB-02 during the SI conducted in 1991 (Baker, 1994). The detection of PCBs within the vicinity of the debris piles indicates that some product containing PCBs may have been spilled or disposed at the site.

Figure 4-2 presents the metals that were detected in the surface soil samples collected at the site. The contamination was observed in the heavy equipment training area and the southern-most debris pile. The distribution of the metals indicate that the contamination may be the result of rusting metal debris disposed at the site and the heavy equipment used for training.

4.7.2 Subsurface Soil

Detected VOCs, SVOCs, pesticides and PCBs in the subsurface soils at Site 65 are depicted on Figures 4-3 and 4-5.

Acetone, 2-butanone, carbon disulfide, and toluene were detected at levels less than 10 times the maximum concentration of these compounds in QA/QC blanks, designating them as probable laboratory contaminants. The relatively low xylene concentrations detected at sample locations 65DW-02, -01, 65SB-09, -10 and 65MW-06 are considered to be site-related contamination. All of the locations appear to be in areas of vehicular traffic and training. Given the low concentrations of the compound, the suspected source of the contamination is the petroleum products commonly used in fueling, lubricating and cleaning the vehicles which commonly trespass the site.

Semivolatile compounds bis(2-ethylhexyl)phthalate and di-n-butyl phthalate were detected in nearly every sample collected at the site. The concentrations observed within the samples were greater than 10 times the maximum concentration detected in the QA/QC blanks. A specific source for the phthalate esters has not been determined. PAH contamination was detected in subsurface soil samples collected from 65SB-06 and 65TP-07 located at the edge of the southern-most debris piles and the edge of the Burn Area, respectively. The disposal of construction debris and the combustion of organic compounds is the likely source of the contamination. The concentrations of PAH contamination is much higher in the subsurface than the surface soils at location 65SB-06. Location

65DW-01, which exhibited the highest concentrations of PAHs in the surface soil, exhibited no PAHs in the subsurface soil.

Pesticides were detected mainly in areas where the soils have been either disturbed by excavation (heavy equipment training) or disposal. The occurrence of pesticide contamination may be attributed to the historical use of pesticides at Camp Lejeune (Water and Air Research, 1983). Although the contamination would be expected to be greater in the surface soils than in the subsurface, the grading and distribution of the soil across the site would mix any contamination found at the surface with soils residing below the surface. Hence, allowing contaminated surface soil to be redistributed as subsurface soil. PCBs were not detected in any subsurface soil samples collected during the RI; indicating that the concentration of Aroclor 1254 detected in 65SB-02 during the SI was not a site-wide concern.

Metals were detected in the subsurface soils. Figure 4-4 and 4-6 presents the metals detected at the site during the RI. The majority of the elemental contamination appears to be concentrated in the area of the debris piles. The suspected source of this contamination is the rusting debris that has been deposited within these piles.

4.7.3 Groundwater

The only organic compound which exceeded state and/or federal groundwater standards was 1,2-dichloroethane. As discussed in Section 4.4, 1,2-dichloroethane was detected at concentrations less than 10 times the concentration of the compound in QA\QC blanks, making the contamination attributable to laboratory contamination. Figure 4-7 presents the organics that were detected in groundwater samples collected at the site.

Iron and manganese were the only elements detected at concentrations exceeding state and/or federal groundwater standards. The 13 elements detected in the groundwater samples are presented on Figure 4-8. The occurrence of iron and manganese at levels that exceed NC DEHNR standards correlates with the evaluation of metals in groundwater (Baker, 1994), which indicates that both of these metals are naturally occurring in shallow and deep groundwater at the base at elevated concentrations. The relatively high concentrations of manganese correlates with the previous work performed during the SI.

4.7.4 Surface Water

The detected organic compounds in surface water are presented on Figure 4-9. As discussed previously, the only compounds detected were acetone and 1,2-dichloroethene, however these compounds were not detected at levels considered to be site-related.

The elevated metals detected in the surface water samples (see Figure 4-10) are considerably less than the surrounding soils, but are higher than the groundwater in the area. The only sources of recharge for the ponds are groundwater and stormwater runoff. Since there are no streams replenishing the ponds with fresh water or removing water from the ponds, it is suspected that the contamination may be the result of water evaporation increasing the concentration of salts and metal while groundwater continues to discharge elements into the ponds. Additionally, soil erosion (especially in the equipment training area) may also contribute to the elevated concentrations of metals.

4.7.5 Sediments

The source for the VOCs detected in the sediments of the two ponds (see Figure 4-9) has not been determined. However, the results indicate that the concentrations observed do not exceed the Sediment Screening Values (SSVs). The single carbon tetrachloride concentration does not correlate to any contamination residing in any other media.

As discussed previously, the pesticide concentrations observed in the sediment samples are similar to the concentrations observed in the surface soils, particularly in the vicinity of the training area. Given the proximity of the two ponds to the equipment training area, the large quantities of earth that is moved during training exercises, and the absence of pesticides in the surface water samples, it is suspected that the pesticide contamination within the sediments was the result of surface soil erosion or the past application of pesticides in the vicinity of the ponds.

The elemental contamination detected in the sediments of the two ponds is suspected to be the result of precipitation of the metals contained within the surface water as evaporation occurs (see Figure 4-10). In addition, the surrounding soils may contribute to the sediments via erosion, especially considering the turbidity of Courthouse Bay Pond, thus increasing the contamination within the sediments.

4.8 Summary

PAH constituents were detected at elevated levels in both surface and subsurface soils at the site. These contaminants are likely attributable to the past activities at the site due to their distribution and concentrations. Relatively low levels of xylene, ethylbenzene and carbon disulfide were detected in the soils and may be attributed to past and/or current activities at the site. Pesticides were detected at low concentrations across most of the site. These contaminants were most likely due to the historical usage of pesticides at the site. PCBs were exhibited at an isolated sample location during this investigation, but were also detected at another location during a previous investigation. There is no history of PCB disposal at Site 65; however, the detection of the compound in the vicinity of the debris piles indicates that some product containing PCBs may have been disposed or spilled at the site. A specific source for the contamination has not been identified.

The groundwater contained no site-related organic contamination that exceeded the state and/or federal standards. No organics were detected in the surface water which can be attributed as site related contamination due to past activities. The only organics which exceeded the SSVs in the sediments were pesticides, which are most likely related to the historical usage of pesticides at the base.

Inorganics were detected in all media. Their wide distribution and concentrations similar to base background levels, and concentrations detected at other areas of the base, indicate that they are not site related.

4.9 References

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TABLES

TABLE 4-1

COMPARISON OF SITE BACKGROUND CONCENTRATIONS TO BASE BACKGROUND LEVELS IN SURFACE SOILS
SITE 65 - ENGINEER AREA DUMP
REMEDIAL INVESTIGATION, CTO-0312
MCB, CAMP LEJEUNE, NORTH CAROLINA

	Site Background (mg/kg)	Base Background (mg/kg)
Aluminum	773	17.7 - 9,570
Antimony	ND	0.33 - 8
Arsenic	ND	0.065 - 3.9
Barium	6.9	0.65 - 20.8
Beryllium	ND	0.02 - 0.26
Cadmium	ND	0.04 - 1.0
Calcium	79.3	4.25 - 10,700
Chromium	ND - 8.6	0.33 - 12.5
Cobalt	ND	0.185 - 4.15
Copper	ND	0.5 - 87.2
Iron	509	69.7 - 9,640
Lead	2	0.47 - 142
Magnesium	30.3	2.55 - 610
Manganese	9.6	0.87 - 66
Mercury	ND	0.01 - 0.13
Nickel	ND	0.45 - 7.2
Potassium	ND	1 - 416
Selenium	ND	0.075 - 1.3
Silver	ND	0.0435 - 4.3
Sodium	ND	4.7 - 126
Thallium	ND	0.055 - 1.2
Vanadium	ND	0.305 - 48.6
Zinc	ND	0.3 - 28.3

Note:
ND = Not Detected

TABLE 4-2

COMPARISON OF SITE BACKGROUND CONCENTRATIONS TO BASE BACKGROUND LEVELS IN SUBSURFACE SOILS
SITE 65 - ENGINEER AREA DUMP
REMEDIAL INVESTIGATION, CTO-0312
MCB, CAMP LEJEUNE, NORTH CAROLINA

	Site Background (mg/kg)	Base Background (mg/kg)
Aluminum	4,560	16.9 - 11,000
Antimony	ND	0.355 - 6.9
Arsenic	ND	0.033 - 15.4
Barium	10.9	0.65 - 22.6
Beryllium	ND	0.01 - 0.31
Cadmium	ND	0.155 - 1.2
Calcium	111	4.75 - 4,410
Chromium	5.7	0.65 - 66.4
Cobalt	ND	0.175 - 7
Copper	ND	0.16 - 9.5
Iron	925	63.3 - 90,500
Lead	2.7	0.465 - 21.4
Magnesium	192	2.85 - 852
Manganese	5.6	0.395 - 19.9
Mercury	ND	0.01 - 0.68
Nickel	ND	0.45 - 9.2
Potassium	ND	1.05 - 1,250
Selenium	ND	0.085 - 2.4
Silver	ND	0.175 - 1
Sodium	69.9	2.2 - 141
Thallium	ND	0.055 - 2.7
Vanadium	4.1	0.34 - 69.4
Zinc	NA	0.32 - 26.6

Note:
ND = Not Detected

TABLE 4-3

SUMMARY OF SITE CONTAMINATION
SITE 65 - ENGINEER AREA DUMP
REMEDIAL INVESTIGATION, CTO-0312
MCB, CAMP LEJEUNE, NORTH CAROLINA

Media	Fraction	Detected Contaminants	Comparison Criteria		Site Contamination					
			Criteria I	Criteria II	Min. Conc.	Max. Conc.	Location(s) of Maximum Concentration	Detection Frequency	Number of Detections Above Comparison Criteria I	Number of Detections Above Comparison Criteria II
Surface Soil[(1)]	Volatiles	Methylene Chloride	$8.5 X 10^4$	NA	2J	2J	65-MW07A-00 & SB12-00	2/13	0	NA
		Acetone	$7.8 X 10^5$	NA	10J	10J	65-MWO5A-00	1/13	0	NA
		Trichloroethene	$5.8 X 10^4$	NA	1J	1J	65-SB06-00	1/13	0	NA
		Toluene	$1.6 X 10^6$	NA	1J	2J	65-DW04-00 & MW07A-0	3/13	0	NA
		Ethylbenzene	$7.8 X 10^5$	NA	1J	1J	65-SB07-00	1/13	0	NA
		Xylene (total)	$1.6 X 10^7$	NA	3J	5J	65-SB07-00	2/13	0	NA
	Semivolatiles	Acenaphthene (PAH)	$4.7 X 10^5$	NA	130J	130J	65-DW01-00	1/13	0	NA
		2,4-Dinitrophenol	$1.6 X 10^4$	NA	150J	150J	65-DW04-00	1/13	0	NA
		Dibenzofuran	$3.1 X 10^4$	NA	58J	58J	65-DW01-00	1/13	0	NA
		Fluorene (PAH)	$3.1 X 10^5$	NA	100J	100J	65-DW01-00	1/13	0	NA
		Phenanthrene (PAH)	$2.3 X 10^5$	NA	59J	860	65-DW01-00	3/13	0	NA
		Anthracene (PAH)	$2.3 X 10^6$	NA	190J	190J	65-DW01-00	1/13	0	NA
		Carbazole	$3.2 X 10^4$	NA	180J	180J	65-DW01-00	1/13	0	NA
		di-n-Butyl-phthalate	$7.8 X 10^5$	NA	260J	390J	65-SB06-00	2/13	0	NA
		Fluoranthene (PAH)	$3.1 X 10^5$	NA	130J	830	65-DW01-00	3/13	0	NA
		Benzo(a)anthracene (PAH)	880	NA	76J	510	65-DW01-00	3/13	0	NA
		Chrysene (PAH)	$8.8 X 10^4$	NA	70J	470	65-DW01-00	3/13	0	NA
		bis(2-Ethylhexyl)phthalate	$4.6 X 10^4$	NA	48J	87J	65-MW06A-00	9/13	0	NA
		Benzo(b)fluoranthene (PAH)	880	NA	89J	360J	65-DW01-00	3/13	0	NA
		Benzo(k)fluoranthene (PAH)	8800	NA	120J	510	65-DW01-00	2/13	0	NA

Notes:

Concentrations are presented in *µg/Kg for organics in soil and sediment and in µg/L for all water contaminants (ppb); metal concentrations for soil and sediment are presented in mg/Kg (ppm).*

NA - Not applicable

ND - Not detected

PAH - Polynuclear aromatic hydrocarbon

(1) Organics and Metals in both surface and subsurface soils are compared to EPA Region III risk based Contaminent of Concern (COC) Screeing Values for a residential area (Criteria I), and two times base background concentrations for MCB, Camp Lejeune (Criteria II) (Metals only). Only priority pollutant metals (i.e., aluminum, antimony, arsenic, barium, cadmium, chromium, cobalt, copper, iron, lead, manganese, nickel, selenium, silver, thallium, vanadium, zinc) are presented on this table. Refer to Table 4-5 and 4-6 for completed metals detection data.

TABLE 4-3 (Continued)

SUMMARY OF SITE CONTAMINATION
SITE 65 - ENGINEER AREA DUMP
REMEDIAL INVESTIGATION, CTO-0312
MCB, CAMP LEJEUNE, NORTH CAROLINA

Media	Fraction	Detected Contaminants	Comparison Criteria		Site Contamination					
			Criteria I	Criteria II	Min. Conc.	Max. Conc.	Location(s) of Maximum Concentration	Detection Frequency	Number of Detections Above Comparison Criteria I	Number of Detections Above Comparison Criteria II
Surface Soil	Semivolatiles (continued)	Benzo(a)pyrene (PAH)	88	NA	100J	400	65-DW01-00	2/13	2	NA
		Indeno(1,2,3-cd)pyrene (PAH)	880	NA	88J	310J	65-DW01-00	2/13	0	NA
		Dibenzo(a,h)anthracene (PAH)	88	NA	45J	150J	65-DW01-00	2/13	1	NA
		Benzo(g,h,i)perylene (PAH)	2.3 X 10^5	NA	70J	250J	65-DW01-00	2/13	0	NA
	Pesticides	Heptachlor epoxide	70	NA	2.3	2.3	65-MW07A-00	1/13	0	NA
		4-4'-DDE	1900	NA	4.3	83J	65-MW07A-00	6/13	0	NA
		Endosulfan II	4.7 X 10^4	NA	3.8NJ	3.9NJ	65-DW02-00	2/13	0	NA
		4-4'-DDD	2700	NA	3.8NJ	59J	65-SB10-00	7/13	0	NA
		4-4'-DDT	1900	NA	25	56J	65-MW07A-00 & SB07-00	3/13	0	NA
	PCBs	Aroclor 1260	83	NA	52J	52J	65-DW01-00	1/13	0	NA
	Metals	Aluminum	7800	5940	656	5040	65-DW01-00	13/13	0	0
		Barium	550	17.36	2.7	36.3	65-DW01-00	13/13	0	3
		Chromium	39	6.693	2.3	8.6	65-DW01-00	11/13	0	2
		Copper	290	7.2	2.5	55.6	65-DW01-00	9/13	0	6
		Iron	NA	3755	50.9	16400	65-SB12-00	13/13	NA	2
		Lead	400	23.75	2	178	65-DW01-00	13/13	0	4
		Manganese	39	18.5	2.9	163J	65-DW01-00	13/13	3	5
		Nickel	160	3.434	4.6	5.7	65-SB12-00	2/13	0	2
		Thallium	NA	0.889	2.3	2.3	65-SB10-00	1/13	NA	1
		Vanadium	55	11.63	2.8	12	65-DW01-00	9/13	0	1
		Zinc	2300	13.88	3.7	377J	65-DW01-00	11/13	0	6

Notes:

Concentrations are presented in µg/Kg for organics in soil and sediment and in µg/L for all water contaminants (ppb); metal concentrations for soil and sediment are presented in mg/Kg (ppm).

NA - Not applicable

ND - Not detected

PAH - Polynuclear aromatic hydrocarbon

TABLE 4-3 (Continued)

SUMMARY OF SITE CONTAMINATION
SITE 65 - ENGINEER AREA DUMP
REMEDIAL INVESTIGATION, CTO-0312
MCB, CAMP LEJEUNE, NORTH CAROLINA

Media	Fraction	Detected Contaminants	Comparison Criteria		Site Contamination					
			Criteria I	Criteria II	Min. Conc.	Max. Conc.	Location(s) of Maximum Concentration	Detection Frequency	Number of Detections Above Comparison Criteria I	Number of Detections Above Comparison Criteria II
Subsurface Soil(1)	Volatiles	Acetone	7.8 X 10^5	NA	7J	380	65-DW02-02	13/19	0	NA
		Carbon Disulfide	7.8 X 10^5	NA	2J	2J	65-TP04	1/19	0	NA
		2-Butanone	4.7 X 10^6	NA	2J	29	65-TP05	3/19	0	NA
		Trichloroethene	5.8 X 10^4	NA	2J	2J	65-SB07-04	1/19	0	NA
		Toluene	1.6 X 10^6	NA	1J	1J	65-SB11-04	1/19	0	NA
		Xylene (total)	1.6 X 10^7	NA	1J	3J	65-SB10-01	5/19	0	NA
	Semivolatiles	Naphthalene (PAH)	3.1 X 10^5	NA	55J	55J	65-TP07	1/19	0	NA
		2-Methylnaphthalene	3.1 X 10^5	NA	60J	60J	65-TP07	1/19	0	NA
		Acenaphthene	4.7 X 10^5	NA	94J	97J	65-SB06-02	2/19	0	NA
		Fluorene	3.1 X 10^5	NA	110J	110J	65-SB06-02	1/19	0	NA
		Dibenzofuran	3.1 X 10^4	NA	42J	42J	65-TP07	1/19	0	NA
		Phenanthrene (PAH)	2.3 X 10^5	NA	150J	1200	65-SB06-02	2/19	0	NA
		Anthracene	2.3 X 10^6	NA	290J	290J	65-SB06-02	1/19	0	NA
		Carbazole	3.2 X 10^4	NA	120J	120J	65-SB06-02	1/19	0	NA
		di-n-Butylphtalate	7.8 X 10^5	NA	160J	340J	65-SB06-02	8/19	0	NA
		Fluoranthene (PAH)	3.1 X 10^5	NA	230J	1900	65-SB06-02	2/19	0	NA
		Pyrene (PAH)	2.3 X 10^5	NA	190J	1400	65-SB06-02	2/19	0	NA
		Benzo(a)anthracene (PAH)	880	NA	100J	900	65-SB06-02	2/19	1	NA
		Chrysene (PAH)	8.8 X 10^4	NA	110J	800	65-SB06-02	2/19	0	NA

Notes:

Concentrations are presented in µg/Kg for organics in soil and sediment and in µg/L for all water contaminants (ppb); metal concentrations for soil and sediment are presented in mg/Kg (ppm).

NA - Not applicable

ND - Not detected

PAH - Polynuclear aromatic hydrocarbon

(1) Organics and Metals in both surface and subsurface soils are compared to EPA Region III risk based Contaminent of Concern (COC) Screeing Values for a residential area (Criteria I), and two times base background concentrations for MCB, Camp Lejeune (Criteria II) (Metals only). Only priority pollutant metals (i.e., aluminum, antimony, arsenic, barium, cadmium, chromium, cobalt, copper, iron, lead, manganese, nickel, selenium, silver, thallium, vanadium, zinc) are presented on this table. Refer to Table 4-5 and 4-6 for completed metals detection data.

TABLE 4-3 (Continued)

SUMMARY OF SITE CONTAMINATION
SITE 65 - ENGINEER AREA DUMP
REMEDIAL INVESTIGATION, CTO-0312
MCB, CAMP LEJEUNE, NORTH CAROLINA

Media	Fraction	Detected Contaminants	Comparison Criteria		Site Contamination					
			Criteria I	Criteria II	Min. Conc.	Max. Conc.	Location(s) of Maximum Concentration	Detection Frequency	Number of Detections Above Comparison Criteria I	Number of Detections Above Comparison Criteria II
Subsurface Soil	Semivolatiles (continued)	bis(2-ethylhexyl)phthalate	4.6 X 10^4	NA	37J	370	65-DW01-04	15/19	0	NA
		Benzo(b)fluoranthene (PAH)	880	NA	96J	710	65-SB06-02	2/19	0	NA
		Benzo(k)fluoranthene (PAH)	8800	NA	110J	620	65-SB06-02	2/19	0	NA
		Benzo(a)pyrene (PAH)	88	NA	69J	680	65-SB06-02	2/19	1	NA
		Ideno(1,2,3-cd)pyrene (PAH)	880	NA	480	480	65-SB06-02	1/19	0	NA
		Benzo(g,h,i)perylene (PAH)	2.3 X 10^5	NA	67J	360J	65-SB06-02	1/19	0	NA
	Pesticides	Endosulfan I	3.2 X 10^4	NA	3.1NJ	3.1NJ	65-TP05	1/19	0	NA
		4,4'-DDE	1900	NA	4.6	45J	65-TP04	8/19	0	NA
		4,4'-DDD	2700	NA	4.4J	340J	65-TP05	8/19	0	NA
		4,4'-DDT	1900	NA	9.6	40	65-TP07	4/19	0	NA
		Endrin Aldehyde	2300	NA	9.4J	9.4J	65-DW01-04	1/19	0	NA
		alpha-Chlordane	490	NA	8.3J	8.3J	65-SB06-02	1/19	0	NA
		gamma-Chlordane	490	NA	3J	7.5J	65-SB06-02	3/19	0	NA
	PCBs	ND	NA	NA	NA	NA	NA	0/19	NA	NA
	Metals	Aluminum	7800	7375	1020	10600	65-SB07-04	19/19	1	1
		Antimony	3.1	6.409	11.8	11.8	65-TP07	1/19	1	1
		Arsenic	0.37	1.968	2.6	3.3	65-SB06-02	3/19	3	3
		Barium	550	14.2	2.7	38.3	65-SB06-02	19/19	0	7
		Cadmium	3.9	0.712	1.3	1.3	65-SB06-02 & TP04	2/19	0	2
		Chromium	39	12.56	2.6	17.3	65-SB07-04	16/19	0	1
		Cobalt	470	1.504	11.5	11.5	65-TP07	1/19	0	1
		Copper	290	2.416	7.7	67.2	65-TP07	8/19	2	8
		Iron	NA	7252	236J	31300	65-SB06-02	19/19	NA	5

Notes:

Concentrations are presented in µg/Kg for organics in soil and sediment and in µg/L for all water contaminants (ppb); metal concentrations for soil and sediment are presented in mg/Kg (ppm).

NA - Not applicable

ND - Not detected

PAH - Po[illegible]clear aromatic hydrocarbon

TABLE 4-3 (Continued)

SUMMARY OF SITE CONTAMINATION
SITE 65 - ENGINEER AREA DUMP
REMEDIAL INVESTIGATION, CTO-0312
MCB, CAMP LEJEUNE, NORTH CAROLINA

Media	Fraction	Detected Contaminants	Comparison Criteria		Site Contamination					
			Criteria I	Criteria II	Min. Conc.	Max. Conc.	Location(s) of Maximum Concentration	Detection Frequency	Number of Detections Above Comparison Criteria I	Number of Detections Above Comparison Criteria II
Subsurface Soil	Metals (continued)	Lead	400	8.327	1.6	539	65-SB06-02	19/19	1	8
		Manganese	39	7.919	2	471	65-SB06-02	19/19	5	10
		Nickel	160	3.714	4.8	243	65-SB06-02	3/19	1	3
		Selenium	39	0.801	1.5	1.5	65-TP07	1/19	0	1
		Silver	39	0.866	4.2	4.2	65-TP07	1/19	0	1
		Thallium	NA	0.955	4.2	4.2	65-SB06-02	1/19	NA	NA
		Vanadium	55	13.45	3.1	27.2	65-SB07-04	15/19	0	1
		Zinc	2300	6.662	2.5J	764	65-SB06-02	16/19	0	12
Groundwater(2)	Volatiles	Methylene Chloride	NA	5	1J	2J	65-MW06	6/11	NA	0
		Acetone	NA	700	5J	7J	65-MW06	7/11	NA	0
		Carbon Disulfide	NA	700	5J	5J	65-MW04	1/11	NA	0
		1,2-Dichloroethane	5	0.38	2J	2J	65-MW07	8/11	0	8
		2-Butanone	NA	NA	1J	1J	65-MW03, 05, & 06	3/11	NA	NA
	Semivolatiles	Naphthalene	NA	21	3J	3J	65-DW04	1/11	NA	0
		di-n-Butylphthalate	NA	700	2J	6J	65-MW07	3/11	NA	0
		bis(2-ethylhexyl)phthalate	NA	3	1J	6J	65-MW07	5/11	NA	2
	Pesticides	ND	NA	NA	NA	NA	NA	0/11	NA	NA
	PCBs	ND	NA	NA	NA	NA	NA	0/11	NA	NA
	Metals	Aluminum	50-200(3)	NA	40.3	421	65-MW06	7/11	NA	6
		Barium	2000	2000	17.9	151	65-MW03	10/11	0	0

Notes:

Concentrations are presented in µg/Kg for organics in soil and sediment and in µg/L for all water contaminants (ppb); metal concentrations for soil and sediment are presented in mg/Kg (ppm).

NA - Not applicable

ND - Not detected

PAH - Polynuclear aromatic hydrocarbon

(2) Comparison Criteria for groundwater are Federal Maximum Contaminant Levels (MCL) (Criteria I) and North Carolina Water Quality Standards (NCWQS) (Criteria II).

(3) Secondary MCL for aluminum, iron, and zinc; if MCL is a range, the lower concetration is used for comparison.

TABLE 4-3 (Continued)

SUMMARY OF SITE CONTAMINATION
SITE 65 - ENGINEER AREA DUMP
REMEDIAL INVESTIGATION, CTO-0312
MCB, CAMP LEJEUNE, NORTH CAROLINA

Media	Fraction	Detected Contaminants	Comparison Criteria		Site Contamination					
			Criteria I	Criteria II	Min. Conc.	Max. Conc.	Location(s) of Maximum Concentration	Detection Frequency	Number of Detections Above Comparison Criteria I	Number of Detections Above Comparison Criteria II
Groundwater	Metals (continued)	Chromium	100	50	10	10.2	65-MW01	2/11	0	0
		Cobalt	NA	NA	20.1	52.4	65-DW02-02	4/11	NA	NA
		Iron	300(3)	300	41.9	6580	65-MW02	10/11	5	5
		Lead	15(4)	15	3.4	3.4	65-DW04	1/11	0	0
		Manganese	NA	50	3	186	65-DW02-02	11/11	NA	5
		Nickel	100	100	53.1	59.6	65-DW02-02	2/11	0	0
		Zinc	5000(3)	2100	11	58.9	65-DW02-02	10/11	NA	0
Surface Water(5)	Volatiles	Acetone	NA	NA	5J	5J	65-SW04-01	1/2		
		1,2-Dichloroethane	0.38 (EPA)	NA	1J	1J	65-SW04-01 & SW05-01	2/2	2	NA
	Semivolatiles	ND	NA	NA	NA	NA	NA	0/2	NA	NA
	Pesticides	ND	NA	NA	NA	NA	NA	0/2	NA	NA
	PCBs	ND	NA	NA	NA	NA	NA	0/2	NA	NA
	Metals	Aluminum	NA	333.17	25800	25800	65-SW04-01	1/2	NA	1
		Barium	1000 (NC)	25.67	36.7	69.3	65-SW04-01	2/2	0	1
		Chromium (total)	50(6) (EPA)	NA	27.6	27.6	65-SW04-01	1/2	0	0
		Copper	1300(7) (EPA)	NA	41.1	41.1	65-SW04-01	1/2	0	NA
		Iron	300(6) (EPA)	575.67	348	7890	65-SW04-01	2/2	2	1

Notes:

Concentrations are presented in µg/Kg for organics in soil and sediment and in µg/L for all water contaminants (ppb); metal concentrations for soil and sediment are presented in mg/Kg (ppm).

NA - Not applicable

ND - Not detected

PAH - Polynuclear aromatic hydrocarbon

(3) Secondary MCL for aluminum, iron, and zinc; if MCL is a range, the lower concetration is used for comparison.

(4) Federal Action Level for lead.

(5) Positive contaminant detections in surface water are compared to freshwater screening values for human health (water and organism consumption): EPA Region IV Water Quality Standards (EPA), 1995 or NCWQS (NC) (Criteria I), and upstream background concentrations from the White Oak River Basin Study (Criteria II).

(6) EPA Water Quality Criteria, 1991, Human Health Published Criteria (water and organism consumption).

(7) EPA Water Quality Criteria, 1991, Human Health Recalculated Values using IRIS, as of 9/[illegible] (water and organism consumption).

TABLE 4-3 (Continued)

SUMMARY OF SITE CONTAMINATION
SITE 65 - ENGINEER AREA DUMP
REMEDIAL INVESTIGATION, CTO-0312
MCB, CAMP LEJEUNE, NORTH CAROLINA

Media	Fraction	Detected Contaminants	Comparison Criteria		Site Contamination					
			Criteria I	Criteria II	Min. Conc.	Max. Conc.	Location(s) of Maximum Concentration	Detection Frequency	Number of Detections Above Comparison Criteria I	Number of Detections Above Comparison Criteria II
Surface Water	Metals (continued)	Lead	50(6) (EPA)	NA	45.8	45.8	65-SW04-01	1/2	0	NA
		Manganese	200 (NC)	NA	57.3	88.4	65-SW04-01	2/2	0	0
		Vanadium	NA	NA	26.2	26.2	65-SW04-01	1/2	NA	NA
		Zinc	NA	NA	33.6	144	65-SW04-01	2/2	NA	NA
Sediment(8)	Volatiles	Acetone	NA	NA	190J	450J	65-SD05-612	4/4	NA	NA
		Chloroform	NA	NA	79J	79J	65-SD04-06	1/4	NA	NA
		2-Butanone	NA	NA	72J	94J	65-SD04-06	4/4	NA	NA
		Carbon Tetrachloride	NA	NA	13J	18J	65-SD04-06	2/4	NA	NA
		Tetrachloroethene	NA	NA	6J	15J	65-SD04-06	2/4	NA	NA
		Toluene	NA	NA	3J	7J	65-SD04-06	3/4	NA	NA
	Semivolatiles	Di-n-Butylphthalate	NA	NA	940J	1,600J	65-SD04-612	4/4	NA	NA
	Pesticides	beta-BHC	NA	2.51	8.3NJ	8.3NJ	65-SD04-612	1/4	NA	1
		4,4'-DDE	NA	2.42	18J	19NJ	65-SD05-06	2/4	NA	2
		4,4'-DDD	NA	1.57	76J	84J	65-SD05-06	2/4	NA	2
	Metals	Vanadium	NA	17.57	40.5	40.5	65-SD04-06	1/4	NA	1
		Zinc	NA	27.38	7.9	280J	65-SD04-06	4/4	NA	3

Notes:

Concentrations are presented in µg/Kg for organics in soil and sediment and in µg/L for all water contaminants (ppb); metal concentrations for soil and sediment are presented in mg/Kg (ppm).

NA - Not applicable

ND - Not detected

PAH - Polynuclear aromatic hydrocarbon

(6) EPA Water Quality Criteria, 1991, Human Health Published Criteria (water and organism consumption).

(7) EPA Water Quality Criteria, 1991, Human Health Recalculated Values using IRIS, as of 9/90 (water and organism consumption).

(8) There are no established criteria for sediment, therefore Criteria I is NA. Criteria II is the average upstream background sediment concetration from the White Oak River Basin Study.

TABLE 4-3 (Continued)

SUMMARY OF SITE CONTAMINATION
SITE 65 - ENGINEER AREA DUMP
REMEDIAL INVESTIGATION, CTO-0312
MCB, CAMP LEJEUNE, NORTH CAROLINA

Media	Fraction	Detected Contaminants	Comparison Criteria		Site Contamination					
			Criteria I	Criteria II	Min. Conc.	Max. Conc.	Location(s) of Maximum Concentration	Detection Frequency	Number of Detections Above Comparison Criteria I	Number of Detections Above Comparison Criteria II
Fish Tissue(9)	Volatiles	Acetone	14000	NA	5600J	7900J	65-FS05-LB01F	2/4	0	NA
	Pesticides	4,4'-DDD	13	NA	5.7J	5.7J	65-FS04-BG01F	1/4	0	NA
	Metals	Aluminum	140	NA	0.99	0.99	65-FS05-LB01F	1/4	0	NA
		Barium	9.5	NA	0.21J	0.21	65-FS04-BG01F	1/4	0	NA
		Copper	5	NA	0.46	0.49	65-FS04-BG01F	2/4	0	NA
		Manganese	0.68	NA	0.092J	0.45J	65-FS04-BG01F	4/4	0	NA
		Mercury	0.041	NA	0.051J	0.3J	65-FS05-LB01F	4/4	4	NA
		Selenium	0.68	NA	0.14	0.22	65-FS04-BG01F	4/4	0	NA
		Thallium	NA	NA	0.11	0.11	65-FS05-RS01F	3/4	NA	NA
		Zinc	41	NA	5.8J	8.4J	65-FS05-BG01F	4/4	0	NA

Notes:

Concentrations are presented in µg/Kg (ppb) for organics in fish tissue and in mg/Kg for metals in fish tissue (ppm).

NA - Not applicable

(9) Organics and Metals in fish tissue (fillet samples) are compared to EPA Region III risk based Contaminent of Concern (COC) Screeing Values for human injestion of fish (Criteria I). There is no Criteria II.

TABLE 4-4

DETECTED ORGANICS IN SURFACE SOILS
SITE 65 - ENGINEER AREA DUMP
REMEDIAL INVESTIGATION, CTO-0312
MCB, CAMP LEJEUNE, NORTH CAROLINA

LOCATION	65-DW01-00	65-DW02-00	65-DW04-00	65-MW05-00	65-MW06-00	65-MW07-00
DATE COLLECTED	04/10/95	04/09/95	04/05/95	04/05/95	04/08/95	04/04/95
DEPTH	0-1'	0-1'	0-1'	0-1'	0-1'	0-1'
VOLATILES (ug/Kg)						
METHYLENE CHLORIDE	ND	ND	ND	ND	ND	2 J
ACETONE	ND	ND	ND	10 J	ND	ND
TRICHLOROETHENE	ND	ND	ND	ND	ND	ND
TOLUENE	ND	ND	2 J	1 J	ND	2 J
ETHYLBENZENE	ND	ND	ND	ND	ND	ND
TOTAL XYLENES	3 J	ND	ND	ND	ND	ND
SEMIVOLATILES (ug/Kg)						
ACENAPHTHENE	130 J	ND	ND	ND	ND	ND
2,4-DINITROPHENOL	ND	ND	150 J	ND	ND	ND
DIBENZOFURAN	58 J	ND	ND	ND	ND	ND
FLUORENE	100 J	ND	ND	ND	ND	ND
PHENANTHRENE	860	ND	ND	ND	ND	ND
ANTHRACENE	190 J	ND	ND	ND	ND	ND
CARBAZOLE	180 J	ND	ND	ND	ND	ND
DI-N-BUTYL PHTHALATE	ND	ND	ND	ND	ND	ND
FLUORANTHENE	830	ND	ND	ND	ND	ND
PYRENE	850	ND	ND	ND	ND	ND
BENZO(A)ANTHRACENE	510	ND	ND	ND	ND	ND
CHRYSENE	470	ND	ND	ND	ND	ND
BIS(2-ETHYLHEXYL)PHTHALATE	64 J	ND	ND	60 J	87 J	51 J
BENZO(B)FLUORANTHENE	360 J	ND	ND	ND	ND	ND
BENZO(K)FLUORANTHENE	510	ND	ND	ND	ND	ND
BENZO(A)PYRENE	400	ND	ND	ND	ND	ND
INDENO(1,2,3-CD)PYRENE	310 J	ND	ND	ND	ND	ND
DIBENZO(A,H)ANTHRACENE	150 J	ND	ND	ND	ND	ND
BENZO(G,H,I)PERYLENE	250 J	ND	ND	ND	ND	ND

NOTES: ug/Kg - Microgram per kilogram
J - value is estimated
ND - Not Detected
All samples were analyzed for TCL Organics per CLP Method.
Only those parameters with positive detections are included on this table. For complete results refer to Appendix O.

TABLE 4-4 (continued)

DETECTED ORGANICS IN SURFACE SOILS
SITE 65 - ENGINEER AREA DUMP
REMEDIAL INVESTIGATION, CTO-0312
MCB, CAMP LEJEUNE, NORTH CAROLINA

LOCATION	65-DW01-00	65-DW02-00	65-DW04-00	65-MW05-00	65-MW06-00	65-MW07-00
DATE COLLECTED	04/10/95	04/09/95	04/05/95	04/05/95	04/08/95	04/04/95
DEPTH	0-1'	0-1'	0-1'	0-1'	0-1'	0-1'
PESTICIDE/PCBS (ug/Kg)						
HEPTACHLOR EPOXIDE	ND	ND	ND	ND	ND	2.3
4,4'-DDE	27	ND	ND	ND	ND	83 J
ENDOSULFAN II	ND	3.9 J	ND	3.8 J	ND	ND
4,4'-DDD	3.8 J	ND	ND	ND	ND	5 J
4,4'-DDT	ND	ND	ND	ND	ND	56 J
PCB-1260	52 J	ND	ND	ND	ND	ND

NOTES: ug/Kg - Microgram per kilogram
J - value is estimated
ND - Not Detected
All samples were analyzed for TCL Organics per CLP Method.
Only those parameters with positive detections are included on this table. For complete results refer to Appendix O.

TABLE 4-4 (continued)

DETECTED ORGANICS IN SURFACE SOILS
SITE 65 - ENGINEER AREA DUMP
REMEDIAL INVESTIGATION, CTO-0312
MCB, CAMP LEJEUNE, NORTH CAROLINA

LOCATION	65-SB06-00	65-SB07-00	65-SB08-00	65-SB09-00	65-SB10-00	65-SB11-00
DATE COLLECTED	04/10/95	04/08/95	04/11/95	04/08/95	04/08/95	04/08/95
DEPTH	0-1'	0-1'	0-1'	0-1'	0-1'	0-1'
VOLATILES (ug/Kg)						
METHYLENE CHLORIDE	ND	ND	ND	ND	ND	ND
ACETONE	ND	ND	ND	ND	ND	ND
TRICHLOROETHENE	1 J	ND	ND	ND	ND	ND
TOLUENE	ND	ND	ND	ND	ND	ND
ETHYLBENZENE	ND	1 J	ND	ND	ND	ND
TOTAL XYLENES	ND	5 J	ND	ND	ND	ND
SEMIVOLATILES (ug/Kg)						
ACENAPHTHENE	ND	ND	ND	ND	ND	ND
2,4-DINITROPHENOL	ND	ND	ND	ND	ND	ND
DIBENZOFURAN	ND	ND	ND	ND	ND	ND
FLUORENE	ND	ND	ND	ND	ND	ND
PHENANTHRENE	74 J	ND	ND	ND	ND	ND
ANTHRACENE	ND	ND	ND	ND	ND	ND
CARBAZOLE	ND	ND	ND	ND	ND	ND
DI-N-BUTYL PHTHALATE	390 J	ND	260 J	ND	ND	ND
FLUORANTHENE	210 J	ND	ND	ND	ND	ND
PYRENE	150 J	ND	ND	ND	ND	ND
BENZO(A)ANTHRACENE	110 J	ND	ND	ND	ND	ND
CHRYSENE	110 J	ND	ND	ND	ND	ND
BIS(2-ETHYLHEXYL)PHTHALATE	72 J	73 J	ND	57 J	48 J	74 J
BENZO(B)FLUORANTHENE	96 J	ND	ND	ND	ND	ND
BENZO(K)FLUORANTHENE	120 J	ND	ND	ND	ND	ND
BENZO(A)PYRENE	100 J	ND	ND	ND	ND	ND
INDENO(1,2,3-CD)PYRENE	88 J	ND	ND	ND	ND	ND
DIBENZO(A,H)ANTHRACENE	45 J	ND	ND	ND	ND	ND
BENZO(G,H,I)PERYLENE	70 J	ND	ND	ND	ND	ND

NOTES: ug/Kg - Microgram per kilogram
J - value is estimated
ND - Not Detected
All samples were analyzed for TCL Organics per CLP Method.
Only those parameters with positive detections are included on this table. For complete results refer to Appendix O.

TABLE 4-4 (continued)

DETECTED ORGANICS IN SURFACE SOILS
SITE 65 - ENGINEER AREA DUMP
REMEDIAL INVESTIGATION, CTO-0312
MCB, CAMP LEJEUNE, NORTH CAROLINA

LOCATION	65-SB06-00	65-SB07-00	65-SB08-00	65-SB09-00	65-SB10-00	65-SB11-00
DATE COLLECTED	04/10/95	04/08/95	04/11/95	04/08/95	04/08/95	04/08/95
DEPTH	0-1'	0-1'	0-1'	0-1'	0-1'	0-1'
PESTICIDE/PCBS (ug/Kg)						
HEPTACHLOR EPOXIDE	ND	ND	ND	ND	ND	ND
4,4'-DDE	47	77 J	ND	ND	ND	4.3
ENDOSULFAN II	ND	ND	ND	ND	ND	ND
4,4'-DDD	17 J	ND	ND	31 J	59 J	16 J
4,4'-DDT	ND	56 J	ND	ND	ND	ND
PCB-1260	ND	ND	ND	ND	ND	ND

NOTES: ug/Kg - Microgram per kilogram
J - value is estimated
ND - Not Detected
All samples were analyzed for TCL Organics per CLP Method.
Only those parameters with positive detections are included on this table. For complete results refer to Appendix O.

TABLE 4-4 (continued)

DETECTED ORGANICS IN SURFACE SOILS
SITE 65 ENGINEER AREA DUMP
REMEDIAL INVESTIGATION, CTO-0312
MCB, CAMP LEJEUNE, NORTH CAROLINA

LOCATION	65-SB12-00
DATE COLLECTED	04/17/95
DEPTH	0-1'
VOLATILES (ug/Kg)	
METHYLENE CHLORIDE	2 J
ACETONE	ND
TRICHLOROETHENE	ND
TOLUENE	ND
ETHYLBENZENE	ND
TOTAL XYLENES	ND
SEMIVOLATILES (ug/Kg)	
ACENAPHTHENE	ND
2,4-DINITROPHENOL	ND
DIBENZOFURAN	ND
FLUORENE	ND
PHENANTHRENE	59 J
ANTHRACENE	ND
CARBAZOLE	ND
DI-N-BUTYL PHTHALATE	ND
FLUORANTHENE	130 J
PYRENE	260 J
BENZO(A)ANTHRACENE	76 J
CHRYSENE	70 J
BIS(2-ETHYLHEXYL)PHTHALATE	ND
BENZO(B)FLUORANTHENE	89 J
BENZO(K)FLUORANTHENE	ND
BENZO(A)PYRENE	ND
INDENO(1,2,3-CD)PYRENE	ND
DIBENZO(A,H)ANTHRACENE	ND
BENZO(G,H,I)PERYLENE	ND

NOTES: ug/Kg - Microgram per kilogram
J - value is estimated
ND - Not Detected
All samples were analyzed for TCL Organics per CLP Method.
Only those parameters with positive detections are included on this table. For complete results refer to Appendix O.

TABLE 4-4 (continued)

DETECTED ORGANICS IN SURFACE SOILS
SITE 65 ENGINEER AREA DUMP
REMEDIAL INVESTIGATION, CTO-0312
MCB, CAMP LEJEUNE, NORTH CAROLINA

LOCATION	65-SB12-00
DATE COLLECTED	04/17/95
DEPTH	0-1'
PESTICIDE/PCBS (ug/Kg)	
HEPTACHLOR EPOXIDE	ND
4,4'-DDE	75
ENDOSULFAN II	ND
4,4'-DDD	20 J
4,4'-DDT	25
PCB-1260	ND

NOTES: ug/Kg - Microgram per kilogram
J - value is estimated
ND - Not Detected
All samples were analyzed for TCL Organics per CLP Method.
Only those parameters with positive detections are included on this table. For complete results refer to Appendix O.

TABLE 4-5

DETECTED METALS IN SURFACE SOILS
SITE 65 - ENGINEER AREA DUMP
REMEDIAL INVESTIGATION, CTO-0312
MCB, CAMP LEJEUNE, NORTH CAROLINA

LOCATION	65-DW01-00	65-DW02-00	65-DW04-00	65-MW05-00	65-MW06-00	65-MW07-00
DATE_STAMP	04/10/95	04/09/95	04/05/95	04/05/95	04/08/95	04/04/95
DEPTH	0-1'	0-1'	0-1'	0-1'	0-1'	0-1'
MOISTURE	10.74	9.43	10.17	10.34	15.45	11.66
ANALYTES (mg/Kg)						
ALUMINUM	5040	1350	773	1050	3190	1520
BARIUM	36.3	5.4	6.9	6.2	6.8	19.2
CALCIUM	806	176	79.3	243	367	3460
CHROMIUM	8.6	2.3	ND	2.4	4.1	2.3
COPPER	55.6	2.5	ND	ND	3.3	ND
IRON	7470 J	773 J	509	1020	1300 J	684
LEAD	178 J	7.7 J	2	3.7	7.3 J	8.6
MAGNESIUM	169	32.4	30.3	42.8	88.1	82.5
MANGANESE	163 J	7.9 J	9.6	8.2	8 J	7.1
NICKEL	4.6	ND	ND	ND	ND	ND
POTASSIUM	ND	ND	ND	ND	ND	ND
SODIUM	51.3	ND	ND	ND	ND	56.3
THALLIUM	ND	ND	ND	ND	ND	ND
VANADIUM	12	ND	ND	2.8	3.4	ND
ZINC	377 J	12.2 J	ND	5.3	13.8 J	ND

NOTES: ug/Kg - Microgram per kilogram
J - Value is estimated
ND - Not Detected
All samples were analyzed for TAL Metals per CLP Method.
Only those parameters with positive detections are included on this table. For complete results refer to Appendix O.

TABLE 4-5 (continued)

DETECTED METALS IN SURFACE SOILS
SITE 65 - ENGINEER AREA DUMP
REMEDIAL INVESTIGATION, CTO-0312
MCB, CAMP LEJEUNE, NORTH CAROLINA

LOCATION	65-SB06-00	65-SB07-00	65-SB08-00	65-SB09-00	65-SB10-00	65-SB11-00
DATE_STAMP	04/10/95	04/08/95	04/11/95	04/08/95	04/08/95	04/08/95
DEPTH	0-1'	0-1'	0-1'	0-1'	0-1'	0-1'
MOISTURE	19.19	23.14	7.48	11.86	13.86	18.31
ANALYTES (mg/Kg)						
ALUMINUM	2140	1490	656	2830	4700	4110
BARIUM	17.5	6.8	2.7	10.9	11.5	9.9
CALCIUM	542	168	121	554	514	470
CHROMIUM	4.6	3	ND	4.6	6.8	6.3
COPPER	51	6	ND	15	10	9
IRON	3600	890 J	597	2110 J	2010 J	2050 J
LEAD	94.5	8.8 J	2.5	40.9 J	20.4 J	15.4 J
MAGNESIUM	55	52	28.5	97.1	187	143
MANGANESE	119	6.9 J	2.9	19.1	19.3 J	17.6 J
NICKEL	ND	ND	ND	ND	ND	ND
POTASSIUM	ND	ND	ND	ND	ND	248
SODIUM	ND	ND	ND	ND	ND	ND
THALLIUM	ND	ND	ND	ND	2.3	ND
VANADIUM	7.2	2.9	ND	3.2	5.1	4.8
ZINC	190	9 J	3.7	39.7 J	33.2 J	24 J

NOTES: ug/Kg - Microgram per kilogram
J - Value is estimated
ND - Not Detected
All samples were analyzed for TAL Metals per CLP Method.
Only those parameters with positive detections are included on this table. For complete results refer to Appendix O.

TABLE 4-5 (continued)

DETECTED METALS IN SURFACE SOILS
SITE 65 - ENGINEER AREA DUMP
REMEDIAL INVESTIGATION, CTO-0312
MCB, CAMP LEJEUNE, NORTH CAROLINA

LOCATION	65-SB12-00
DATE_STAMP	04/17/95
DEPTH	0-1'
MOISTURE	9.13
ANALYTES (mg/Kg)	
ALUMINUM	2940
BARIUM	12.6
CALCIUM	729
CHROMIUM	4.8
COPPER	42.3
IRON	16400
LEAD	117
MAGNESIUM	54.8
MANGANESE	75.4
NICKEL	5.7
POTASSIUM	ND
SODIUM	ND
THALLIUM	ND
VANADIUM	5.1
ZINC	110

NOTES: ug/Kg - Microgram per kilogram
J - Value is estimated
ND - Not Detected
All samples were analyzed for TAL Metals per CLP Method.
Only those parameters with positive detections are included on this table. For complete results refer to Appendix O.

TABLE 4-6

DETECTED ORGANICS IN SUBSURFACE SOILS
SITE 65 - ENGINEER AREA DUMP
REMEDIAL INVESTIGATION, CTO-312
MCB, CAMP LEJEUNE, NORTH CAROLINA

LOCATION	65-DW01-04	65-DW02-02	65-DW04-05	65-MW05-04	65-MW06-03	65-MW07-05
DATE COLLECTED	04/10/95	04/09/95	04/05/95	04/05/95	04/08/95	04/04/95
DEPTH	7-9'	3-5'	9-11'	7-9'	5-7'	9-11'
VOLATILES (ug/Kg)						
ACETONE	ND	380	180	10 J	ND	ND
2-BUTANONE	ND	ND	ND	ND	ND	ND
TRICHLOROETHENE	ND	ND	ND	ND	ND	ND
TOLUENE	ND	ND	ND	ND	ND	ND
TOTAL XYLENES	3 J	1 J	ND	ND	1 J	ND
SEMIVOLATILES (ug/Kg)						
ACENAPHTHENE	ND	ND	ND	ND	ND	ND
FLUORENE	ND	ND	ND	ND	ND	ND
PHENANTHRENE	ND	ND	ND	ND	ND	ND
ANTHRACENE	ND	ND	ND	ND	ND	ND
CARBAZOLE	ND	ND	ND	ND	ND	ND
DI-N-BUTYL PHTHALATE	ND	ND	ND	ND	ND	ND
FLUORANTHENE	ND	ND	ND	ND	ND	ND
PYRENE	ND	ND	ND	ND	ND	ND
BENZO(A)ANTHRACENE	ND	ND	ND	ND	ND	ND
CHRYSENE	ND	ND	ND	ND	ND	ND
BIS(2-ETHYLHEXYL)PHTHALATE	370	65 J	ND	96 J	49 J	61 J
BENZO(B)FLUORANTHENE	ND	ND	ND	ND	ND	ND
BENZO(K)FLUORANTHENE	ND	ND	ND	ND	ND	ND
BENZO(A)PYRENE	ND	ND	ND	ND	ND	ND
INDENO(1,2,3-CD)PYRENE	ND	ND	ND	ND	ND	ND
BENZO(G,H,I)PERYLENE	ND	ND	ND	ND	ND	ND
PESTICIDE/PCBS (ug/Kg)						
4,4'-DDE	8.8 J	ND	ND	ND	ND	ND
4,4'-DDD	4.4 J	ND	ND	ND	ND	ND
ENDRIN ALDEHYDE	9.4 J	ND	ND	ND	ND	ND
ALPHA CHLORDANE	ND	ND	ND	ND	ND	ND
GAMMA CHLORDANE	ND	ND	ND	ND	ND	ND

NOTES: ug/Kg - Microgram per kilogram
J - Value is estimated
ND - Not Detected
All samples were analyzed for TCL Organics per CLP Method.
Only those parameters with positive detections are included on this table. For complete results refer to Appendix O.

TABLE 4-6 (continued)

DETECTED ORGANICS IN SUBSURFACE SOILS
SITE 65 - ENGINEER AREA DUMP
REMEDIAL INVESTIGATION, CTO-312
MCB, CAMP LEJEUNE, NORTH CAROLINA

LOCATION	65-SB06-02	65-SB07-04	65-SB08-04	65-SB09-02	65-SB10-01	65-SB11-04
DATE COLLECTED	04/10/95	04/08/95	04/11/95	04/08/95	04/08/95	04/08/95
DEPTH	3-5'	7-9'	7-9'	3-5'	1-3'	7-9'
VOLATILES (ug/Kg)						
ACETONE	ND	79	ND	31	26	37
2-BUTANONE	ND	ND	ND	4 J	2 J	ND
TRICHLOROETHENE	ND	2 J	ND	ND	ND	ND
TOLUENE	ND	ND	ND	ND	ND	1 J
TOTAL XYLENES	ND	ND	ND	2 J	3 J	ND
SEMIVOLATILES (ug/Kg)						
ACENAPHTHENE	97 J	ND	ND	ND	ND	ND
FLUORENE	110 J	ND	ND	ND	ND	ND
PHENANTHRENE	1200	ND	ND	ND	ND	ND
ANTHRACENE	290 J	ND	ND	ND	ND	ND
CARBAZOLE	120 J	ND	ND	ND	ND	ND
DI-N-BUTYL PHTHALATE	340 J	ND	240 J	ND	ND	ND
FLUORANTHENE	1900	ND	ND	ND	ND	ND
PYRENE	1400	ND	ND	ND	ND	ND
BENZO(A)ANTHRACENE	900	ND	ND	ND	ND	ND
CHRYSENE	800	ND	ND	ND	ND	ND
BIS(2-ETHYLHEXYL)PHTHALATE	110 J	90 J	95 J	81 J	93 J	110 J
BENZO(B)FLUORANTHENE	710	ND	ND	ND	ND	ND
BENZO(K)FLUORANTHENE	620	ND	ND	ND	ND	ND
BENZO(A)PYRENE	680	ND	ND	ND	ND	ND
INDENO(1,2,3-CD)PYRENE	480 J	ND	ND	ND	ND	ND
BENZO(G,H,I)PERYLENE	360 J	ND	ND	ND	ND	ND
PESTICIDE/PCBS (ug/Kg)						
4,4'-DDE	41	ND	ND	13	4.6	ND
4,4'-DDD	9.1 J	ND	ND	68 J	76 J	ND
ENDRIN ALDEHYDE	ND	ND	ND	ND	ND	ND
ALPHA CHLORDANE	8.3 J	ND	ND	ND	ND	ND
GAMMA CHLORDANE	7.5 J	ND	ND	ND	ND	ND

NOTES: ug/Kg - Microgram per kilogram
J - Value is estimated
ND - Not Detected
All samples were analyzed for TCL Organics per CLP Method.
Only those parameters with positive detections are included on this table. For complete results refer to Appendix O.

TABLE 4-6 (continued)

DETECTED ORGANICS IN SUBSURFACE SOILS
SITE 65 - ENGINEER AREA DUMP
REMEDIAL INVESTIGATION, CTO-312
MCB, CAMP LEJEUNE, NORTH CAROLINA

LOCATION	65-SB12-05
DATE COLLECTED	04/17/95
DEPTH	9-11'
VOLATILES (ug/Kg)	
ACETONE	ND
2-BUTANONE	ND
TRICHLOROETHENE	ND
TOLUENE	ND
TOTAL XYLENES	ND
SEMIVOLATILES (ug/Kg)	
ACENAPHTHENE	ND
FLUORENE	ND
PHENANTHRENE	ND
ANTHRACENE	ND
CARBAZOLE	ND
DI-N-BUTYL PHTHALATE	ND
FLUORANTHENE	ND
PYRENE	ND
BENZO(A)ANTHRACENE	ND
CHRYSENE	ND
BIS(2-ETHYLHEXYL)PHTHALATE	ND
BENZO(B)FLUORANTHENE	ND
BENZO(K)FLUORANTHENE	ND
BENZO(A)PYRENE	ND
INDENO(1,2,3-CD)PYRENE	ND
BENZO(G,H,I)PERYLENE	ND
PESTICIDE/PCBS (ug/Kg)	
4,4'-DDE	ND
4,4'-DDD	ND
ENDRIN ALDEHYDE	ND
ALPHA CHLORDANE	ND
GAMMA CHLORDANE	ND

NOTES: ug/Kg - Microgram per kilogram
J - Value is estimated
ND - Not Detected
All samples were analyzed for TCL Organics per CLP Method.
Only those parameters with positive detections are included on this table. For complete results refer to Appendix O.

TABLE 4-7

DETECTED METALS IN SUBSURFACE SOILS
SITE 65 - ENGINEER AREA DUMP
REMEDIAL INVESTIGATION, CTO-0312
MCB, CAMP LEJEUNE, NORTH CAROLINA

LOCATION	65-DW01-04	65-DW02-02	65-DW04-05	65-MW05-04	65-MW06-03	65-MW07-05
DATE COLLECTED	04/10/95	04/09/95	04/05/95	04/05/95	04/08/95	04/04/95
DEPTH	7-9'	3-5'	9-11'	7-9'	5-7'	9-11'
MOISTURE	13.13	16.36	4.68	14.25	9.72	13.65
ANALYTES (mg/Kg)						
ALUMINUM	4840	1020	4560	1380	3790	1050
ARSENIC	ND	ND	ND	ND	ND	ND
BARIUM	35.5	5.6	10.9	2.7	3.3	3.5
CADMIUM	ND	ND	ND	ND	ND	ND
CALCIUM	1040	320	111	ND	208	90.6
CHROMIUM	10.8	ND	5.7	2.8	2.6	ND
COPPER	55.8	ND	ND	ND	ND	ND
IRON	9120 J	1250 J	925	686	236 J	412
LEAD	159 J	2.9 J	2.7	1.6	2.1 J	1.7
MAGNESIUM	159	23.8	192	83.1	102	67.1
MANGANESE	127 J	4.8 J	5.6	3	3.2 J	2
NICKEL	8.9	ND	ND	ND	ND	ND
POTASSIUM	ND	ND	ND	ND	ND	ND
SODIUM	ND	ND	69.9	ND	ND	ND
THALLIUM	ND	ND	ND	ND	ND	ND
VANADIUM	9.8	ND	4.1	3.1	ND	ND
ZINC	302 J	4.2 J	ND	ND	2.5 J	ND

NOTES: mg/Kg - Milligram per kilogram
J - Value is estimated
ND - Not Detected
All samples were analyzed for TAL Metals per CLP Method.
Only those parameters with positive detection are included on this table. For complete results refer to appendix O.

TABLE 4-7 (continued)

DETECTED METALS IN SUBSURFACE SOILS
SITE 65 - ENGINEER AREA DUMP
REMEDIAL INVESTIGATION, CTO-0312
MCB, CAMP LEJEUNE, NORTH CAROLINA

LOCATION	65-SB06-02	65-SB07-04	65-SB08-04	65-SB09-02	65-SB10-01	65-SB11-04
DATE COLLECTED	04/10/95	04/08/95	04/11/95	04/08/95	04/08/95	04/08/95
DEPTH	3-5'	7-9'	7-9'	3-5'	1-3'	7-9'
MOISTURE	19.19	26.15	19.45	10.99	12.23	15.06
ANALYTES (mg/Kg)						
ALUMINUM	4340	10600	3190	5730	4720	6440
ARSENIC	3.3	2.8	ND	ND	ND	ND
BARIUM	38.3	17.5	6.4	16.4	11.6	9.4
CADMIUM	1.3	ND	ND	ND	ND	ND
CALCIUM	1350	49.8	103	628	511	219
CHROMIUM	10.4	17.3	7.3	7.8	6.4	7.7
COPPER	478	ND	ND	11.5	12.2	ND
IRON	31300	8890 J	7850	2450 J	2610 J	1570 J
LEAD	539	6.9 J	3.6	24.6 J	19.1 J	3.4 J
MAGNESIUM	180	410	223	201	183	309
MANGANESE	471	3.7 J	2.7	21.1 J	15.1 J	3.4 J
NICKEL	243	ND	ND	ND	ND	ND
POTASSIUM	ND	453	292	253	ND	284
SODIUM	63.9	130	50.8	ND	ND	ND
THALLIUM	4.2	ND	ND	ND	ND	ND
VANADIUM	11.1	27.2	10.5	5	5.9	6.2
ZINC	764	7.8 J	5.3	44.7 J	41.7 J	15.2 J

NOTES: mg/Kg - Milligram per kilogram
J - Value is estimated
ND - Not Detected
All samples were analyzed for TAL Metals per CLP Method.
Only those parameters with positive detection are included on this table. For complete results refer to appendix O.

TABLE 4-7 (continued)

DETECTED METALS IN SUBSURFACE SOILS
SITE 65 - ENGINEER AREA DUMP
REMEDIAL INVESTIGATION, CTO-0312
MCB, CAMP LEJEUNE, NORTH CAROLINA

LOCATION	65-SB12-05
DATE COLLECTED	04/17/95
DEPTH	9-11'
MOISTURE	10.3
ANALYTES (mg/Kg)	
ALUMINUM	5190
ARSENIC	ND
BARIUM	10.1
CADMIUM	ND
CALCIUM	587
CHROMIUM	4.8
COPPER	ND
IRON	1010
LEAD	3.1
MAGNESIUM	122
MANGANESE	4.9
NICKEL	ND
POTASSIUM	ND
SODIUM	ND
THALLIUM	ND
VANADIUM	3.5
ZINC	5.5

NOTES: mg/Kg - Milligram per kilogram
J - Value is estimated
ND - Not Detected
All samples were analyzed for TAL Metals per CLP Method.
Only those parameters with positive detection are included on this table. For complete results refer to appendix O.

TABLE 4-8

DETECTED ORGANICS IN SUBSURFACE SOILS (TEST PITS)
SITE 65 - ENGINEER AREA DUMP
REMEDIAL INVESTIGATION, CTO-0312
MCB, CAMP LEJEUNE, NORTH CAROLINA

LOCATION	65-TP01	65-TP02	65-TP04	65-TP05	65-TP06	65-TP07
DATE SAMPLED	05/07/95	05/08/95	05/07/95	05/07/95	05/08/95	05/07/95
VOLATILES (ug/Kg)						
ACETONE	12	46	25	210	9 J	7 J
CARBON DISULFIDE	ND	ND	2 J	ND	ND	ND
2-BUTANONE	ND	ND	ND	29	ND	ND
SEMIVOLATILES (ug/Kg)						
NAPHTHALENE	ND	ND	ND	ND	ND	55 J
2-METHYLNAPHTHALENE	ND	ND	ND	ND	ND	60 J
ACENAPHTHENE	ND	ND	ND	ND	ND	94 J
DIBENZOFURAN	ND	ND	ND	ND	ND	42 J
PHENANTHRENE	ND	ND	ND	ND	ND	150 J
DI-N-BUTYL PHTHALATE	280 J	250 J	200 J	160 J	210 J	270 J
FLUORANTHENE	ND	ND	ND	ND	ND	230 J
PYRENE	ND	ND	ND	ND	ND	190 J
BENZO(A)ANTHRACENE	ND	ND	ND	ND	ND	100 J
CHRYSENE	ND	ND	ND	ND	ND	110 J
BIS(2-ETHYLHEXYL)PHTHALATE	ND	37 J	ND	49 J	39 J	230 J
BENZO(B)FLUORANTHENE	ND	ND	ND	ND	ND	96 J
BENZO(K)FLUORANTHENE	ND	ND	ND	ND	ND	110 J
BENZO(A)PYRENE	ND	ND	ND	ND	ND	69 J
BENZO(G,H,I)PERYLENE	ND	ND	ND	ND	ND	67 J
PESTICIDE/PCBS (ug/Kg)						
ENDOSULFAN I	ND	ND	ND	3.1 J	ND	ND
4,4'-DDE	ND	28	45 J	38 J	ND	43 J
4,4'-DDD	ND	7.3 J	140	340 J	ND	110
4,4'-DDT	ND	15	31	9.6	ND	40
GAMMA CHLORDANE	ND	ND	3.1 J	ND	ND	3 J

NOTES: ug/Kg - Microgram per kilogram
J - Value is estimated
ND - Not Detected
TP - Sample was collected from a test pit excavation.
All samples were analyzed for TCL Organics per CLP Methods.
Only those samples with positive detections are included on this table . For complete results refer to Appendix O.

TABLE 4-9

DETECTED METALS IN SUBSURFACE SOILS (TEST PITS)
SITE 65 - ENGINEER AREA DUMP
REMEDIAL INVESTIGATION, CTO-0312
MCB, CAMP LEJEUNE, NORTH CAROLINA

LOCATION	65-TP01	65-TP02	65-TP04	65-TP05	65-TP06	65-TP07
DATE SAMPLED	05/07/95	05/08/95	05/07/95	05/07/95	05/08/95	05/07/95
ANALYTES (mg/Kg)						
ALUMINUM	2750	4740	5030	5730	2590	3680
ANTIMONY	ND	ND	ND	ND	ND	11.8
ARSENIC	ND	ND	2.6	ND	ND	ND
BARIUM	4.2	9.9	21.6	34.7	6.4	31.8
CADMIUM	ND	ND	1.3	ND	ND	ND
CALCIUM	259	439	847	1270	130	1230
CHROMIUM	ND	4.4	8.5	6.6	3.2	8.2
COBALT	ND	ND	ND	ND	ND	11.5
COPPER	ND	7.7	61.4	29.4	ND	672
IRON	571	1010	4290	3640	992	9170
LEAD	3.7	12.1	129	59.2	4.9	210
MAGNESIUM	57.7	80.7	193	223	82.1	136
MANGANESE	10.1	11.5	132	60.2	13.3	223
NICKEL	ND	ND	ND	ND	ND	4.8
SELENIUM	ND	ND	ND	ND	ND	1.5
SILVER	ND	ND	ND	ND	ND	4.2
SODIUM	ND	ND	ND	110	ND	ND
VANADIUM	ND	3.4	8.9	5.3	3.5	9.1
ZINC	11.4	30.6	480	158	10.1	418

NOTES: ug/Kg - Microgram per kilogram
ND - Not Detected
TP - Sample was collected from a test pit excavation.
All samples were analyzed for TAL Metals per CLP Methods.
Only those samples with positive detections are included on this table. For complete results refer to Appendix O.

TABLE 4-10

DETECTED ORGANICS IN GROUNDWATER
SITE 65 - ENGINEER AREA DUMP
REMEDIAL INVESTIGATION, CTO-0312
MCB, CAMP LEJEUNE, NORTH CAROLINA

LOCATION	65-DW01-01	65-DW02-01	65-DW02-02	65-DW04-01	65-MW01-01	65-MW02-01	65-MW03-01
DATE COLLECTED	05/08/95	05/09/95	05/18/95	05/16/95	05/08/95	05/09/95	05/09/95
VOLATILES (ug/L)							
METHYLENE CHLORIDE	ND	1 J	ND	ND	ND	1 J	1 J
ACETONE	ND	5 J	5 J	ND	ND	5 J	7 J
CARBON DISULFIDE	ND	ND	ND	ND	ND	ND	ND
1,2-DICHLOROETHANE	2 J	2 J	ND	ND	2 J	ND	2 J
2-BUTANONE	ND	ND	ND	ND	ND	ND	1 J
SEMIVOLATILES (ug/L)							
NAPHTHALENE	ND	ND	ND	3 J	ND	ND	ND
DI-N-BUTYL PHTHALATE	ND	3 J	ND	ND	ND	ND	2 J
BIS(2-ETHYLHEXYL)PHTHALATE	1 J	4 J	ND	ND	1 J	ND	2 J

NOTES: ug/L - Microgram per liter
J - Value is estimated
ND - Not Detected
DW - Sample was collected from a deep well (ie, upper portion of Castle Hayne Aquifer).
MW - Sample was collected from a shallow well (ie, surficial aquifer).
All samples were analyzed for TCL Organics per CLP Methods.
Only those samples with positive detections are included on this table. For complete results refer to Appendix O.

TABLE 4-10 (continued)

DETECTED ORGANICS IN GROUNDWATER
SITE 65 - ENGINEER AREA DUMP
REMEDIAL INVESTIGATION, CTO-0312
MCB, CAMP LEJEUNE, NORTH CAROLINA

LOCATION	65-MW04-01	65-MW05-01	65-MW06-01	65-MW07-01
DATE COLLECTED	05/16/95	05/09/95	05/09/95	05/09/95
VOLATILES (ug/L)				
METHYLENE CHLORIDE	ND	1 J	2 J	1 J
ACETONE	ND	5 J	7 J	5 J
CARBON DISULFIDE	5 J	ND	ND	ND
1,2-DICHLOROETHANE	2 J	2 J	2 J	2 J
2-BUTANONE	ND	1 J	1 J	ND
SEMIVOLATILES (ug/L)				
NAPHTHALENE	ND	ND	ND	ND
DI-N-BUTYL PHTHALATE	ND	ND	ND	6 J
BIS(2-ETHYLHEXYL)PHTHALATE	ND	ND	ND	6 J

NOTES: ug/L - Microgram per liter
J - Value is estimated
ND - Not Detected
DW - Sample was collected from a deep well (ie, upper portion of Castle Hayne Aquifer).
MW - Sample was collected from a shallow well (ie, surficial aquifer).
All samples were analyzed for TCL Organics per CLP Methods.
Only those samples with positive detections are included on this table. For complete results refer to Appendix O.

TABLE 4-11

DETECTED METALS IN GROUNDWATER
SITE 65 - ENGINEER AREA DUMP
REMEDIAL INVESTIGATION, CTO-0312
MCB, CAMP LEJEUNE, NORTH CAROLINA

LOCATION	65-DW01-01	65-DW02-01	65-DW02-02	65-DW04-01	65-MW01-01	65-MW02-01
DATE COLLECTED	05/08/95	05/09/95	05/18/95	05/16/95	05/08/95	05/09/95
ANALYTES (ug/L)						
ALUMINUM	233	ND	ND	322	ND	68.5
BARIUM	ND	33.6	32.6	17.9	54.6	27.7
CALCIUM	52000	107000	116000	33600	146000	58200
CHROMIUM	ND	ND	ND	ND	10.2	ND
COBALT	ND	40.9	52.4	ND	20.1	ND
IRON	84.4	2060	2300	557	253	6580
LEAD	ND	ND	ND	3.4	ND	ND
MAGNESIUM	2030	6120	6400	1200	16200	2470
MANGANESE	4.2	172	186	15.7	178	20.1
NICKEL	ND	53.1	59.6	ND	ND	ND
POTASSIUM	3000	2150	2340	2440	5790	1590
SODIUM	6720	11000	11500	8240	10700	6350
ZINC	19.4	27.6	58.9	31.8	19.1	20.5

NOTES: ug/L - Microgram per liter
ND - Not Detected
DW - Sample was collected from a deep well (ie, upper portion of Castle Hayne Aquifer).
MW - Sample was collected from a shallow well (ie, surficial aquifer).
All samples were analyzed for TAL Metals per CLP Methods.
Only those samples with positive detections are included on this table. For complete results refer to Appendix O.

TABLE 4-11 (continued)

DETECTED METALS IN GROUNDWATER
SITE 65 - ENGINEER AREA DUMP
REMEDIAL INVESTIGATION, CTO-0312
MCB, CAMP LEJEUNE, NORTH CAROLINA

LOCATION	65-MW03-01	65-MW04-01	65-MW05-01	65-MW06-01	65-MW07-01	65-MW01F-01
DATE COLLECTED	05/09/95	05/16/95	05/09/95	05/09/95	05/09/95	05/08/95
ANALYTES (ug/L)						
ALUMINUM	ND	121	40.3	421	138	ND
BARIUM	151	21	35.3	25.8	44.3	61.4
CALCIUM	50500	2820	21100	2700	30400	161000
CHROMIUM	10	ND	ND	ND	ND	ND
COBALT	ND	ND	ND	ND	20.4	ND
IRON	41.9	ND	232	1730	99.4	187
LEAD	ND	ND	ND	ND	ND	ND
MAGNESIUM	5160	2550	7810	2890	8160	18300
MANGANESE	6.6	3	52.8	28.7	87.8	182
NICKEL	ND	ND	ND	ND	ND	ND
POTASSIUM	3650	ND	4030	1200	7940	6220
SODIUM	5620	5880	11400	16400	9390	11900
ZINC	11	ND	22.5	17.8	14.5	ND

NOTES: ug/L - Microgram per liter
ND - Not Detected
DW - Sample was collected from a deep well (ie, upper portion of Castle Hayne Aquifer).
MW - Sample was collected from a shallow well (ie, surficial aquifer).
All samples were analyzed for TAL Metals per CLP Methods.
Only those samples with positive detections are included on this table. For complete results refer to Appendix O.

TABLE 4-12

DETECTED ORGANICS IN SURFACE WATER
SITE 65 - ENGINEER AREA DUMP
REMEDIAL INVESTIGATION, CTO-0312
MCB, CAMP LEJEUNE, NORTH CAROLINA

LOCATION	65-SW04-01	65-SW05-01
DATE COLLECTED	05/15/95	05/16/95
VOLATILES (ug/L)		
ACETONE	5 J	ND
1,2-DICHLOROETHANE	1 J	1 J

NOTES: ug/L - Microgram per liter
J - Value is estimated
ND - Not Detected
All samples were analyzed for TCL Organics per CLP Methods.
Only those parameters with positive detections are included on this table. For complete results refer to Appendix O.

TABLE 4-13

DETECTED METALS IN SURFACE WATER
SITE 65 - ENGINEER AREA DUMP
REMEDIAL INVESTIGATION, CTO-0312
MCB, CAMP LEJEUNE, NORTH CAROLINA

LOCATION	65-SW04-01	65-SW05-01
DATE COLLECTED	05/15/95	05/16/95
ANALYTES (ug/L)		
ALUMINUM	25800	ND
BARIUM	69.3	36.7
CALCIUM	12000	26800
CHROMIUM	27.6	ND
COPPER	41.1	ND
IRON	7890	348
LEAD	45.8	ND
MAGNESIUM	2060	2520
MANGANESE	88.4	57.3
POTASSIUM	2970	ND
SODIUM	3330	6320
VANADIUM	26.2	ND
ZINC	144	33.6

NOTES: ug/L - Microgram per liter
ND - Not Detected
All samples were analyzed for TAL Metals per CLP Methods.
Only those parameters with positive detections are included on this table. For complete results refer to Appendix O.

TABLE 4-14

DETECTED ORGANICS IN SEDIMENTS
SITE 65 - ENGINEER AREA DUMP
REMEDIAL INVESTIGATION, CTO-0312
MCB, CAMP LEJEUNE, NORTH CAROLINA

LOCATION	65-SD04-06	65-SD04-612	65-SD05-06	65-SD05-612
DATE COLLECTED	05/16/95	05/16/95	05/17/95	05/17/95
DEPTH	0-6"	6-12"	0-6"	6-12"
VOLATILES (ug/Kg)				
ACETONE	220 J	190 J	260 J	450 J
CHLOROFORM	79 J	ND	ND	ND
2-BUTANONE	94 J	79	72 J	88
CARBON TETRACHLORIDE	18 J	13 J	ND	ND
TETRACHLOROETHENE	15 J	6 J	ND	ND
TOLUENE	7 J	ND	6 J	3 J
SEMIVOLATILES (ug/Kg)				
DI-N-BUTYL PHTHALATE	1400 J	1600 J	1200 J	940 J
PESTICIDE/PCBS (ug/Kg)				
BETA-BHC	ND	8.3 J	ND	ND
4,4'-DDE	18 J	ND	19 J	ND
4,4'-DDD	76 J	ND	84 J	ND

NOTES: ug/Kg- Microgram per kilogram
J - Value is estimated
ND - Not Detected
All samples were analyzed for TCL Organics per CLP Methods.
Only those parameters with positive detections are included on this table. For complete results refer to Appendix O.

TABLE 4-15

DETECTED METALS IN SEDIMENTS
SITE 65 - ENGINEER AREA DUMP
REMEDIAL INVESTIGATION, CTO-0312
MCB, CAMP LEJEUNE, NORTH CAROLINA

LOCATION	65-SD04-06	65-SD04-612	65-SD05-06	65-SD05-612
DATE COLLECTED	05/16/95	05/16/95	05/17/95	05/17/95
DEPTH	0-6"	6-12"	0-6"	6-12"
ANALYTES (mg/Kg)				
ALUMINUM	37000 J	10900 J	3090	394
ANTIMONY	46.6 J	ND	ND	ND
BARIUM	110	94.2	86.1	13.6
CALCIUM	4470	2470	4640	322
CHROMIUM	43.6 J	9.8 J	ND	ND
COBALT	36.3	ND	ND	ND
COPPER	100 J	21.4 J	8.2	ND
IRON	14600 J	3250 J	985	414
LEAD	176 J	38.5 J	23.9	ND
MAGNESIUM	1140	674	ND	94.8
MANGANESE	126 J	37.4 J	38.7	25.6
POTASSIUM	1410	ND	ND	ND
SODIUM	203	177	139	ND
VANADIUM	40.5	ND	ND	ND
ZINC	280 J	56.3 J	36.5	7.9

NOTES: mg/Kg- Milligram per kilogram
J - Value is estimated
ND - Not Detected
All samples were analyzed for TAL Metals per CLP Methods.
Only those parameters with positive detections are included on this table. For complete results refer to Appendix O.

TABLE 4-16

DETECTED ORGANICS IN FISH (FILLET)
SITE 65 - ENGINEER AREA DUMP
REMEDIAL INVESTIGATION, CTO-0312
MCB, CAMP LEJEUNE, NORTH CAROLINA

SAMPLE ID	65-FS04-BG01F	65-FS05-BG01F	65-FS05-LB01F	65-FS05-RS01F
METHOD	8240	8240	8240	8240
DATE COLLECTED	05/17/95	05/16/95	05/16/95	05/16/95
VOLATILES (ug/Kg)				
ACETONE	ND	5600 J	7900 J	ND
PESTICIDE/PCBS (ug/Kg)				
4,4'-DDD	5.7 J	ND	ND	ND

NOTES: ug/Kg - Microgram per kilogram
J - Value is estimated
ND - Not Detected
All samples were analyzed for TCL Organics per CLP Methods.
Only those parameters with positive detections are included on this table. For complete results refer to Appendix O.

TABLE 4-17

DETECTED METALS IN FISH (FILLET)
SITE 65 - ENGINEER AREA DUMP
REMEDIAL INVESTIGATION, COT-0312
MCB, CAMP LEJEUNE, NORTH CAROLINA

SAMPLE ID.	65-FS04-BG01F	65-FS05-BG01F	65-FS05-LB01F	65-FS05-RS01F
METHOD	CLP	CLP	CLP	CLP
DATE COLLECTED	05/17/95	05/16/95	05/16/95	05/16/95
ANALYTES (mg/Kg)				
ALUMINUM	ND	ND	0.99	ND
BARIUM	0.21 J	ND	ND	ND
CALCIUM	2100 J	560 J	399 J	385 J
COPPER	0.49	0.46	ND	ND
MAGNESIUM	298 J	299 J	290 J	293 J
MANGANESE	0.45 J	0.22 J	0.092 J	0.14 J
MERCURY	0.22 J	0.07 J	0.3 J	0.051 J
POTASSIUM	2700 J	3220 J	3540 J	3520 J
SELENIUM	0.22	0.15	0.16	0.14
SODIUM	869	708	441	620
THALLIUM	0.11	ND	0.11	0.11
ZINC	8.1 J	8.4 J	5.8 J	8.2 J

NOTES: mg/Kg - Milligram per kilogram
J - Value is estimated
ND - Not Detected
All samples were analyzed for TAL Metals per CLP Methods.
Only those parameters with positive detections are included in this table. For complete results refer to Appendix O.

TABLE 4-18

DETECTED ORGANICS IN FISH (WHOLE BODY)
SITE 65 - ENGINEER AREA DUMP
REMEDIAL INVESTIGATION, CTO-0312
MCB, CAMP LEJEUNE, NORTH CAROLINA

SAMPLE ID.	65-FS04-BG01W	65-FS04-RS01W	65-FS05-BG01W	65-FS05-LB01W	65-FS05-RS01W
METHOD	8240	8240	8240	8240	8240
DATE COLLECTED	05/17/95	05/17/95	05/16/95	05/16/95	05/16/95
VOLATILES (ug/kg)					
METHYLENE CHLORIDE	ND	1000 J	ND	ND	ND
ACETONE	ND	ND	1400000 J	690000 J	27000
2-BUTANONE (MEK)	ND	ND	ND	ND	560 J
TOLUENE	ND	ND	ND	5000 J	ND
PESTICIDE/PCBS (ug/kg)					
4,4'-DDE	15 J	ND	ND	ND	ND
4,4'-DDD	40 J	6.9 J	ND	ND	ND

NOTES: ug/Kg - Microgram per kilogram
J - Value is estimated
ND - Not Detected
All samples were analyzed for TCL Organics per CLP Methods.
Only those parameters with positive detections are included in this table. For complete results refer to Appendix O.

TABLE 4-19

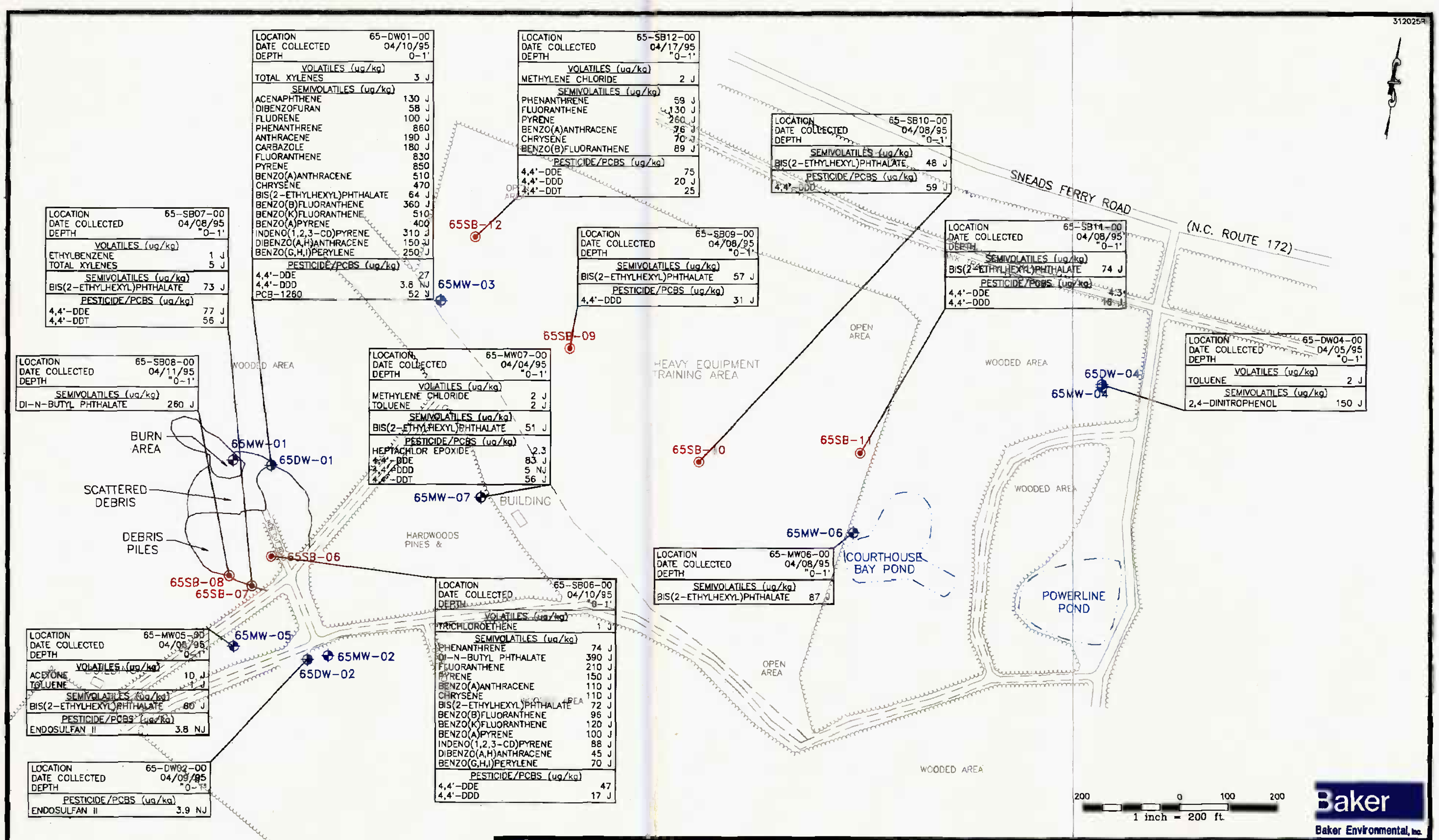
DETECTED METALS IN FISH (WHOLE BODY)
SITE 65 - ENGINEER AREA DUMP
REMEDIAL INVESTIGATION, COT-0312
MCB, CAMP LEJEUNE, NORTH CAROLINA

SAMPLE ID.	65-FS04-BG01W	65-FS04-RS01W	65-FS05-BG01W	65-FS05-LB01W	65-FS05-RS01W
METHOD	CLP	CLP	CLP	CLP	CLP
DATE COLLECTED	05/17/95	05/17/95	05/16/95	05/16/95	05/16/95
ANALYTES (mg/Kg)					
ALUMINUM	18.8 J	18 J	ND	9.6 J	ND
ANTIMONY	ND	1.5	1.1	1.4	1.1
ARSENIC	0.15 J	ND	ND	ND	ND
BARIUM	1.8 J	2.9 J	1.8 J	1.3 J	0.44 J
BERYLLIUM	ND	ND	0.028	ND	ND
CALCIUM	19600 J	42500 J	22600 J	22400 J	8840 J
COPPER	1.1	ND	ND	ND	8.6
IRON	22.9 J	24.4 J	7.8 J	26.1 J	11.8 J
LEAD	0.17	0.49	ND	ND	0.33
MAGNESIUM	557 J	951 J	538 J	593 J	370 J
MANGANESE	3.6 J	4.1 J	4.9 J	2.3 J	1 J
MERCURY	ND	0.11 J	ND	0.11 J	ND
POTASSIUM	2580 J	1850 J	2790 J	2860 J	2740 J
SELENIUM	0.42	0.17	0.16	0.33	0.32
SODIUM	1260	2400	1250	1160	992
THALLIUM	0.12	0.11	0.11	0.11	0.11
ZINC	26.2 J	31.5 J	26.6 J	14.8 J	23.3 J

NOTES: mg/Kg - Milligram per kilogram
J - Value is estimated
ND - Not Detected
All samples were analyzed for TAL Metals per CLP Methods.
Only those parameters with positive detections are included in this table. For complete results refer to Appendix O.

FIGURES

312025R



LOCATION	65-DW01-00
DATE COLLECTED	04/10/95
DEPTH	0-1'
VOLATILES (ug/kg)	
TOTAL XYLENES	3 J
SEMIVOLATILES (ug/kg)	
ACENAPHTHENE	130 J
DIBENZOFURAN	58 J
FLUDRENE	100 J
PHENANTHRENE	860
ANTHRACENE	190 J
CARBAZOLE	180 J
FLUORANTHENE	830
PYRENE	850
BENZO(A)ANTHRACENE	510
CHRYSENE	470
BIS(2-ETHYLHEXYL)PHTHALATE	64 J
BENZO(B)FLUORANTHENE	360 J
BENZO(K)FLUORANTHENE	510
BENZO(A)PYRENE	400
INDENO(1,2,3-CD)PYRENE	310 J
DIBENZO(A,H)ANTHRACENE	150 J
BENZO(G,H,I)PERYLENE	250 J
PESTICIDE/PCBS (ug/kg)	
4,4'-DDE	27
4,4'-DDD	3.8 NJ
PCB-1260	52 J

LOCATION	65-SB12-00
DATE COLLECTED	04/17/95
DEPTH	"0-1'
VOLATILES (ug/kg)	
METHYLENE CHLORIDE	2 J
SEMIVOLATILES (ug/kg)	
PHENANTHRENE	59 J
FLUORANTHENE	130 J
PYRENE	260 J
BENZO(A)ANTHRACENE	76 J
CHRYSENE	70 J
BENZO(B)FLUORANTHENE	89 J
PESTICIDE/PCBS (ug/kg)	
4,4'-DDE	75
4,4'-DDD	20 J
4,4'-DDT	25

LOCATION	65-SB10-00
DATE COLLECTED	04/08/95
DEPTH	"0-1'
SEMIVOLATILES (ug/kg)	
BIS(2-ETHYLHEXYL)PHTHALATE	48 J
PESTICIDE/PCBS (ug/kg)	
4,4'-DDD	59 J

LOCATION	65-SB07-00
DATE COLLECTED	04/08/95
DEPTH	"0-1'
VOLATILES (ug/kg)	
ETHYLBENZENE	1 J
TOTAL XYLENES	5 J
SEMIVOLATILES (ug/kg)	
BIS(2-ETHYLHEXYL)PHTHALATE	73 J
PESTICIDE/PCBS (ug/kg)	
4,4'-DDE	77 J
4,4'-DDT	56 J

LOCATION	65-SB09-00
DATE COLLECTED	04/08/95
DEPTH	"0-1'
SEMIVOLATILES (ug/kg)	
BIS(2-ETHYLHEXYL)PHTHALATE	57 J
PESTICIDE/PCBS (ug/kg)	
4,4'-DDD	31 J

LOCATION	65-SB11-00
DATE COLLECTED	04/08/95
DEPTH	"0-1'
SEMIVOLATILES (ug/kg)	
BIS(2-ETHYLHEXYL)PHTHALATE	74 J
PESTICIDE/PCBS (ug/kg)	
4,4'-DDE	4.3
4,4'-DDD	16 J

LOCATION	65-SB08-00
DATE COLLECTED	04/11/95
DEPTH	"0-1'
SEMIVOLATILES (ug/kg)	
DI-N-BUTYL PHTHALATE	260 J

LOCATION	65-MW07-00
DATE COLLECTED	04/04/95
DEPTH	"0-1'
VOLATILES (ug/kg)	
METHYLENE CHLORIDE	2 J
TOLUENE	2 J
SEMIVOLATILES (ug/kg)	
BIS(2-ETHYLHEXYL)PHTHALATE	51 J
PESTICIDE/PCBS (ug/kg)	
HEPTACHLOR EPOXIDE	2.3
4,4'-DDE	83 J
4,4'-DDD	5 NJ
4,4'-DDT	56 J

LOCATION	65-DW04-00
DATE COLLECTED	04/05/95
DEPTH	"0-1'
VOLATILES (ug/kg)	
TOLUENE	2 J
SEMIVOLATILES (ug/kg)	
2,4-DINITROPHENOL	150 J

LOCATION	65-MW06-00
DATE COLLECTED	04/08/95
DEPTH	"0-1'
SEMIVOLATILES (ug/kg)	
BIS(2-ETHYLHEXYL)PHTHALATE	87 J

LOCATION	65-SB06-00
DATE COLLECTED	04/10/95
DEPTH	"0-1'
VOLATILES (ug/kg)	
TRICHLOROETHENE	1 J
SEMIVOLATILES (ug/kg)	
PHENANTHRENE	74 J
DI-N-BUTYL PHTHALATE	390 J
FLUORANTHENE	210 J
PYRENE	150 J
BENZO(A)ANTHRACENE	110 J
CHRYSENE	110 J
BIS(2-ETHYLHEXYL)PHTHALATE	72 J
BENZO(B)FLUORANTHENE	96 J
BENZO(K)FLUORANTHENE	120 J
BENZO(A)PYRENE	100 J
INDENO(1,2,3-CD)PYRENE	88 J
DIBENZO(A,H)ANTHRACENE	45 J
BENZO(G,H,I)PERYLENE	70 J
PESTICIDE/PCBS (ug/kg)	
4,4'-DDE	47
4,4'-DDD	17 J

LOCATION	65-MW05-00
DATE COLLECTED	04/05/95
DEPTH	"0-1'
VOLATILES (ug/kg)	
ACETONE	10 J
TOLUENE	1 J
SEMIVOLATILES (ug/kg)	
BIS(2-ETHYLHEXYL)PHTHALATE	60 J
PESTICIDE/PCBS (ug/kg)	
ENDOSULFAN II	3.8 NJ

LOCATION	65-DW02-00
DATE COLLECTED	04/09/95
DEPTH	"0-1'
PESTICIDE/PCBS (ug/kg)	
ENDOSULFAN II	3.9 NJ

LEGEND

65MW-01 ⊕	MONITORING WELL LOCATION
65DW-01 ⊕	DEEP MONITORING WELL LOCATION
65SB-07 ◉	SOIL BORING LOCATION

SOURCE: BRENT A. LANIER, SURVEYING AND PLANNING, MAY 1995

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FIGURE 4-1
DETECTED ORGANICS IN SURFACE SOILS
SITE 65 - ENGINEER AREA DUMP
REMEDIAL INVESTIGATION, CTO-0312
MARINE CORPS BASE, CAMP LEJEUNE
NORTH CAROLINA

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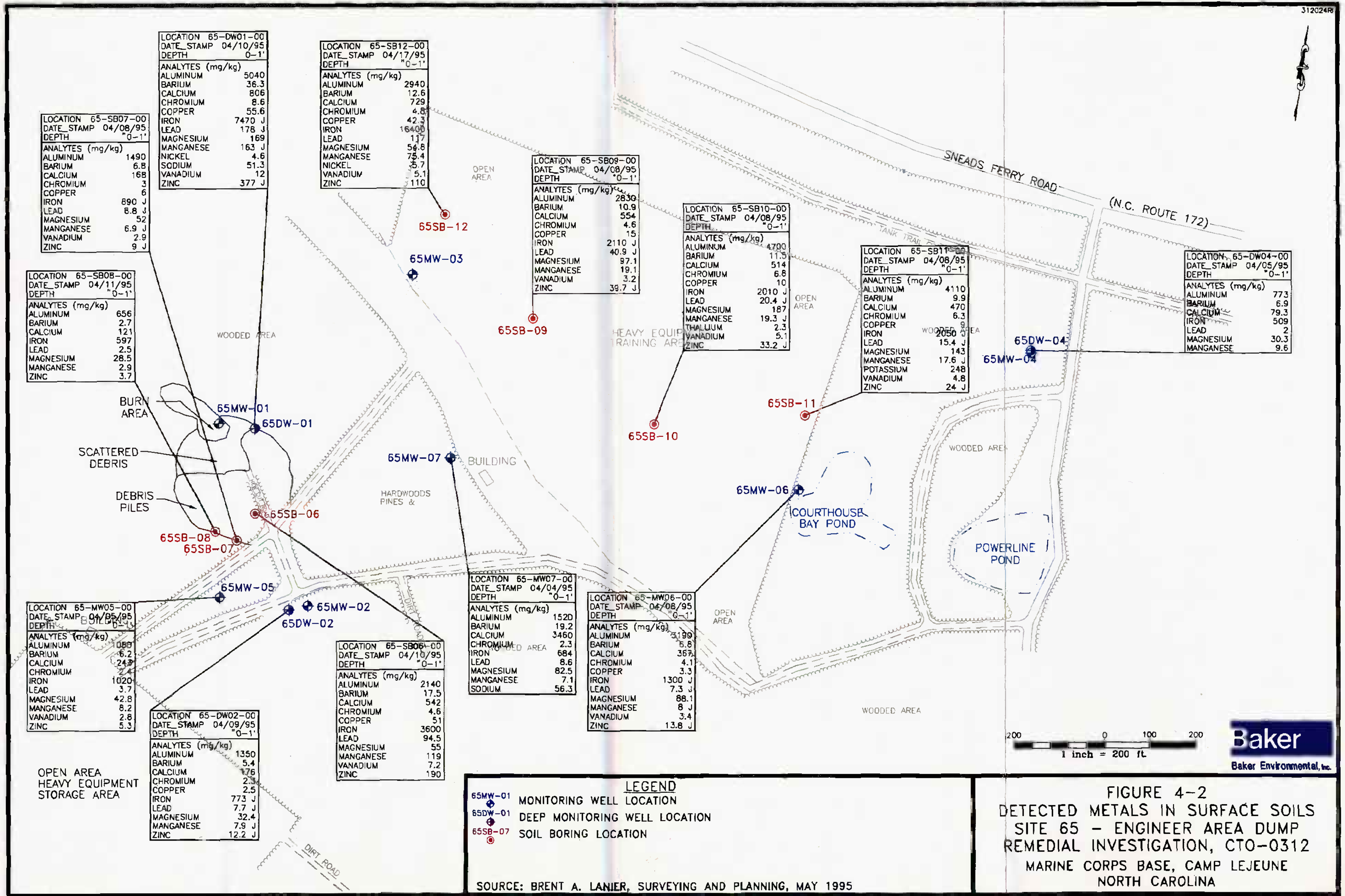

LOCATION	65-SB07-00
DATE_STAMP	04/08/95
DEPTH	"0-1'
ANALYTES (mg/kg)	
ALUMINUM	1490
BARIUM	6.8
CALCIUM	168
CHROMIUM	3
COPPER	6
IRON	890 J
LEAD	8.8 J
MAGNESIUM	52
MANGANESE	6.9 J
VANADIUM	2.9
ZINC	9 J

LOCATION	65-DW01-00
DATE_STAMP	04/10/95
DEPTH	0-1'
ANALYTES (mg/kg)	
ALUMINUM	5040
BARIUM	36.3
CALCIUM	806
CHROMIUM	8.6
COPPER	55.6
IRON	7470 J
LEAD	178 J
MAGNESIUM	169
MANGANESE	163 J
NICKEL	4.6
SODIUM	51.3
VANADIUM	12
ZINC	377 J

LOCATION	65-SB12-00
DATE_STAMP	04/17/95
DEPTH	"0-1'
ANALYTES (mg/kg)	
ALUMINUM	2940
BARIUM	12.6
CALCIUM	729
CHROMIUM	4.8
COPPER	42.3
IRON	16400
LEAD	117
MAGNESIUM	54.8
MANGANESE	75.4
NICKEL	5.7
VANADIUM	5.1
ZINC	110

LOCATION	65-SB09-00
DATE_STAMP	04/08/95
DEPTH	"0-1'
ANALYTES (mg/kg)	
ALUMINUM	2830
BARIUM	10.9
CALCIUM	554
CHROMIUM	4.6
COPPER	15
IRON	2110 J
LEAD	40.9 J
MAGNESIUM	97.1
MANGANESE	19.1
VANADIUM	3.2
ZINC	39.7 J

LOCATION	65-SB10-00
DATE_STAMP	04/08/95
DEPTH	"0-1'
ANALYTES (mg/kg)	
ALUMINUM	4700
BARIUM	11.5
CALCIUM	514
CHROMIUM	6.8
COPPER	10
IRON	2010 J
LEAD	20.4 J
MAGNESIUM	187
MANGANESE	19.3 J
THALLIUM	2.3
VANADIUM	5.1
ZINC	33.2 J

LOCATION	65-SB11-00
DATE_STAMP	04/08/95
DEPTH	"0-1'
ANALYTES (mg/kg)	
ALUMINUM	4110
BARIUM	9.9
CALCIUM	470
CHROMIUM	6.3
COPPER	9
IRON	2050 J
LEAD	15.4 J
MAGNESIUM	143
MANGANESE	17.6 J
POTASSIUM	248
VANADIUM	4.8
ZINC	24 J

LOCATION	65-DW04-00
DATE_STAMP	04/05/95
DEPTH	"0-1'
ANALYTES (mg/kg)	
ALUMINUM	773
BARIUM	6.9
CALCIUM	79.3
IRON	509
LEAD	2
MAGNESIUM	30.3
MANGANESE	9.6

LOCATION	65-SB08-00
DATE_STAMP	04/11/95
DEPTH	"0-1'
ANALYTES (mg/kg)	
ALUMINUM	656
BARIUM	2.7
CALCIUM	121
IRON	597
LEAD	2.5
MAGNESIUM	28.5
MANGANESE	2.9
ZINC	3.7

LOCATION	65-MW05-00
DATE_STAMP	04/05/95
DEPTH	"0-1'
ANALYTES (mg/kg)	
ALUMINUM	1050
BARIUM	6.2
CALCIUM	243
CHROMIUM	2.4
IRON	1020
LEAD	3.7
MAGNESIUM	42.8
MANGANESE	8.2
VANADIUM	2.8
ZINC	5.3

LOCATION	65-DW02-00
DATE_STAMP	04/09/95
DEPTH	"0-1'
ANALYTES (mg/kg)	
ALUMINUM	1350
BARIUM	5.4
CALCIUM	176
CHROMIUM	2.3
COPPER	2.5
IRON	773 J
LEAD	7.7 J
MAGNESIUM	32.4
MANGANESE	7.9 J
ZINC	12.2 J

LOCATION	65-SB06-00
DATE_STAMP	04/10/95
DEPTH	"0-1'
ANALYTES (mg/kg)	
ALUMINUM	2140
BARIUM	17.5
CALCIUM	542
CHROMIUM	4.6
COPPER	51
IRON	3600
LEAD	94.5
MAGNESIUM	55
MANGANESE	119
VANADIUM	7.2
ZINC	190

LOCATION	65-MW07-00
DATE_STAMP	04/04/95
DEPTH	"0-1'
ANALYTES (mg/kg)	
ALUMINUM	1520
BARIUM	19.2
CALCIUM	3460
CHROMIUM	2.3
IRON	684
LEAD	8.6
MAGNESIUM	82.5
MANGANESE	7.1
SODIUM	56.3

LOCATION	65-MW06-00
DATE_STAMP	04/08/95
DEPTH	"0-1'
ANALYTES (mg/kg)	
ALUMINUM	3190
BARIUM	5.8
CALCIUM	367
CHROMIUM	4.1
COPPER	3.3
IRON	1300 J
LEAD	7.3 J
MAGNESIUM	88.1
MANGANESE	8 J
VANADIUM	3.4
ZINC	13.8 J

LEGEND

65MW-01 ⊕	MONITORING WELL LOCATION
65DW-01 ⊕	DEEP MONITORING WELL LOCATION
65SB-07 ◉	SOIL BORING LOCATION

SOURCE: BRENT A. LANIER, SURVEYING AND PLANNING, MAY 1995

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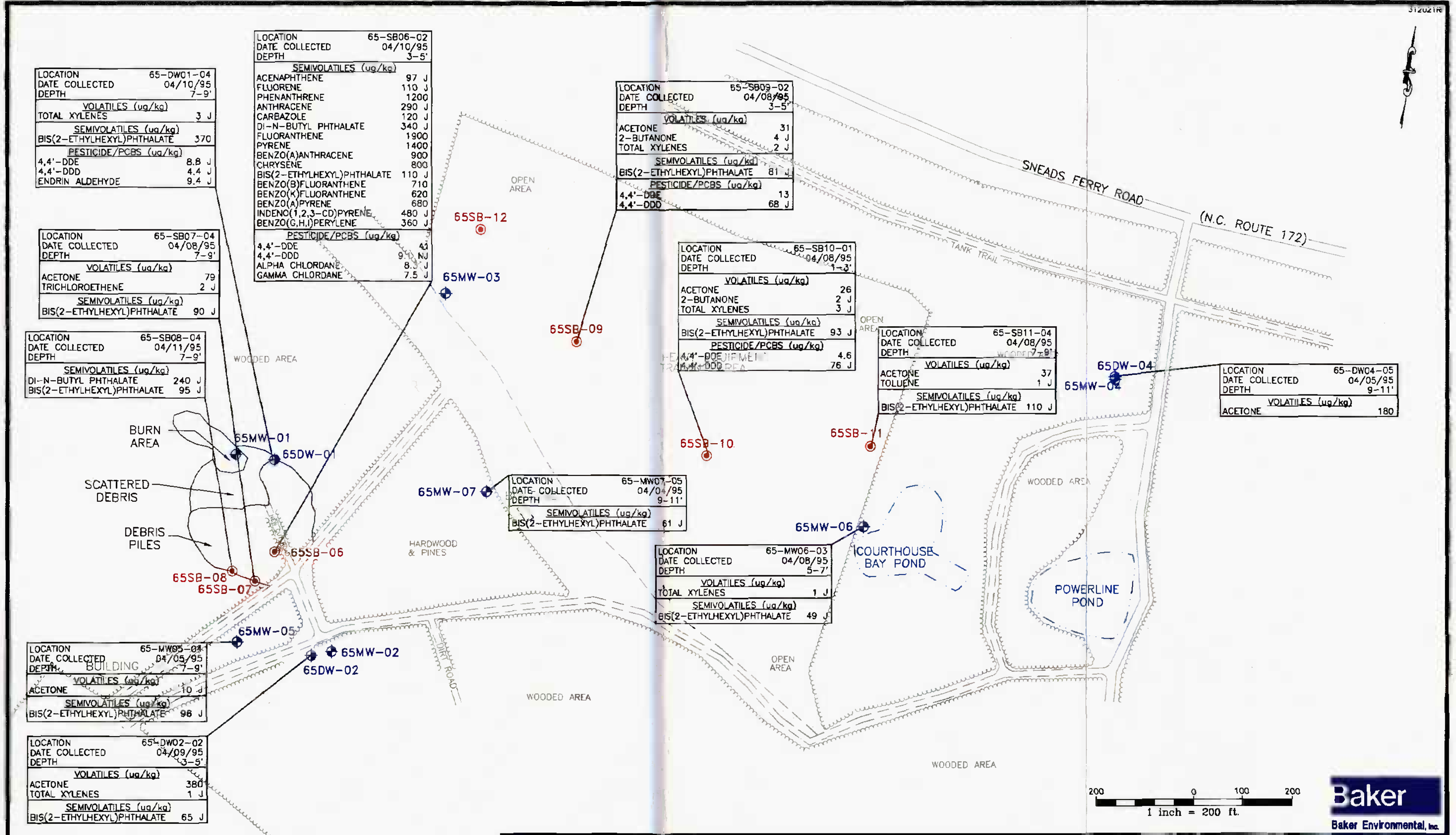
FIGURE 4-2
DETECTED METALS IN SURFACE SOILS
SITE 65 – ENGINEER AREA DUMP
REMEDIAL INVESTIGATION, CTO-0312
MARINE CORPS BASE, CAMP LEJEUNE
NORTH CAROLINA



LOCATION	65-DW01-04
DATE COLLECTED	04/10/95
DEPTH	7-9'
VOLATILES (ug/kg)	
TOTAL XYLENES	3 J
SEMIVOLATILES (ug/kg)	
BIS(2-ETHYLHEXYL)PHTHALATE	370
PESTICIDE/PCBS (ug/kg)	
4,4'-DDE	8.8 J
4,4'-DDD	4.4 J
ENDRIN ALDEHYDE	9.4 J

LOCATION	65-SB06-02
DATE COLLECTED	04/10/95
DEPTH	3-5'
SEMIVOLATILES (ug/kg)	
ACENAPHTHENE	97 J
FLUORENE	110 J
PHENANTHRENE	1200
ANTHRACENE	290 J
CARBAZOLE	120 J
DI-N-BUTYL PHTHALATE	340 J
FLUORANTHENE	1900
PYRENE	1400
BENZO(A)ANTHRACENE	900
CHRYSENE	800
BIS(2-ETHYLHEXYL)PHTHALATE	110 J
BENZO(B)FLUORANTHENE	710
BENZO(K)FLUORANTHENE	620
BENZO(A)PYRENE	680
INDENO(1,2,3-CD)PYRENE	480 J
BENZO(G,H,I)PERYLENE	360 J
PESTICIDE/PCBS (ug/kg)	
4,4'-DDE	43
4,4'-DDD	9. NJ
ALPHA CHLORDANE	8.3 J
GAMMA CHLORDANE	7.5 J

LOCATION	65-SB09-02
DATE COLLECTED	04/08/95
DEPTH	3-5'
VOLATILES (ug/kg)	
ACETONE	31
2-BUTANONE	4 J
TOTAL XYLENES	2 J
SEMIVOLATILES (ug/kg)	
BIS(2-ETHYLHEXYL)PHTHALATE	81 J
PESTICIDE/PCBS (ug/kg)	
4,4'-DDE	13
4,4'-DDD	68 J

LOCATION	65-SB07-04
DATE COLLECTED	04/08/95
DEPTH	7-9'
VOLATILES (ug/kg)	
ACETONE	79
TRICHLOROETHENE	2 J
SEMIVOLATILES (ug/kg)	
BIS(2-ETHYLHEXYL)PHTHALATE	90 J

LOCATION	65-SB10-01
DATE COLLECTED	04/08/95
DEPTH	1-3'
VOLATILES (ug/kg)	
ACETONE	26
2-BUTANONE	2 J
TOTAL XYLENES	3 J
SEMIVOLATILES (ug/kg)	
BIS(2-ETHYLHEXYL)PHTHALATE	93 J
PESTICIDE/PCBS (ug/kg)	
4,4'-DDE	4.6
4,4'-DDD	76 J

LOCATION	65-SB08-04
DATE COLLECTED	04/11/95
DEPTH	7-9'
SEMIVOLATILES (ug/kg)	
DI-N-BUTYL PHTHALATE	240 J
BIS(2-ETHYLHEXYL)PHTHALATE	95 J

LOCATION	65-SB11-04
DATE COLLECTED	04/08/95
DEPTH	7-9'
VOLATILES (ug/kg)	
ACETONE	37
TOLUENE	1 J
SEMIVOLATILES (ug/kg)	
BIS(2-ETHYLHEXYL)PHTHALATE	110 J

LOCATION	65-DW04-05
DATE COLLECTED	04/05/95
DEPTH	9-11'
VOLATILES (ug/kg)	
ACETONE	180

LOCATION	65-MW07-05
DATE COLLECTED	04/04/95
DEPTH	9-11'
SEMIVOLATILES (ug/kg)	
BIS(2-ETHYLHEXYL)PHTHALATE	61 J

LOCATION	65-MW06-03
DATE COLLECTED	04/08/95
DEPTH	5-7'
VOLATILES (ug/kg)	
TOTAL XYLENES	1 J
SEMIVOLATILES (ug/kg)	
BIS(2-ETHYLHEXYL)PHTHALATE	49 J

LOCATION	65-MW05-04
DATE COLLECTED	04/05/95
DEPTH	7-9'
VOLATILES (ug/kg)	
ACETONE	10 J
SEMIVOLATILES (ug/kg)	
BIS(2-ETHYLHEXYL)PHTHALATE	96 J

LOCATION	65-DW02-02
DATE COLLECTED	04/09/95
DEPTH	3-5'
VOLATILES (ug/kg)	
ACETONE	380
TOTAL XYLENES	1 J
SEMIVOLATILES (ug/kg)	
BIS(2-ETHYLHEXYL)PHTHALATE	65 J

LEGEND

65MW-01 ⊕	MONITORING WELL LOCATION
65DW-01 ⊕	DEEP MONITORING WELL LOCATION
65SB-07 ◉	SOIL BORING LOCATION

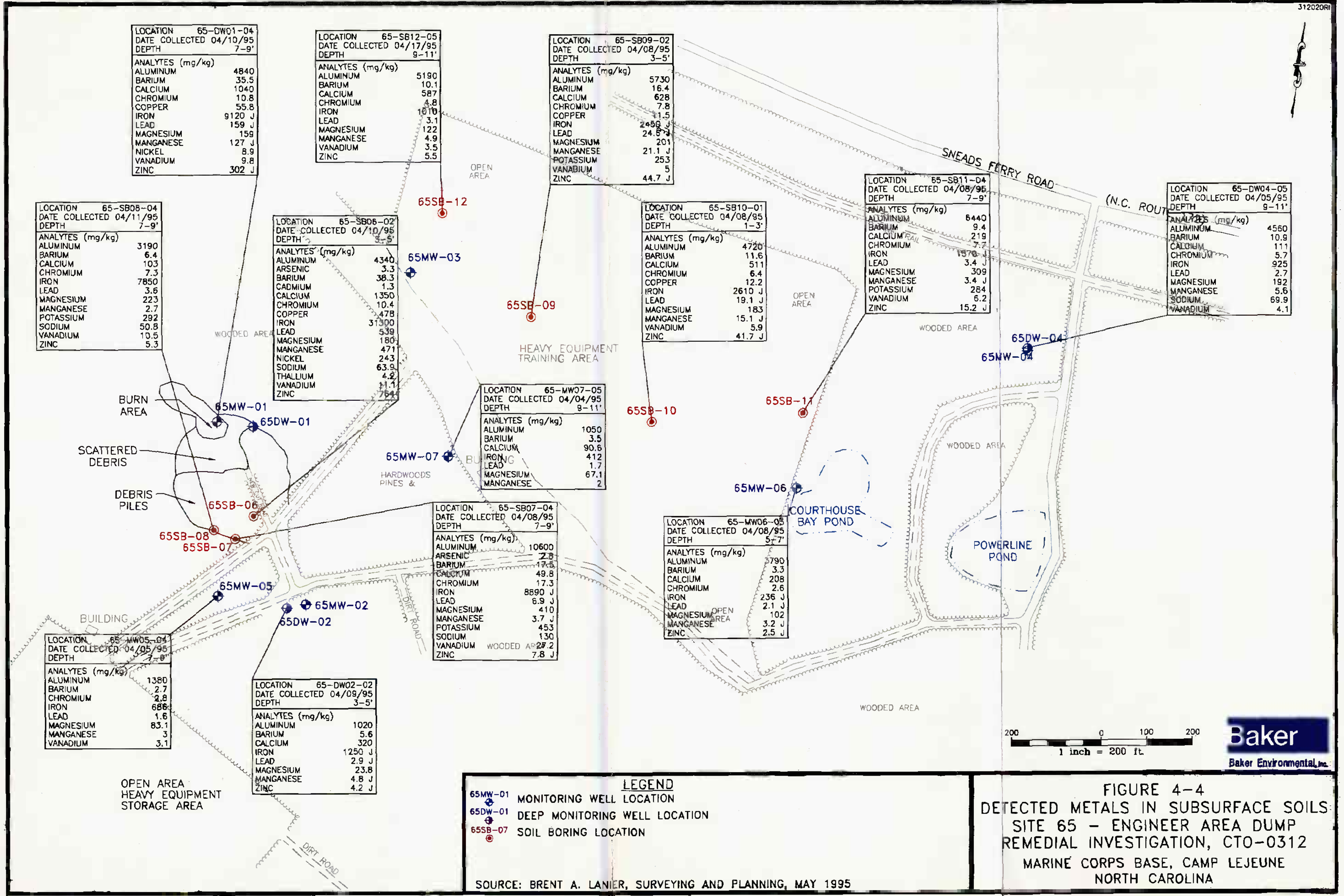
SOURCE: BRENT A. LANIER, SURVEYING AND PLANNING, MAY 1995

Baker
Baker Environmental, Inc.

FIGURE 4-3
DETECTED ORGANICS IN SUBSURFACE SOILS
SITE 65 – ENGINEER AREA DUMP
REMEDIAL INVESTIGATION, CTO-0312

MARINE CORPS BASE, CAMP LEJEUNE
NORTH CAROLINA

312020RI



LOCATION	65-DW01-04
DATE COLLECTED	04/10/95
DEPTH	7-9'
ANALYTES (mg/kg)	
ALUMINUM	4840
BARIUM	35.5
CALCIUM	1040
CHROMIUM	10.8
COPPER	55.8
IRON	9120 J
LEAD	159 J
MAGNESIUM	159
MANGANESE	127 J
NICKEL	8.9
VANADIUM	9.8
ZINC	302 J

LOCATION	65-SB12-05
DATE COLLECTED	04/17/95
DEPTH	9-11'
ANALYTES (mg/kg)	
ALUMINUM	5190
BARIUM	10.1
CALCIUM	587
CHROMIUM	4.8
IRON	1010
LEAD	3.1
MAGNESIUM	122
MANGANESE	4.9
VANADIUM	3.5
ZINC	5.5

LOCATION	65-SB09-02
DATE COLLECTED	04/08/95
DEPTH	3-5'
ANALYTES (mg/kg)	
ALUMINUM	5730
BARIUM	16.4
CALCIUM	628
CHROMIUM	7.8
COPPER	11.5
IRON	2450 J
LEAD	24.6 J
MAGNESIUM	201
MANGANESE	21.1 J
POTASSIUM	253
VANADIUM	5
ZINC	44.7 J

LOCATION	65-SB11-04
DATE COLLECTED	04/08/95
DEPTH	7-9'
ANALYTES (mg/kg)	
ALUMINUM	6440
BARIUM	9.4
CALCIUM	219
CHROMIUM	7.7
IRON	1570 J
LEAD	3.4 J
MAGNESIUM	309
MANGANESE	3.4 J
POTASSIUM	284
VANADIUM	6.2
ZINC	15.2 J

LOCATION	65-DW04-05
DATE COLLECTED	04/05/95
DEPTH	9-11'
ANALYTES (mg/kg)	
ALUMINUM	4560
BARIUM	10.9
CALCIUM	111
CHROMIUM	5.7
IRON	925
LEAD	2.7
MAGNESIUM	192
MANGANESE	5.6
SODIUM	69.9
VANADIUM	4.1

LOCATION	65-SB08-04
DATE COLLECTED	04/11/95
DEPTH	7-9'
ANALYTES (mg/kg)	
ALUMINUM	3190
BARIUM	6.4
CALCIUM	103
CHROMIUM	7.3
IRON	7850
LEAD	3.6
MAGNESIUM	223
MANGANESE	2.7
POTASSIUM	292
SODIUM	50.8
VANADIUM	10.5
ZINC	5.3

LOCATION	65-SB06-02
DATE COLLECTED	04/10/95
DEPTH	3-5'
ANALYTES (mg/kg)	
ALUMINUM	4340
ARSENIC	3.3
BARIUM	38.3
CADMIUM	1.3
CALCIUM	1350
CHROMIUM	10.4
COPPER	478
IRON	31300
LEAD	539
MAGNESIUM	180
MANGANESE	471
NICKEL	243
SODIUM	63.9
THALLIUM	4.2
VANADIUM	11.1
ZINC	764

LOCATION	65-SB10-01
DATE COLLECTED	04/08/95
DEPTH	1-3'
ANALYTES (mg/kg)	
ALUMINUM	4720
BARIUM	11.6
CALCIUM	511
CHROMIUM	6.4
COPPER	12.2
IRON	2610 J
LEAD	19.1 J
MAGNESIUM	183
MANGANESE	15.1 J
VANADIUM	5.9
ZINC	41.7 J

LOCATION	65-MW07-05
DATE COLLECTED	04/04/95
DEPTH	9-11'
ANALYTES (mg/kg)	
ALUMINUM	1050
BARIUM	3.5
CALCIUM	90.6
IRON	412
LEAD	1.7
MAGNESIUM	67.1
MANGANESE	2

LOCATION	65-SB07-04
DATE COLLECTED	04/08/95
DEPTH	7-9'
ANALYTES (mg/kg)	
ALUMINUM	10600
ARSENIC	2.8
BARIUM	17.5
CALCIUM	49.8
CHROMIUM	17.3
IRON	8890 J
LEAD	6.9 J
MAGNESIUM	410
MANGANESE	3.7 J
POTASSIUM	453
SODIUM	130
VANADIUM	27.2
ZINC	7.8 J

LOCATION	65-MW06-03
DATE COLLECTED	04/08/95
DEPTH	5-7'
ANALYTES (mg/kg)	
ALUMINUM	3790
BARIUM	3.3
CALCIUM	208
CHROMIUM	2.6
IRON	236 J
LEAD	2.1 J
MAGNESIUM	102
MANGANESE	3.2 J
ZINC	2.5 J

LOCATION	65-MW05-04
DATE COLLECTED	04/05/95
DEPTH	7-9'
ANALYTES (mg/kg)	
ALUMINUM	1380
BARIUM	2.7
CHROMIUM	2.8
IRON	686
LEAD	1.6
MAGNESIUM	83.1
MANGANESE	3
VANADIUM	3.1

LOCATION	65-DW02-02
DATE COLLECTED	04/09/95
DEPTH	3-5'
ANALYTES (mg/kg)	
ALUMINUM	1020
BARIUM	5.6
CALCIUM	320
IRON	1250 J
LEAD	2.9 J
MAGNESIUM	23.8
MANGANESE	4.8 J
ZINC	4.2 J

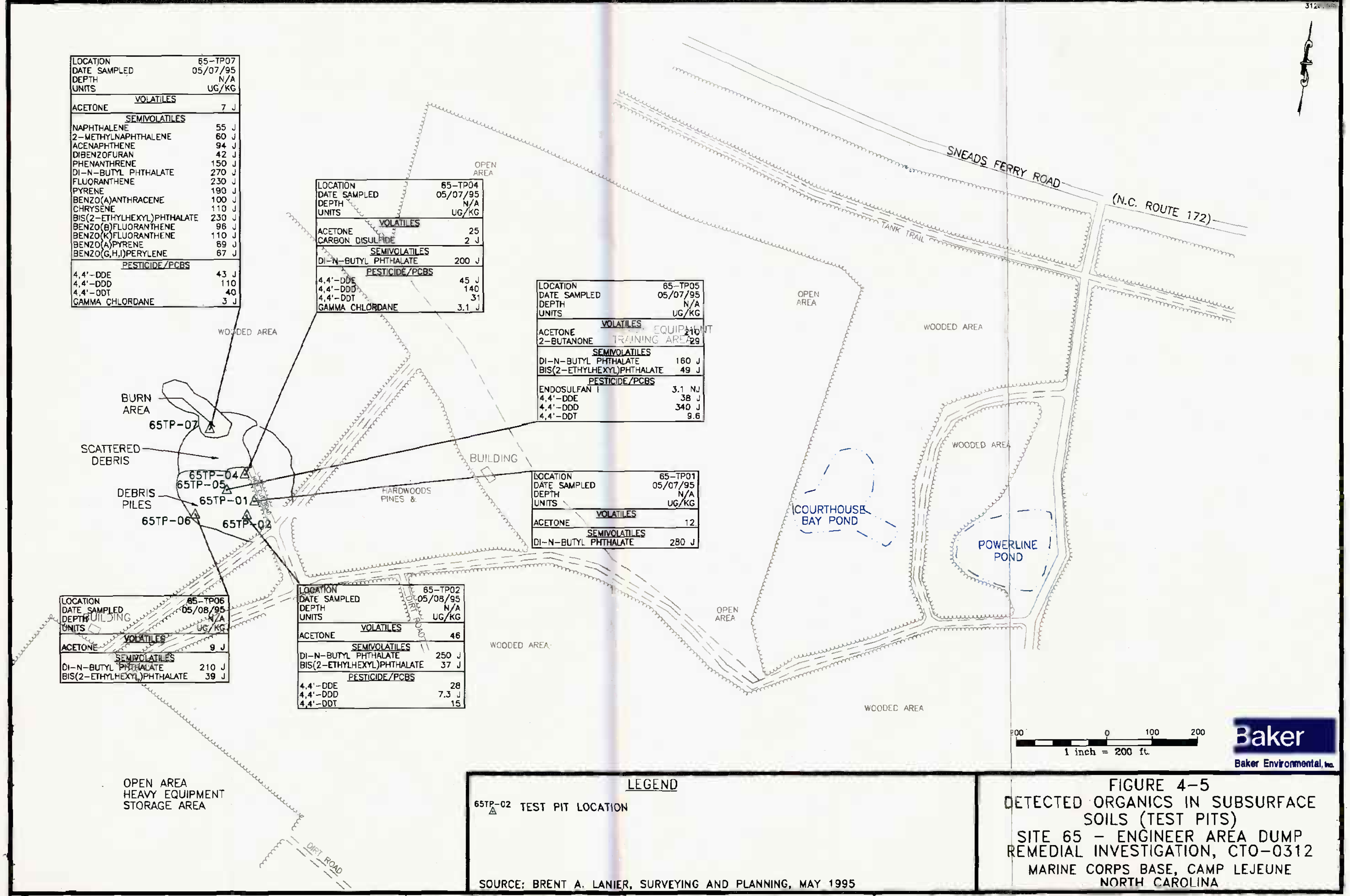
LEGEND

65MW-01 ⊕	MONITORING WELL LOCATION
65DW-01 ⊕	DEEP MONITORING WELL LOCATION
65SB-07 ⊙	SOIL BORING LOCATION

SOURCE: BRENT A. LANIER, SURVEYING AND PLANNING, MAY 1995

FIGURE 4-4
DETECTED METALS IN SUBSURFACE SOILS
SITE 65 – ENGINEER AREA DUMP
REMEDIAL INVESTIGATION, CTO-0312

MARINE CORPS BASE, CAMP LEJEUNE
NORTH CAROLINA



LOCATION	65-TP07
DATE SAMPLED	05/07/95
DEPTH	N/A
UNITS	UG/KG
VOLATILES	
ACETONE	7 J
SEMIVOLATILES	
NAPHTHALENE	55 J
2-METHYLNAPHTHALENE	60 J
ACENAPHTHENE	94 J
DIBENZOFURAN	42 J
PHENANTHRENE	150 J
DI-N-BUTYL PHTHALATE	270 J
FLUORANTHENE	230 J
PYRENE	190 J
BENZO(A)ANTHRACENE	100 J
CHRYSENE	110 J
BIS(2-ETHYLHEXYL)PHTHALATE	230 J
BENZO(B)FLUORANTHENE	96 J
BENZO(K)FLUORANTHENE	110 J
BENZO(A)PYRENE	69 J
BENZO(G,H,I)PERYLENE	67 J
PESTICIDE/PCBS	
4,4'-DDE	43 J
4,4'-DDD	110
4,4'-ODT	40
GAMMA CHLORDANE	3 J

LOCATION	65-TP04
DATE SAMPLED	05/07/95
DEPTH	N/A
UNITS	UG/KG
VOLATILES	
ACETONE	25
CARBON DISULFIDE	2 J
SEMIVOLATILES	
DI-N-BUTYL PHTHALATE	200 J
PESTICIDE/PCBS	
4,4'-DDE	45 J
4,4'-DDD	140
4,4'-DDT	31
GAMMA CHLORDANE	3.1 J

LOCATION	65-TP05
DATE SAMPLED	05/07/95
DEPTH	N/A
UNITS	UG/KG
VOLATILES	
ACETONE	210
2-BUTANONE	29
SEMIVOLATILES	
DI-N-BUTYL PHTHALATE	160 J
BIS(2-ETHYLHEXYL)PHTHALATE	49 J
PESTICIDE/PCBS	
ENDOSULFAN I	3.1 NJ
4,4'-DDE	38 J
4,4'-DDD	340 J
4,4'-DDT	9.6

LOCATION	65-TP01
DATE SAMPLED	05/07/95
DEPTH	N/A
UNITS	UG/KG
VOLATILES	
ACETONE	12
SEMIVOLATILES	
DI-N-BUTYL PHTHALATE	280 J

LOCATION	65-TP06
DATE SAMPLED	05/08/95
DEPTH	N/A
UNITS	UG/KG
VOLATILES	
ACETONE	9 J
SEMIVOLATILES	
DI-N-BUTYL PHTHALATE	210 J
BIS(2-ETHYLHEXYL)PHTHALATE	39 J

LOCATION	65-TP02
DATE SAMPLED	05/08/95
DEPTH	N/A
UNITS	UG/KG
VOLATILES	
ACETONE	46
SEMIVOLATILES	
DI-N-BUTYL PHTHALATE	250 J
BIS(2-ETHYLHEXYL)PHTHALATE	37 J
PESTICIDE/PCBS	
4,4'-DDE	28
4,4'-DDD	7.3 J
4,4'-DDT	15

LEGEND

65TP-02 △ TEST PIT LOCATION

SOURCE: BRENT A. LANIER, SURVEYING AND PLANNING, MAY 1995

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FIGURE 4-5
DETECTED ORGANICS IN SUBSURFACE SOILS (TEST PITS)
SITE 65 - ENGINEER AREA DUMP
REMEDIAL INVESTIGATION, CTO-0312
MARINE CORPS BASE, CAMP LEJEUNE
NORTH CAROLINA

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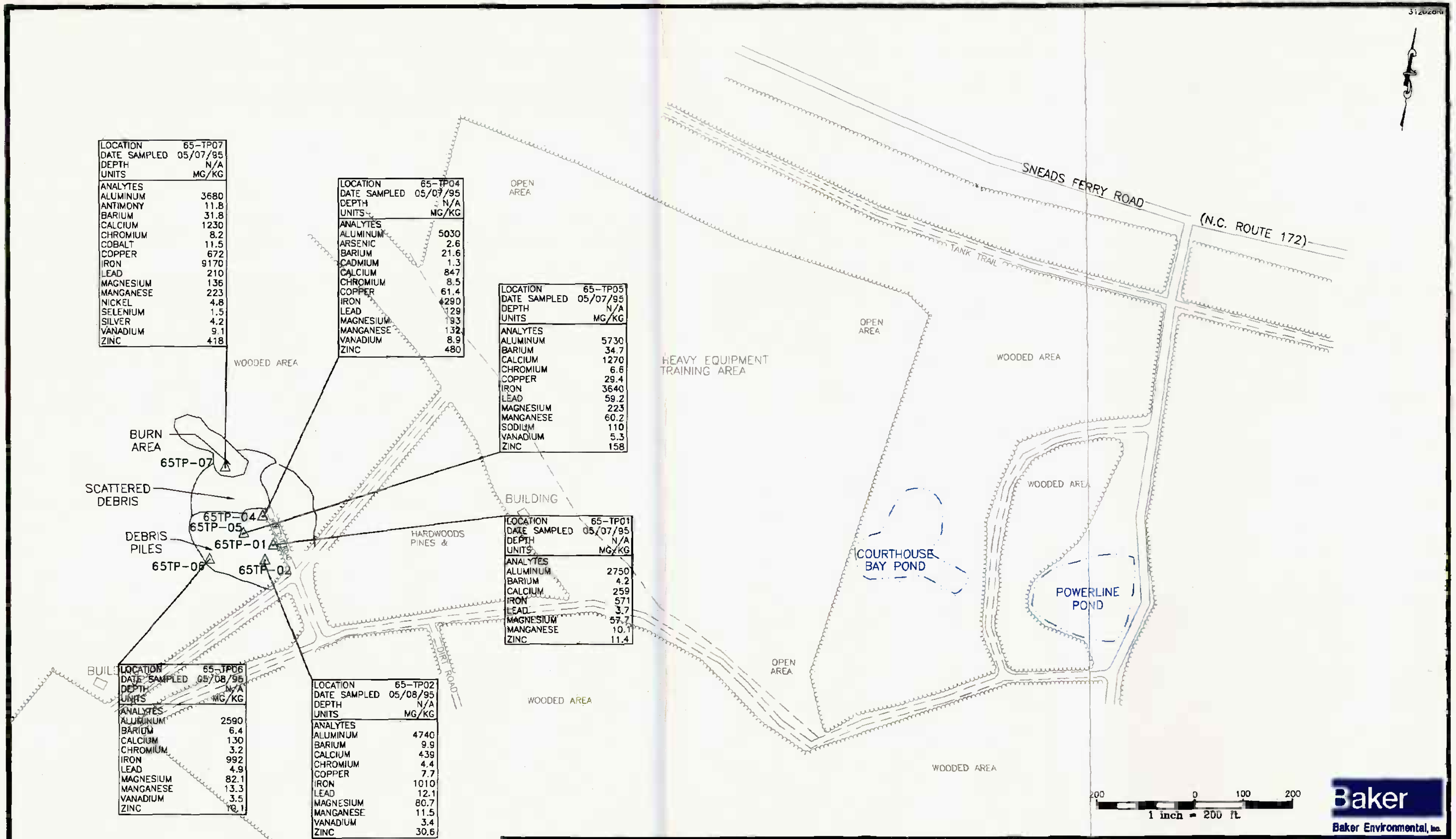

LOCATION	65-TP07
DATE SAMPLED	05/07/95
DEPTH	N/A
UNITS	MG/KG
ANALYTES	
ALUMINUM	3680
ANTIMONY	11.8
BARIUM	31.8
CALCIUM	1230
CHROMIUM	8.2
COBALT	11.5
COPPER	672
IRON	9170
LEAD	210
MAGNESIUM	136
MANGANESE	223
NICKEL	4.8
SELENIUM	1.5
SILVER	4.2
VANADIUM	9.1
ZINC	418

LOCATION	65-TP04
DATE SAMPLED	05/07/95
DEPTH	N/A
UNITS	MG/KG
ANALYTES	
ALUMINUM	5030
ARSENIC	2.6
BARIUM	21.6
CADMIUM	1.3
CALCIUM	847
CHROMIUM	8.5
COPPER	61.4
IRON	4290
LEAD	129
MAGNESIUM	193
MANGANESE	132
VANADIUM	8.9
ZINC	480

LOCATION	65-TP05
DATE SAMPLED	05/07/95
DEPTH	N/A
UNITS	MG/KG
ANALYTES	
ALUMINUM	5730
BARIUM	34.7
CALCIUM	1270
CHROMIUM	6.6
COPPER	29.4
IRON	3640
LEAD	59.2
MAGNESIUM	223
MANGANESE	60.2
SODIUM	110
VANADIUM	5.3
ZINC	158

LOCATION	65-TP01
DATE SAMPLED	05/07/95
DEPTH	N/A
UNITS	MG/KG
ANALYTES	
ALUMINUM	2750
BARIUM	4.2
CALCIUM	259
IRON	571
LEAD	3.7
MAGNESIUM	57.7
MANGANESE	10.1
ZINC	11.4

LOCATION	65-TP06
DATE SAMPLED	05/08/95
DEPTH	N/A
UNITS	MG/KG
ANALYTES	
ALUMINUM	2590
BARIUM	6.4
CALCIUM	130
CHROMIUM	3.2
IRON	992
LEAD	4.9
MAGNESIUM	82.1
MANGANESE	13.3
VANADIUM	3.5
ZINC	10.1

LOCATION	65-TP02
DATE SAMPLED	05/08/95
DEPTH	N/A
UNITS	MG/KG
ANALYTES	
ALUMINUM	4740
BARIUM	9.9
CALCIUM	439
CHROMIUM	4.4
COPPER	7.7
IRON	1010
LEAD	12.1
MAGNESIUM	80.7
MANGANESE	11.5
VANADIUM	3.4
ZINC	30.6

LEGEND

65TP-02 △ TEST PIT LOCATION

SOURCE: BRENT A. LANIER, SURVEYING AND PLANNING, MAY 1995

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FIGURE 4-6
DETECTED METALS IN SUBSURFACE SOILS (TEST PITS)
SITE 65 – ENGINEER AREA DUMP
REMEDIAL INVESTIGATION, CTO-0312
MARINE CORPS BASE, CAMP LEJEUNE
NORTH CAROLINA

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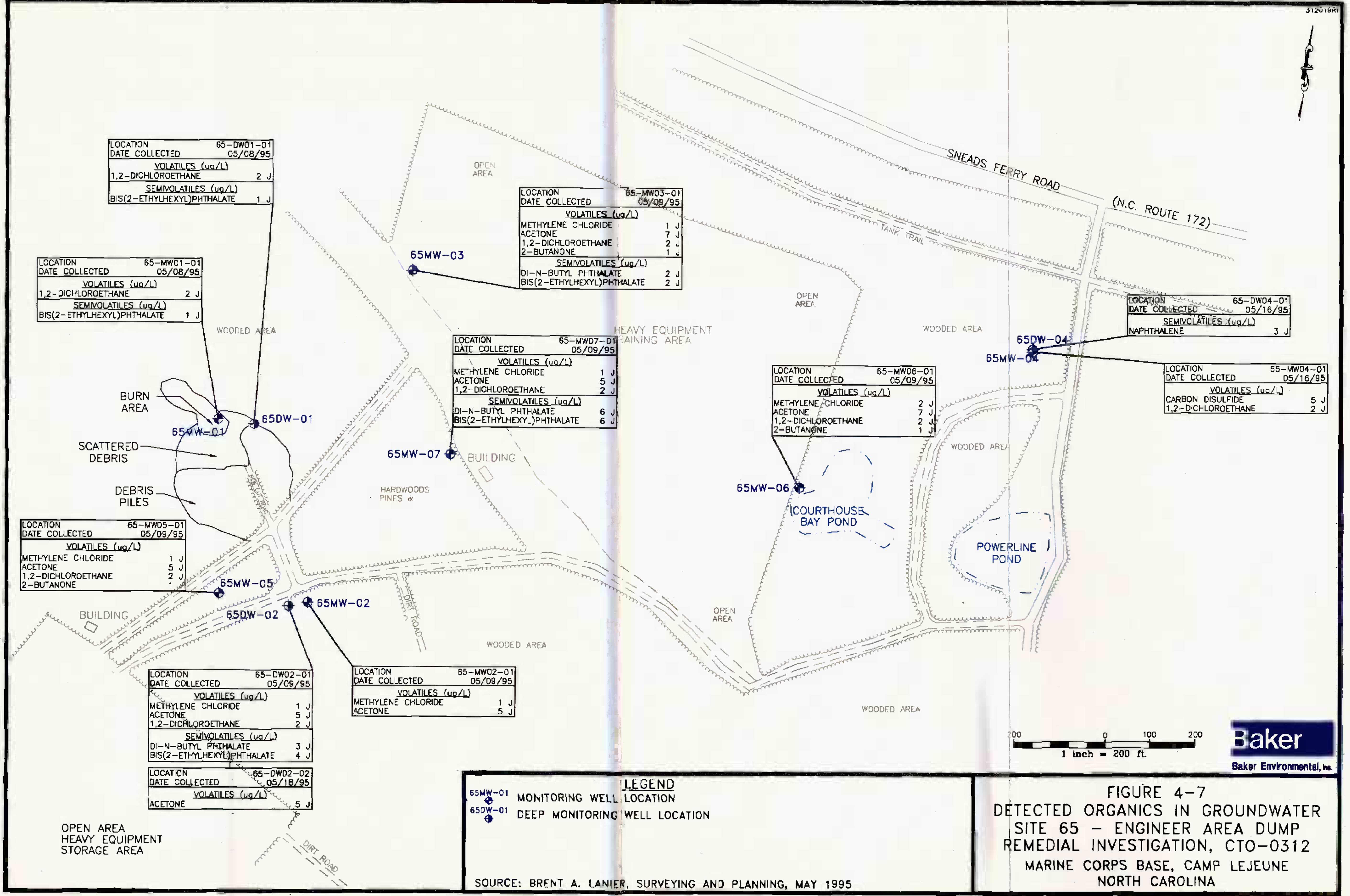

LOCATION	65-DW01-01
DATE COLLECTED	05/08/95
VOLATILES (ug/L)	
1,2-DICHLOROETHANE	2 J
SEMIVOLATILES (ug/L)	
BIS(2-ETHYLHEXYL)PHTHALATE	1 J

LOCATION	65-MW01-01
DATE COLLECTED	05/08/95
VOLATILES (ug/L)	
1,2-DICHLOROETHANE	2 J
SEMIVOLATILES (ug/L)	
BIS(2-ETHYLHEXYL)PHTHALATE	1 J

LOCATION	65-MW03-01
DATE COLLECTED	05/09/95
VOLATILES (ug/L)	
METHYLENE CHLORIDE	1 J
ACETONE	7 J
1,2-DICHLOROETHANE	2 J
2-BUTANONE	1 J
SEMIVOLATILES (ug/L)	
DI-N-BUTYL PHTHALATE	2 J
BIS(2-ETHYLHEXYL)PHTHALATE	2 J

LOCATION	65-MW07-01
DATE COLLECTED	05/09/95
VOLATILES (ug/L)	
METHYLENE CHLORIDE	1 J
ACETONE	5 J
1,2-DICHLOROETHANE	2 J
SEMIVOLATILES (ug/L)	
DI-N-BUTYL PHTHALATE	6 J
BIS(2-ETHYLHEXYL)PHTHALATE	6 J

LOCATION	65-DW04-01
DATE COLLECTED	05/16/95
SEMIVOLATILES (ug/L)	
NAPHTHALENE	3 J

LOCATION	65-MW06-01
DATE COLLECTED	05/09/95
VOLATILES (ug/L)	
METHYLENE CHLORIDE	2 J
ACETONE	7 J
1,2-DICHLOROETHANE	2 J
2-BUTANONE	1 J

LOCATION	65-MW04-01
DATE COLLECTED	05/16/95
VOLATILES (ug/L)	
CARBON DISULFIDE	5 J
1,2-DICHLOROETHANE	2 J

LOCATION	65-MW05-01
DATE COLLECTED	05/09/95
VOLATILES (ug/L)	
METHYLENE CHLORIDE	1 J
ACETONE	5 J
1,2-DICHLOROETHANE	2 J
2-BUTANONE	1

LOCATION	65-DW02-01
DATE COLLECTED	05/09/95
VOLATILES (ug/L)	
METHYLENE CHLORIDE	1 J
ACETONE	5 J
1,2-DICHLOROETHANE	2 J
SEMIVOLATILES (ug/L)	
DI-N-BUTYL PHTHALATE	3 J
BIS(2-ETHYLHEXYL)PHTHALATE	4 J

LOCATION	65-DW02-02
DATE COLLECTED	05/18/95
VOLATILES (ug/L)	
ACETONE	5 J

LOCATION	65-MW02-01
DATE COLLECTED	05/09/95
VOLATILES (ug/L)	
METHYLENE CHLORIDE	1 J
ACETONE	5 J

LEGEND

65MW-01 ⊕	MONITORING WELL LOCATION
65DW-01 ⊕	DEEP MONITORING WELL LOCATION

SOURCE: BRENT A. LANIER, SURVEYING AND PLANNING, MAY 1995

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FIGURE 4-7
DETECTED ORGANICS IN GROUNDWATER
SITE 65 – ENGINEER AREA DUMP
REMEDIAL INVESTIGATION, CTO-0312
MARINE CORPS BASE, CAMP LEJEUNE
NORTH CAROLINA

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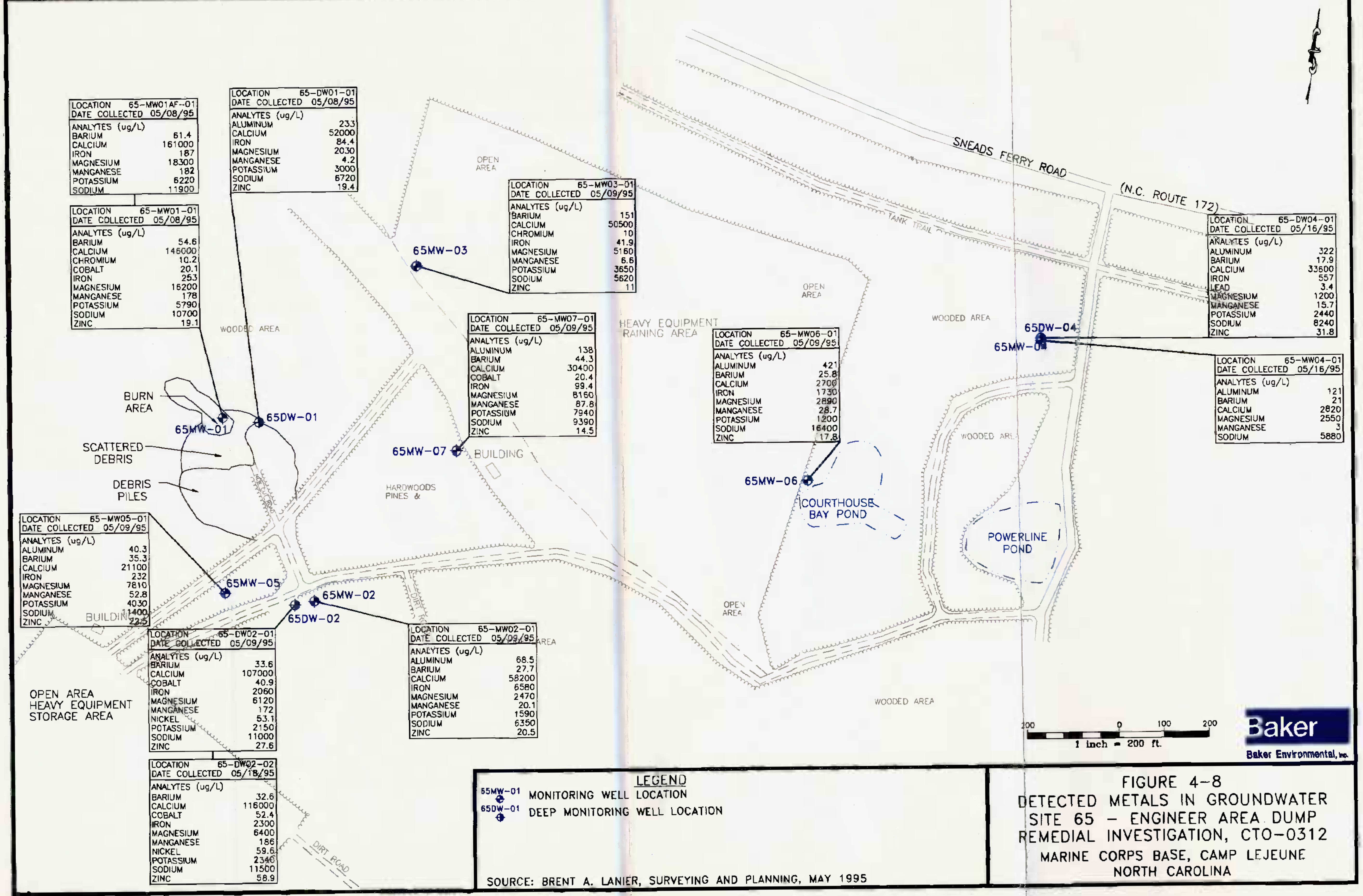

LOCATION	65-MW01AF-01
DATE COLLECTED	05/08/95
ANALYTES (ug/L)	
BARIUM	61.4
CALCIUM	161000
IRON	187
MAGNESIUM	18300
MANGANESE	182
POTASSIUM	6220
SODIUM	11900

LOCATION	65-MW01-01
DATE COLLECTED	05/08/95
ANALYTES (ug/L)	
BARIUM	54.6
CALCIUM	146000
CHROMIUM	10.2
COBALT	20.1
IRON	253
MAGNESIUM	16200
MANGANESE	178
POTASSIUM	5790
SODIUM	10700
ZINC	19.1

LOCATION	65-DW01-01
DATE COLLECTED	05/08/95
ANALYTES (ug/L)	
ALUMINUM	233
CALCIUM	52000
IRON	84.4
MAGNESIUM	2030
MANGANESE	4.2
POTASSIUM	3000
SODIUM	6720
ZINC	19.4

LOCATION	65-MW03-01
DATE COLLECTED	05/09/95
ANALYTES (ug/L)	
BARIUM	151
CALCIUM	50500
CHROMIUM	10
IRON	41.9
MAGNESIUM	5160
MANGANESE	6.6
POTASSIUM	3650
SODIUM	5620
ZINC	11

LOCATION	65-MW07-01
DATE COLLECTED	05/09/95
ANALYTES (ug/L)	
ALUMINUM	138
BARIUM	44.3
CALCIUM	30400
COBALT	20.4
IRON	99.4
MAGNESIUM	8160
MANGANESE	87.8
POTASSIUM	7940
SODIUM	9390
ZINC	14.5

LOCATION	65-MW06-01
DATE COLLECTED	05/09/95
ANALYTES (ug/L)	
ALUMINUM	421
BARIUM	25.8
CALCIUM	2700
IRON	1730
MAGNESIUM	2890
MANGANESE	28.7
POTASSIUM	1200
SODIUM	16400
ZINC	17.8

LOCATION	65-DW04-01
DATE COLLECTED	05/16/95
ANALYTES (ug/L)	
ALUMINUM	322
BARIUM	17.9
CALCIUM	33600
IRON	557
LEAD	3.4
MAGNESIUM	1200
MANGANESE	15.7
POTASSIUM	2440
SODIUM	8240
ZINC	31.8

LOCATION	65-MW04-01
DATE COLLECTED	05/16/95
ANALYTES (ug/L)	
ALUMINUM	121
BARIUM	21
CALCIUM	2820
MAGNESIUM	2550
MANGANESE	3
SODIUM	5880

LOCATION	65-MW05-01
DATE COLLECTED	05/09/95
ANALYTES (ug/L)	
ALUMINUM	40.3
BARIUM	35.3
CALCIUM	21100
IRON	232
MAGNESIUM	7810
MANGANESE	52.8
POTASSIUM	4030
SODIUM	11400
ZINC	22.5

LOCATION	65-DW02-01
DATE COLLECTED	05/09/95
ANALYTES (ug/L)	
BARIUM	33.6
CALCIUM	107000
COBALT	40.9
IRON	2060
MAGNESIUM	6120
MANGANESE	172
NICKEL	53.1
POTASSIUM	2150
SODIUM	11000
ZINC	27.6

LOCATION	65-DW02-02
DATE COLLECTED	05/18/95
ANALYTES (ug/L)	
BARIUM	32.6
CALCIUM	116000
COBALT	52.4
IRON	2300
MAGNESIUM	6400
MANGANESE	186
NICKEL	59.6
POTASSIUM	2340
SODIUM	11500
ZINC	58.9

LOCATION	65-MW02-01
DATE COLLECTED	05/09/95
ANALYTES (ug/L)	
ALUMINUM	68.5
BARIUM	27.7
CALCIUM	58200
IRON	6580
MAGNESIUM	2470
MANGANESE	20.1
POTASSIUM	1590
SODIUM	6350
ZINC	20.5

LEGEND

65MW-01 ⊕	MONITORING WELL LOCATION
65DW-01 ⊕	DEEP MONITORING WELL LOCATION

SOURCE: BRENT A. LANIER, SURVEYING AND PLANNING, MAY 1995

FIGURE 4-8
DETECTED METALS IN GROUNDWATER
SITE 65 – ENGINEER AREA DUMP
REMEDIAL INVESTIGATION, CTO-0312
MARINE CORPS BASE, CAMP LEJEUNE
NORTH CAROLINA

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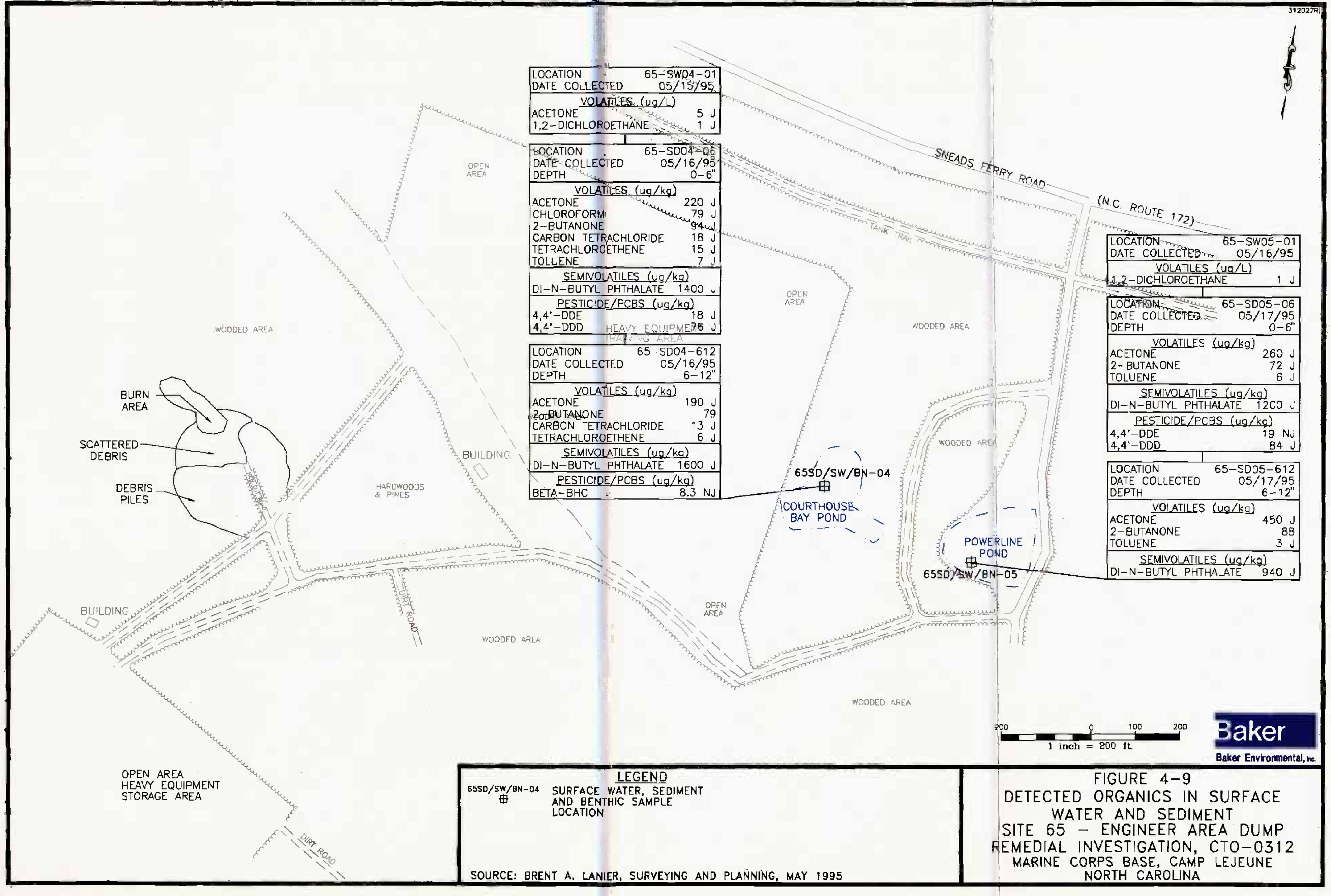

LOCATION	65-SW04-01
DATE COLLECTED	05/15/95
VOLATILES (ug/L)	
ACETONE	5 J
1,2-DICHLOROETHANE	1 J

LOCATION	65-SD04-06
DATE COLLECTED	05/16/95
DEPTH	0-6"
VOLATILES (ug/kg)	
ACETONE	220 J
CHLOROFORM	79 J
2-BUTANONE	94 J
CARBON TETRACHLORIDE	18 J
TETRACHLOROETHENE	15 J
TOLUENE	7 J
SEMIVOLATILES (ug/kg)	
DI-N-BUTYL PHTHALATE	1400 J
PESTICIDE/PCBS (ug/kg)	
4,4'-DDE	18 J
4,4'-DDD	76 J

LOCATION	65-SD04-612
DATE COLLECTED	05/16/95
DEPTH	6-12"
VOLATILES (ug/kg)	
ACETONE	190 J
2-BUTANONE	79
CARBON TETRACHLORIDE	13 J
TETRACHLOROETHENE	6 J
SEMIVOLATILES (ug/kg)	
DI-N-BUTYL PHTHALATE	1600 J
PESTICIDE/PCBS (ug/kg)	
BETA-BHC	8.3 NJ

LOCATION	65-SW05-01
DATE COLLECTED	05/16/95
VOLATILES (ug/L)	
1,2-DICHLOROETHANE	1 J

LOCATION	65-SD05-06
DATE COLLECTED	05/17/95
DEPTH	0-6"
VOLATILES (ug/kg)	
ACETONE	260 J
2-BUTANONE	72 J
TOLUENE	6 J
SEMIVOLATILES (ug/kg)	
DI-N-BUTYL PHTHALATE	1200 J
PESTICIDE/PCBS (ug/kg)	
4,4'-DDE	19 NJ
4,4'-DDD	84 J

LOCATION	65-SD05-612
DATE COLLECTED	05/17/95
DEPTH	6-12"
VOLATILES (ug/kg)	
ACETONE	450 J
2-BUTANONE	88
TOLUENE	3 J
SEMIVOLATILES (ug/kg)	
DI-N-BUTYL PHTHALATE	940 J

LEGEND

65SD/SW/BN-04 ⊞	SURFACE WATER, SEDIMENT AND BENTHIC SAMPLE LOCATION

SOURCE: BRENT A. LANIER, SURVEYING AND PLANNING, MAY 1995

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Baker Environmental, Inc.

FIGURE 4-9
DETECTED ORGANICS IN SURFACE WATER AND SEDIMENT
SITE 65 – ENGINEER AREA DUMP
REMEDIAL INVESTIGATION, CTO-0312
MARINE CORPS BASE, CAMP LEJEUNE
NORTH CAROLINA

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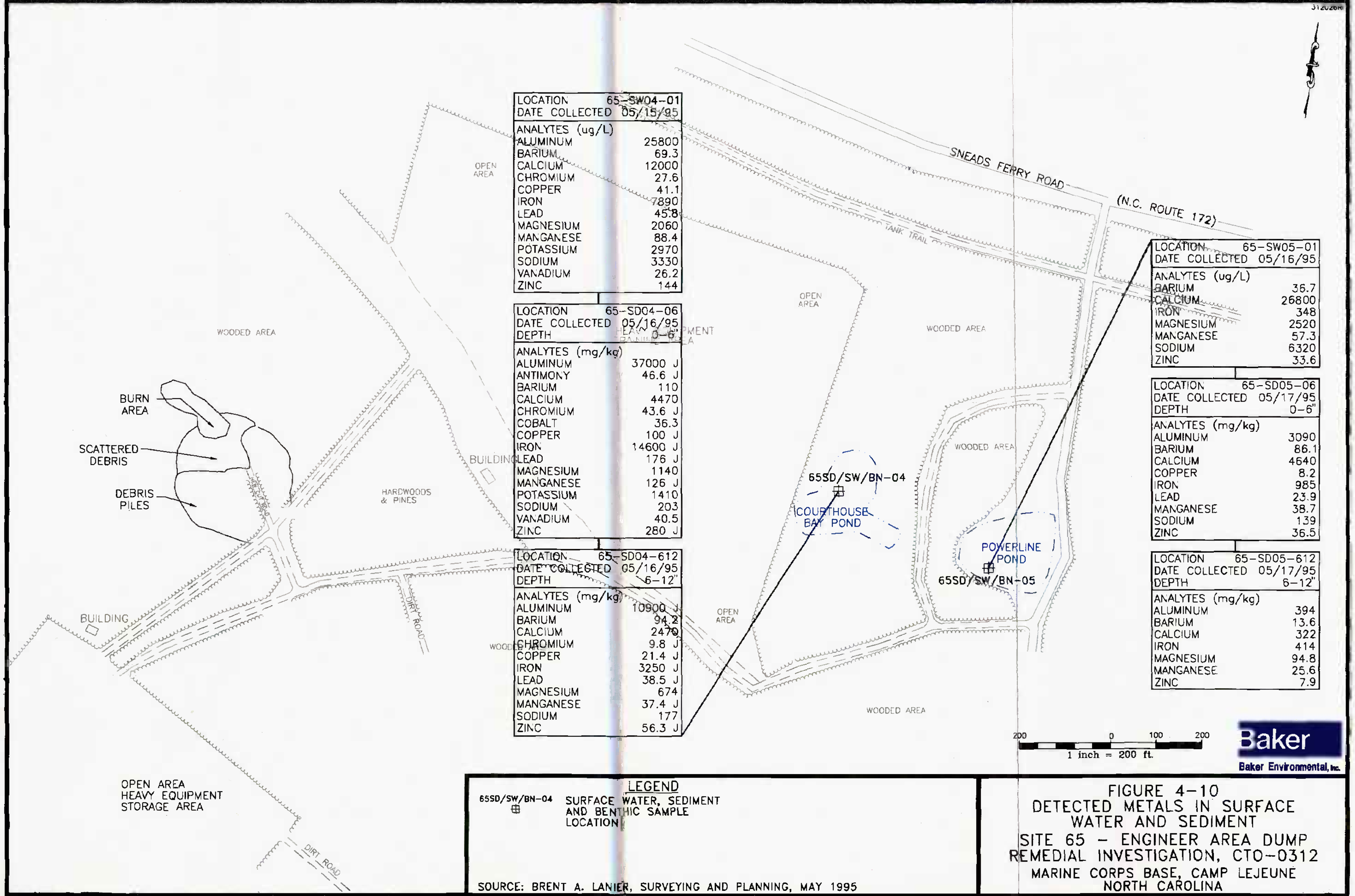

LOCATION	65-SW04-01
DATE COLLECTED	05/15/95
ANALYTES (ug/L)	
ALUMINUM	25800
BARIUM	69.3
CALCIUM	12000
CHROMIUM	27.6
COPPER	41.1
IRON	7890
LEAD	45.8
MAGNESIUM	2060
MANGANESE	88.4
POTASSIUM	2970
SODIUM	3330
VANADIUM	26.2
ZINC	144

LOCATION	65-SD04-06
DATE COLLECTED	05/16/95
DEPTH	0-6"
ANALYTES (mg/kg)	
ALUMINUM	37000 J
ANTIMONY	46.6 J
BARIUM	110
CALCIUM	4470
CHROMIUM	43.6 J
COBALT	36.3
COPPER	100 J
IRON	14600 J
LEAD	176 J
MAGNESIUM	1140
MANGANESE	126 J
POTASSIUM	1410
SODIUM	203
VANADIUM	40.5
ZINC	280 J

LOCATION	65-SD04-612
DATE COLLECTED	05/16/95
DEPTH	6-12"
ANALYTES (mg/kg)	
ALUMINUM	10900 J
BARIUM	94.2
CALCIUM	2470
CHROMIUM	9.8 J
COPPER	21.4 J
IRON	3250 J
LEAD	38.5 J
MAGNESIUM	674
MANGANESE	37.4 J
SODIUM	177
ZINC	56.3 J

LOCATION	65-SW05-01
DATE COLLECTED	05/16/95
ANALYTES (ug/L)	
BARIUM	36.7
CALCIUM	26800
IRON	348
MAGNESIUM	2520
MANGANESE	57.3
SODIUM	6320
ZINC	33.6

LOCATION	65-SD05-06
DATE COLLECTED	05/17/95
DEPTH	0-6"
ANALYTES (mg/kg)	
ALUMINUM	3090
BARIUM	86.1
CALCIUM	4640
COPPER	8.2
IRON	985
LEAD	23.9
MANGANESE	38.7
SODIUM	139
ZINC	36.5

LOCATION	65-SD05-612
DATE COLLECTED	05/17/95
DEPTH	6-12"
ANALYTES (mg/kg)	
ALUMINUM	394
BARIUM	13.6
CALCIUM	322
IRON	414
MAGNESIUM	94.8
MANGANESE	25.6
ZINC	7.9

LEGEND

65SD/SW/BN-04 ⊞	SURFACE WATER, SEDIMENT AND BENTHIC SAMPLE LOCATION

SOURCE: BRENT A. LANIER, SURVEYING AND PLANNING, MAY 1995

Baker
Baker Environmental, Inc.

FIGURE 4-10
DETECTED METALS IN SURFACE WATER AND SEDIMENT
SITE 65 – ENGINEER AREA DUMP
REMEDIAL INVESTIGATION, CTO-0312
MARINE CORPS BASE, CAMP LEJEUNE
NORTH CAROLINA

00145026Y

5.0 CONTAMINANT FATE AND TRANSPORT

The potential for a contaminant to migrate and persist in an environmental medium is critical when evaluating the potential for a chemical to elicit an adverse human health or ecological effect. The environmental mobility of a chemical is influenced by its physical and chemical properties, the physical characteristics of the site, and the site chemistry. This section presents a discussion of the various physical and chemical properties of contaminants detected at OU No. 9, Site 65, that impact the fate and transport of the contaminants in the environment. The basis for this discussion of contaminant fate and transport is presented in Section 4.0, Nature and Extent of Contamination.

5.1 Chemical and Physical Properties Impacting Fate and Transport

Table 5-1 presents the physical and chemical properties associated with a representative group of organic contaminants detected at the site which determine inherent environmental mobility and fate. These properties include:

- Vapor pressure
- Water solubility
- Octanol/water partition coefficient
- Organic carbon partition coefficient
- 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 is not as important when evaluating groundwater and subsurface soils. Vapor pressure for monocyclic aromatics are generally higher than vapor pressures for PAHs. Contaminants with higher vapor pressures will enter the atmosphere at a quicker rate than the contaminants with low vapor pressures.

The rate at which a contaminant is leached from soil by infiltrating precipitation is proportional to its water solubility. More soluble contaminants are usually more readily leached than less soluble contaminants. The water solubilities indicate that the volatile organic contaminants, including monocyclic aromatics, are usually several orders-of-magnitude more soluble than PAHs.

The octanol/water partition coefficient (K_{ow}) is a measure of the equilibrium partitioning of contaminants between octanol and water. A linear relationship between octanol/water partition coefficient and the uptake of chemicals by fatty tissues of animal and human receptors (the bioconcentration factor - BCF) has been established (Lyman et al., 1982). The coefficient is also useful in characterizing the sorption of compounds by organic soils where experimental values are not available.

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

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

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

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

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

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

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

5.2 Contaminant Transport Pathways

Based on the evaluation of existing conditions at Site 65, the following potential contaminant transport pathways have been identified:

- Erosion of contaminated soils and transportation of the soils to surface water and sediment.
- Off-site atmospheric deposition of windblown dust.
- Leaching of sediment contaminants to surface water.
- Leaching of soil contaminants to groundwater.
- Migration of groundwater contaminants off site.
- Groundwater infiltration from the shallow aquifer to the deep aquifer.
- Groundwater discharge to surface water.

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

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

The following paragraphs describe the potential transport pathways listed above.

5.2.1 Erosion of Contaminated Soils and Transportation to Surface Water and Sediment

Surface water run-off can transport contaminated surface soils from the site to a surface water body, contaminating the surface water and/or sediment. This is influenced by the velocity of the surface water run-off; vegetation; grain size of the soils; solubility of the contaminants; distance to the water body and the proximity of the contaminated soils to the water body.

The majority of Site 65 is covered with vegetation, except the heavy equipment training area located directly west of Courthouse Bay Pond and Powerline Pond. Erosion is likely to occur in the training area carrying potential contaminants to Courthouse Bay Pond or other portions of the site. However, surface and subsurface soils are primarily sand, indicating that a high probability exists that most of the rainfall will infiltrate the soils and become groundwater.

5.2.2 Off-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.

The majority of Site 65 is covered with vegetation and, therefore would not be susceptible to wind erosion. However, the training area would be very susceptible and would be the suspected source area of any airborne contaminant.

5.2.3 Contaminant Transfer Between Sediments and Surface Water

When in contact with surface water, contaminants attached to sediment particles can disassociate from the sediment particle into surface water or visa versa. 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}).

Surface water sample analytical results indicate that there has not been significant leaching of sediment contaminants into surface water (Section 4.0), based on the infrequent occurrence and level of contamination. However, the concentrations of elemental contamination observed in the sediments may have originated by evaporation of surface water causing precipitation of the elements into the sediments.

5.2.4 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. This is influenced by the depth to the water table, precipitation, infiltration, physical and chemical properties of the soil, and physical and chemical properties of the contaminant.

Groundwater samples were collected from shallow, and deep monitoring wells at Site 65. 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. The analytical results indicate that contamination residing within the soils do not appear to have leached into groundwater at the site.

5.2.5 Migration of Groundwater Contaminants

Contaminants leaching from soils to underlying groundwater can migrate as dissolved constituents in groundwater in the direction of groundwater flow. Three general processes govern the migration of dissolved contaminants caused by the flow of water: (1) advection - movement caused by flow of groundwater; (2) dispersion - movement caused by irregular mixing of waters during advection; and (3) retardation - principally chemical mechanisms which occur during advection. Subsurface transport of the immiscible contaminants is governed by a set of factors different from those of dissolved contaminants. The potential movement of immiscible organic liquids (non-aqueous phase liquids) will not be discussed in this section.

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

The average seepage velocity of groundwater flow at Site 65 for both the shallow and deep water-bearing zones can be estimated using a variation of Darcy's Equation:

$$V_x = \frac{Ki}{N_e} \qquad (Fetter, 1988)$$

Where: V_x = average seepage velocity
K = hydraulic conductivity (cm/sec)
i = hydraulic gradient
N_e = effective porosity

Thus, when monitoring wells or potable supply wells in sandy aquifers are located hundreds of meters downgradient of a contaminant source, the average travel time for the groundwater to flow from the source to the well point is typically on the order of years. In the zone of influence created by a high capacity production well or well field; however, the artificially increased gradient could substantially increase the local velocity, and the average travel times for groundwater flow are increased.

Dispersion results from two basic processes, molecular diffusion and mechanical mixing. The kinetic activity of dissolved solutes result 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 plume). For simple hydrogeological systems, the spreading is reported to be proportional to the flow rate. Furthermore, dispersion in the direction of flow is often observed to be markedly greater than dispersion in the directions transverse (perpendicular) to the flow. In the absence of detailed studies to determine dispersive characteristics at Site 65, 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. Certain halogenated organic solvents sorption is affected by hydrophobility (antipathy for dissolving in water) and the fraction of solid organic matter in the aquifer solids (organic carbon content). If the aquifer below Site 65 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 which affect the rates of biotransformation of organic compounds include: water temperature and pH, the number of species of microorganisms present, the concentration of substrate, and presence of microbial toxicants and nutrients, and the availability of electron acceptors. Transformation of a toxic organic solute is no assurance that it has been converted to harmless or even less harmless hazardous products. Biotransformation of common groundwater contaminants, such as trichloroethene and tetrachloroethene, 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. Currently, information is available on the interrelation of soil organic properties to the binding of pesticides, herbicides, and high molecular weight pollutants such as PCBs. However, data is lacking for the non-ionic components of solvents and fuels. 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 active chemically; surface sites are negatively or positively charged or they are electronically neutral. Oppositely charged metallic counterions from solutions in soils (i.e., groundwater) are attracted to these charged surfaces. The relative proportions of ions attracted to these various sites depends on the degree of acidity or alkalinity of the soil, on its mineralogical composition, and on its content of organic matter. The extent of adsorption depends on either the respective charges on the adsorbing surface and the metallic cation. In addition to these adsorption reactions, precipitation of new mineral phases also may occur if the chemical composition of the soil solution becomes supersaturated with respect to the insoluble precipitates. Of the probable precipitates, the most important of these phases are hydroxides, carbonates, and sulfides. The precipitation of hydroxide minerals is important for metals such as iron and aluminum. The precipitation of carbonate minerals is significant for calcium and barium; and the precipitation of sulfide minerals dominates the soil chemistry of zinc, cadmium, and mercury. A number of precipitates may form if metals are added to soils. The concentration of metal in solution, will be controlled, at equilibrium, by the solid phase that results in the lowest value of the activity of the metallic ion in solution (Evans, 1989).

5.2.6 Groundwater Discharge to Surface Water

Groundwater discharge to Courthouse Bay Pond and Powerline Pond is likely at Site 65. Groundwater can transport contamination to these ponds, but is dependent on the solubility of the contamination. Like groundwater flow, three general processes govern the flow of the water: advection, dispersion and retardation. These three processes are described in detail in section 5.2.5.

5.2.7 Groundwater Infiltration from the Shallow to the Deep Aquifer

Vertical movement of groundwater from one aquifer system to another, through a semi-confining unit is dependent on a number of factors including: intrinsic permeability of all involved units; density of the fluid (i.e., water and/or contaminant); viscosity of the fluid; hydraulic head; unit thickness; effective porosity; and bulk density of the soil comprising the semi-confining unit. At Site 65, the vertical hydraulic gradient was calculated using the three deep wells (completed below the confining unit) and adjacent shallow wells (screened across the water table). A potential for downward movement through the semi-confining unit exists at the site. Since there is a head difference between the aquifers, migration will continued from the surficial into the Castle Hayne aquifer.

5.3 Fate and Transport Summary

The following paragraphs summarize the contaminant group fate and transport data for contaminants detected in media collected at Site 65.

5.3.1 Volatile Organic Compounds

VOCs tend to be mobile in environmental media as indicated by their presence in groundwater and their corresponding 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 (see Table 5-1). Without a continuing source, VOCs do not generally tend to persist in environmental media because photolysis, oxidation, and biodegradation figure significantly in their removal.

5.3.2 Polynuclear Aromatic Hydrocarbons

Low water solubilities, high K_{ow} and K_{oc} indicate a strong tendency for PAHs to adsorb to soils. Of the PAHs, fluoranthene, is probably the best marker compound, since it is consistently the most abundant of the PAHs measured and provides the strongest correlation with total PAH values. Benzo(g, h, i) perylene is usually the most abundant compound in soils with low PAH values, but becomes less important with increasing total PAH values. Other PAHs are benzo(a)anthracene, chrysene, pyrene, benzo(g,h,i) 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 aromatic ring numbers. Photolysis and oxidation may be important removal mechanisms in surface waters and surficial soils, while biodegradation could be an important fate process in groundwater, surface soils or deeper soils. PAHs are ubiquitous in nature. The presence of PAHs in the soil may be the result of aerially deposited material, and the chemical and biological conditions in the soil which result in selective microbial degradation/breakdown.

5.3.3 Pesticides/PCBs

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

5.3.4 Inorganics

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

The most complicated pathway for inorganic contaminants is migration in subsurface soils and groundwaters, where oxidation reduction potential (Eh) and pH play critical roles. Table 5-2 presents and assessment of relative inorganic environmental mobilities as a function of Eh and pH. Soils at MCB, Camp Lejeune are relatively neutral; therefore, inorganics in the subsurface soil should be relatively immobile.

Transport of inorganic species in groundwater is mainly a function of the inorganic's solubility in solution under the chemical conditions of the soil-solution matrix. The inorganic must be dissolved (i.e., in solution) for leaching and transport by advection with the groundwater to occur. Generally, dynamic and reversible processes control solubility and transport of the dissolved metal ions. Such processes 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. As stated in Section 4.5.3, the only metals that exceeded state and/or federal standards in groundwater at the site were iron and manganese. These elements occur historically at elevated levels throughout MCB, Camp Lejeune.

5.4 References

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TABLES

TABLE 5-1

PHYSICAL AND CHEMICAL PROPERTIES OF ORGANIC COMPOUNDS
SITE 65 - ENGINEER AREA DUMP
REMEDIAL INVESTIGATION, CTO-312
MCB, CAMP LEJEUNE, NORTH CAROLINA

COPCs	Vapor Pressure (mm Hg)	Water Solubility (mg/L)	Log K_{ow}	Log K_{oc}	Specific Gravity (g/cm^3)	Henry's Law Constant ($atm\text{-}m^3/mole$)	Mobility Index
VOLATILE ORGANIC COMPOUNDS							
Carbon disulfide	3.6 x 10^{02}	1.2 x 10^{03}	2.0	1.73	1.263	3.0 x 10^{-02}	3.9
Ethyl benzene	9.6	1.7 x 10^{02}	3.2	3.04	0.867	8.4 x 10^{-03}	0.2
Xylenes Total	10	1.98 x 10^{02}	3.26	2.38	0.87	7.04 x 10^{-03}	0.9
SEMIVOLATILE ORGANIC COMPOUNDS							
2,4-Dimethylphenol	9.8 x 10^{-02}	6.2 x 10^{03}	2.30	1.98	NA	6.30 x 10^{-07}	NA
Acenaphthene	1.5 x 10^{-03}	3.42	4.33	1.25	0.994	1.50 x 10^{-04}	2.5
Anthracene	9.6 x 10^{-04}	1.0	4.45	4.20	1.24	2.25 x 10^{-04}	-7.2
Benzo(a)anthracene	2.2 x 10^{-08}	5.7 x 10^{-03}	5.61	5.34	NA	7.34 x 10^{-07}	-15.2
Benzo(a)pyrene	5.6 x 10^{-09}	3.8 x 10^{-03}	6.04	NA	1.274	4.90 x 10^{-07}	NA
Benzo(b)fluoranthene	5.0 x 10^{-07}	1.0 x 10^{-03}	6.08	NA	NA	1.66 x 10^{-04}	NA
Benzo(g,h,i)perylene	1.0 x 10^{-10}	3.0 x 10^{-04}	6.51	NA	NA	1.21 x 10^{-07}	NA
Benzo(k)fluoranthene	5.0 x 10^{-07}	5.5 x 10^{-04}	6.08	NA	NA	3.02 x 10^{-04}	NA
Bis(2-ethylhexyl)phthalate	9.8 x 10^{-06}	0.34	5.11	8.73	0.99	1.5 x 10^{-05}	-14.2
Carbazole	7.0 x 10^{-04}	1.2	NA	3.72	1.1	NA	NA
Chrysene	6.3 x 10^{-09}	1.8 x 10^{-03}	5.61	5.44	1.274	1.10 x 10^{-06}	-16.3
Di-n-butyl phthalate	7.3 x 10^{-05}	11	5.23	5.2	1.047	NA	-8.3
Dibenzo(a,h)anthracene	1 x 10^{-10}	2.5 x 10^{-06}	6.52	6.5	NA	1.2 x 10^{-04}	-22.1
Dibenzofuran	NA	10	3.9-4.1	4.12-4.31	1.089	NA	NA
2,4 Dinitrophenol	NA	NA	NA	NA	NA	NA	NA
Fluoranthene	5.0 x 10^{-06}	0.265	5.33	4.64	NA	5.12 x 10^{-06}	-10.5
Fluorene	1.0 x 10^{-02}	1.69	4.2	3.65	NA	1.29 x 10^{-03}	-5.4

Note:
NA = Not Available

TABLE 5-1 (Continued)

PHYSICAL AND CHEMICAL PROPERTIES OF ORGANIC COMPOUNDS
SITE 65 - ENGINEER AREA DUMP
REMEDIAL INVESTIGATION, CTO-312
MCB, CAMP LEJEUNE, NORTH CAROLINA

COPCs	Vapor Pressure (mm Hg)	Water Solubility (mg/L)	Log K_{ow}	Log K_{oc}	Specific Gravity (g/cm^3)	Henry's Law Constant (atm-m^3/mole)	Mobility Index
Indeno(1,2,3-cd)pyrene	1.0 x 10^{-10}	5.3 x 10^{-04}	6.51	NA	NA	6.0 x 10^{-10}	NA
2-Methynaphthalene	NA	insoluble	3.03	3.6	1.006	NA	NA
Naphthalene	8.2 x 10^{-02}	31.7	3.60	2.97	1.152	4.83 x 10^{-04}	-2.5
Phenanthrene	9.6 x 10^{-04}	1.29	4.46	4.2	1.025	2.25 x 10^{-04}	-7.2
Pyrene	2.5 x 10^{-06}	0.14	5.32	4.91	1.271	5.10 x 10^{-06}	-11.90
PESTICIDES/PCBs							
Beta-BHC	2.8 x 10^{-07}	0.70	3.35	3.80	NA	NA	-10
4,4'-DDD	1.0 x 10^{-06}	0.16	6.2	5.9	NA	4 x 10^{-06}	-12.7
4,4'-DDE	6.5 x 10^{-06}	0.12	7.0	6.6	NA	2.1 x 10^{-05}	-10.0
4,4'-DDT	1.9 x 10^{-07}	3.4 x 10^{-03}	6.19	5.4	NA	8.3 x 10^{-06}	-14.6
Endosulfan I	NA	NA	NA	NA	NA	NA	NA
Endosulfan II	1.5 x 10^{-05}	0.51	3.83	3.31	NA	1.1 x 10^{-05}	-8.6
Endrin Aldehyde	3.0 x 10^{-06}	2.5 x 10^{-04}	3.92	4.56	NA	7.52 x 10^{-06}	-13
Heptachlor epoxide	1.95 x 10^{-05}	0.20	5.40	NA	NA	3.20 x 10^{-05}	NA
alpha-Chlordane	9.8 x 10^{-06}	5.6 x 10^{-02}	5.54	NA	NA	4.85 x 10^{-05}	-11.4
gamma-Chlordane	9.8 x 10^{-06}	5.6 x 10^{-02}	5.54	NA	NA	4.85 x 10^{-05}	-11.4
PCB-1260	4.1 x 10^{-05}	2.7 x 10^{-03}	6.8	5.72	1.58	4.6 x 10^{-03}	-12.7

Notes:
NA = Not Available

References:
ATSDR, 1989
Clement, 1985
Howard, 1989-1991
Montgomery, 1990
Sax and Lewis, 1987
SCDM, 1991, 1992
SPHEM, 1986
USEPA, 1986
USEPA, 1986a
Verscheuren, 1983

TABLE 5-2

RELATIVE MOBILITIES OF INORGANICS AS A FUNCTION OF ENVIRONMENTAL CONDITIONS (Eh, pH)
SITE 65, ENGINEER AREA DUMP
REMEDIAL INVESTIGATION CTO-0312
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
Zn = Zinc
Cu = Copper
Ni = Nickel
Hg = Mercury
Ag = Silver
As = Arsenic
Cd = Cadmium
Ba = Barium
Pb = Lead
Fe = Iron
Cr = Chromium
Be = Beryllium
Zn = Zinc

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

6.0 BASELINE RISK ASSESSMENT

6.1 Introduction

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

The BRA for Operable Unit (OU) No. 9, Site 65 has been conducted in accordance with current USEPA Risk Assessment Guidance (USEPA, 1989a and USEPA, 1991a) and USEPA Region IV Supplemental Risk Guidance (USEPA, 1991b).

The components of the BRA include:

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

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

6.2 Contaminants of Potential Concern

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

6.2.1 Criteria for Selecting Contaminants of Potential Concern

Criteria used in selecting COPCs from constituents detected during the field sampling and analytical phase of the investigation are:

- Historical information
- Comparison to background or naturally occurring levels
- Comparison to field and laboratory blank data
- Comparison to USEPA Region III Contaminants of Concern (COCs)
- Prevalence
- Federal and State criteria and standards
- Toxicity
- Comparison to anthropogenic levels
- Persistence
- Mobility

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

6.2.1.1 Historical Information

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

6.2.1.2 Background or Naturally-Occurring Levels

Naturally-occurring levels of chemicals are present under ambient conditions. Generally, a comparison to naturally-occurring levels applies only to inorganic analytes, because the majority of organic contaminants are not naturally occurring. Background samples are collected from areas that are known to be uninfluenced by site contamination. An inorganic concentration is considered site-related only if it exceeds two times the mean concentration estimated for the site-specific, background samples. The mean for surface soil inorganics was estimated using results from 41 sample locations. The mean for subsurface soil inorganics was estimated using results from 35 sample locations.

Background soil data is presented in Appendix L.

6.2.1.3 Contaminant Concentrations in Blanks

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

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

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

Eliminating a sample result correlates directly to a reduction in the contaminant prevalence in that medium. Consequently, if elimination due to blank concentration reduces the prevalence of a contaminant to less than five percent, a contaminant that may have been previously included according to its prevalence is eliminated as a COPC. Maximum concentrations of common laboratory contaminants detected in blanks are presented in Table 6-1.

Blanks containing organic constituents that are not considered common laboratory contaminants (i.e., all other TCL compounds) are regarded as positive results only when observed concentrations exceed five times the maximum concentration detected in any blank (USEPA, 1989b). All TCL compounds at concentrations less than five times the maximum level of contamination noted in any blank are considered not detected in that sample. Maximum concentrations of other contaminants detected in blanks are presented in Table 6-1.

6.2.1.4 USEPA Region III COC Screening Values

Contaminant of concern (COC) screening values are derived using conservative USEPA promulgated default values and the most recent toxicological criteria available. COC screening values for potentially carcinogenic and noncarcinogenic chemicals are individually derived based on a target incremental lifetime cancer risk (ICR) of 1.0E-06 and a target hazard quotient of 0.1, respectively. For potential carcinogens, the toxicity criteria applicable to the derivation of COC screening values are oral and inhalation cancer slope factors; for noncarcinogens, they are chronic oral and inhalation reference doses. These toxicity criteria are subject to change as more updated information and results from the most recent toxicological/epidemiological studies become available. Therefore, the use of toxicity criteria in the derivation of COC screening values requires that the screening concentrations be updated periodically to reflect changes in the toxicity criteria.

Since the most recent COC screening values table was issued by USEPA in March 1994, the values from these tables can be updated by incorporating information from another set of tables containing risk-based concentrations (RBCs) that are issued by USEPA Region III on a semi-annual basis. The RBCs are derived using the same equations and USEPA promulgated default exposure assumptions that were used by Region III to derive the COC screening values. In addition, the quarterly RBCs for potentially carcinogenic chemicals are based on a target ILCR of 1.0E-06. The only difference in the derivation methodologies for the COC screening values and the RBCs is that the RBCs for noncarcinogens are based on a target hazard quotient of 1.0 rather than 0.1. The COC screening values for noncarcinogens are derived based on a target hazard quotient of 0.1, to account for cumulative risk from multiple chemicals in a medium. Re-derivation of the semi-annual noncarcinogenic RBCs based on a target hazard quotient of 0.1, while using the most recent toxicological criteria available, results in a set of values that can be used as COC screening values. In other words, COC screening values can be updated every six months by using the carcinogenic RBCs issued semi-annually USEPA Region III and dividing the accompanying noncarcinogenic RBCs by a factor of 10.

6.2.1.5 Prevalence

The frequency of positive detections in sample sets and the level at which a contaminant is detected in a given medium are factors that determine a chemical's prevalence. The frequency of detection for a contaminant is determined as the number of positive detections of the contaminant out of the total number of samples analyzed for that contaminant. Contaminants that are infrequently detected, (i.e., less than 5 percent when at least 20 samples of a medium are available) do not necessarily indicate contamination. Such detections may result from certain sampling or analytical practices. A contaminant may not be retained for quantitative evaluation in the BRA if: (1) it is detected infrequently in an environmental medium; (2) it is absent or detected at low concentrations in other media; or (3) site history does not provide evidence to suggest that the contaminant should be present.

6.2.1.6 State and Federal Criteria and Standards

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

Regulatory guidelines are used, when necessary, to infer potential human health risks and environmental impacts. Relevant regulatory guidelines include Ambient Water Quality Criteria (AWQC) for surface water and Health Advisories (HA) for drinking water.

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

Tables 6-2 through 6-9 present analytical data from samples collected during the RI compared to applicable standards and criteria. A brief explanation of the criteria and standards used for qualitative evaluation of COPCs is presented below.

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

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

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

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

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

6.2.1.7 Toxicity

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

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

6.2.1.8 Anthropogenic Levels

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

The remaining sections apply the aforementioned selection criteria, beginning with prevalence of detected analytical results in each medium of interest, in order to establish a preliminary list of COPCs for Site 65. Once this task is completed, a final list of media-specific COPCs is selected using the remaining criteria (persistence, mobility, toxicity, ARARs, RBCs, blank concentrations, background concentrations, and anthropogenic concentrations).

6.2.1.9 Persistence

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

6.2.1.10 Mobility

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

6.2.2 Selection of Contaminants of Potential Concern

The following sections present an overview of the analytical data obtained for each environmental medium during the RI and the subsequent retention or elimination of COPCs using the aforementioned selection criteria. Summaries of the analytical data are provided in Table 6-2 through 6-9 and aided in the selection of COPCs in each environmental medium. Worksheets used for COPC selection are presented in Appendix S.

6.2.2.1 Surface Soil

Table 6-2 shows that thirteen surface soil samples were analyzed for volatile organic contaminants (VOCs). Toluene was detected in three of 13 samples, at a maximum concentration of 2 µg/kg. This value is less than the corresponding residential soil COC screening value and toluene is not retained as a COPC. In addition, toluene was detected in blanks at a concentration of 4 µg/kg. Methylene chloride and total xylenes were detected in two of 13 samples at concentrations less than their respective COC screening values for residential soil. Methylene chloride was also detected in blanks at a concentration of 1 µg/kg. These compounds were not retained as surface soil COPCs. Finally, acetone, trichloroethene, and ethylbenzene were each detected in one out of 13 samples at concentrations below the corresponding residential soil COC screening values. Acetone was also detected in blanks at a concentration of 93 µg/kg. Therefore, no VOCs are retained as surface soil COPCs.

Thirteen surface soil samples were analyzed for SVOCs. Acenaphthene, 2,4-dinitrophenol, dibenzofuran, fluorene, anthracene, and carbazole were detected in one out of 13 samples. In each case, maximum concentrations are less than respective residential soil COC screening values. These compounds were not retained as surface soil COPCs. Di-n-butylphalate, benzo(k)fluoranthene, indeno(1,2,3-cd)pyrene, and benzo(g,h,i,)perylene were detected in two of 13 samples at concentrations less than corresponding COC screening values for residential soil. These compounds were not retained as surface soil COPCs. Phenanthrene, fluoranthene, pyrene, benzo(a)anthracene, chrysene, and benzo(b)fluoranthene were detected in three out of 13 samples. In all instances, maximum concentrations are less than respective COC screening values. In addition, bis(2-ethylhexyl)phthalate, a common laboratory contaminant, was detected in nine out of 13 samples. However, the maximum concentration detected is below the COC screening value for bis(2-ethylhexyl)phthalate in residential soils. Therefore, bis(2-ethylhexyl)phthalate is not retained as a surface soil COPC.

Benzo(a)pyrene was detected in two of 13 samples, a frequency greater than 5 percent. At 400 µg/kg, its maximum concentration exceeds its residential soil COC screening value. In addition, dibenzo(a,h)anthracene was detected in two out of 13 samples. Furthermore, its maximum concentration of 150 µg/kg exceeds its residential soil COC screening value. Consequently, these SVOCs are retained as COPCs in surface soil.

Thirteen surface soil samples were analyzed for pesticides/PCBs. Heptachlor epoxide, endosulfan II, Aroclor-1260, 4,4'-DDD, 4,4'-DDE, and 4,4'-DDT were detected at concentrations less than respective residential soil COC screening values. Therefore, no pesticide/PCBs are retained as surface soil COPCs.

Table 6-3 shows that thirteen surface soil samples were analyzed for inorganic contaminants. Aluminum, barium, chromium, copper, manganese, nickel, vanadium and zinc were detected at maximum concentrations less than respective residential soil COC screening values. Lead was detected in 13 of 13 samples at a maximum concentration of 178 mg/kg, which is less than the USEPA lead action level for soil of 400 mg/kg. For this reason, these inorganics are not retained as COPCs. Calcium, magnesium, potassium and sodium are not retained as COPCs, because these inorganics are considered essential nutrients.

Iron was detected in all surface soil samples. Its maximum concentration of 16,400 mg/kg exceeds the respective background level and residential soil COC screening value. Thallium was detected in one of 13 samples at a concentration of 2.3 mg/kg that exceeds its residential soil COC screening value. Consequently, manganese and thallium are retained as surface soil COPCs.

6.2.2.2 Subsurface Soil

Table 6-4 shows that 19 subsurface soil samples (13 subsurface soil samples and six test pit samples) were analyzed for VOCs. Acetone, carbon disulfide, 2-butanone, trichloroethene, toluene, and total xylenes were detected at maximum concentrations less than respective residential soil COC screening values. For this reason, none of the VOCs detected are retained as COPCs.

Nineteen subsurface soil samples were analyzed for SVOCs. The following SVOCs are not retained as COPCs, because they were detected at maximum concentrations less than respective residential soil COC screening values: naphthalene, 2-methylnaphthalene, acenaphthene, fluorene, dibenzofuran, phenanthrene, anthracene, carbazole, di-n-butylphtalate, fluoranthene, pyrene, chrysene, bis(2-ethylhexyl)phthalate, benzo(b)fluoranthene, benzo(k)fluoranthene, ideno(1,2,3-cd)pyrene, and benzo(g,h,i)perylene.

Benzo(a)anthracene and benzo(a)pyrene were detected at a relatively low frequency of two of 19 samples. However, in each case, the maximum concentrations of 900µg/kg and 680 µg/kg, respectively, exceed the corresponding residential soil COC screening values. For this reason, benzo(a)anthracene and benzo(a)pyrene are retained as subsurface soil COC screening values.

Nineteen subsurface soil samples were analyzed for pesticides/PCBs. The following pesticide/PCBs are not retained as COPCs, because they were detected at maximum concentrations less than respective residential soil COC screening values: endosulfan I, 4,4'-DDE, 4,4'-DDE, 4,4'-DDT, endrin aldehyde, alpha-chlordane, and gamma-chlordane.

Table 6-5 shows that 19 subsurface soil samples were analyzed for inorganic contaminants. The following inorganics are not retained as COPCs because they were detected at concentrations less than respective residential soil COC screening values: barium, cadmium, chromium, cobalt, selenium, silver, vanadium and zinc. Calcium, magnesium, potassium and sodium are not retained as COPCs because these inorganics are considered essential nutrients.

Aluminum, iron, and manganese were detected in all nineteen subsurface soil samples. The maximum concentrations for these analytes (10,600 mg/kg, 31,300 mg/kg, and 471 mg/kg, respectively) exceeded background levels as well as the corresponding COC screening values for residential soil. Lead was also detected in all samples at a maximum concentration (539 mg/kg) exceeding both background and the lead action level. For this reason, aluminum, iron, lead, and manganese are retained as subsurface soil COPCs. In addition, antimony, arsenic, copper, nickel, and thallium were detected in subsurface soil samples at concentrations exceeding background and/or residential soil COC screening values. Therefore, these analytes are also retained as subsurface soil COPCs.

6.2.2.3 Groundwater

Table 6-6 shows that eleven groundwater samples were analyzed for VOCs. Methylene chloride and acetone, common laboratory contaminants, were detected at fairly high frequencies of six of 11 and seven of 11, respectively. They were not retained as COPCs; however, because the maximum sample concentrations (2 µg/L and 7 µg/L, respectively) are less than the tap water COC screening values. 1,2-Dichloroethane was detected in eight of 11 groundwater samples at a maximum concentration of 2 µg/L. It was also detected in the blanks at a concentration of 2 µg/L. Since the maximum concentration of 1,2-dichloroethane does not exceed five times the blank concentration of this contaminant, it is not retained as a COPC. 2-Butanone was detected in three of 11 samples. This compound is not retained as a groundwater COPC because its maximum concentration is below the corresponding tap water COC screening value.

Carbon disulfide was detected in one of 11 samples at a maximum concentration of 5 µg/L. It is retained as a COPC since it exceeded its tap water screening value.

Eleven groundwater samples were analyzed for SVOCs. Naphthalene and di-n-butylphthalate were detected at maximum concentrations less than respective tap water COC screening values. For this reason, these SVOCs are not retained as COPCs. Bis(2-ethylhexyl)phthalate was detected in blanks at 2 µg/L. Because bis(2-ethylhexyl)phthalate is a common lab contaminant, this concentration is multiplied by 10 to yield a blank concentration of 20 µg/L. Bis(2-ethylhexyl)phthalate was detected in five of 11 samples, at a maximum concentration of 6 µg/L. Because the sample concentration is less than the concentration in blanks, bis(2-ethylhexyl)phthalate is not retained as a COPC.

No pesticides/PCBs were detected in the groundwater samples; therefore, none were retained as COPCs.

Eleven groundwater samples were analyzed for inorganic contaminants. Aluminum, barium, chromium, cobalt, nickel, and zinc were detected at maximum concentrations less than respective tap water COC screening values. Lead was detected at a maximum concentration less than its action level for drinking water. Calcium, magnesium, potassium, and sodium are not retained as COPCs, because these inorganics are considered essential nutrients.

Manganese was detected in all 11 groundwater samples at a maximum concentration of 186 µg/L. Iron was detected in 10 of 11 groundwater samples at 6,580 µg/L. These concentrations exceed the corresponding tap water COC screening values. Therefore, manganese and iron are retained as groundwater COPCs.

6.2.2.4 Surface Water

Table 6-7 shows that two surface water samples were analyzed for VOCs. Acetone, a common laboratory contaminant, was detected in one of two samples at a maximum concentration of 5 µg/L. It was also detected in the blanks at a concentration of 44 µg/L. For this reason, acetone is not retained as a surface water COPC. 1,2-Dichloroethane was detected in both surface water samples at 1 µg/L. It was also; however, detected in blanks at 2 µg/L. As 1,2-dichloroethane is considered a contaminant not common to the laboratory, the blank concentration is multiplied by a factor of five to yield a blank concentration. of 5 µg/L. The 1,2-dichloroethane concentration in the samples is less than the blank concentration, so it is not retained as a COPC.

No SVOCs were detected in surface water; therefore, none were retained as COPCs.

No pesticides/PCBs were detected in surface water samples; therefore, none were retained as COPCs.

Two surface water samples were analyzed for inorganic contaminants. Chromium was detected at a concentration less than its NCWQS and was therefore, not retained as a surface water COPC. Calcium, magnesium, potassium, and sodium were detected in the surface water samples. However, these inorganics are not retained as COPCs, because they are considered essential nutrients.

Aluminum, barium, copper, iron, lead, manganese, vanadium, and zinc were detected in surface water samples. Copper, iron, lead, and zinc were detected at maximum concentrations that exceeded corresponding NCWQS and retained as surface water COPCs. There were no NCWQS for aluminum, barium, manganese, and vanadium For this reason, these analytes are also retained as surface water COPCs.

6.2.2.5 Sediment

Table 6-8 shows that four sediment samples were analyzed for VOCs. Toluene, a common laboratory contaminant, was detected in three of four sediment samples at maximum concentration of 7 µg/kg. This contaminant was also detected in blanks at 4 µg/L. When the blank concentrations of toluene is multiplied by 10, the concentrations for comparison becomes 40 µg/kg. Consequently, toluene is not retained as a COPC.

Acetone, chloroform, 2-butanone, carbon tetrachloride, and tetrachloroethene were detected in all sediment samples at a maximum concentrations less than their respective residential soil COC screening values. Therefore, these VOCs were not retained as sediment COPCs.

Four sediment samples were analyzed for SVOCs. Di-n-butylphthalate was detected in all sediment samples at a maximum concentration less than its residential soil COC screening value. Di-n-butylphalate is not retained as a sediment COPC.

Four sediment samples were analyzed for pesticides/PCBs. Beta-BHC, 4,4'-DDE, and 4,4'-DDD were detected at maximum concentrations less than their respective soil COC screening values. Therefore, beta-BHC, 4,4'-DDE, and 4,4'-DDD are not retained as sediment COPCs.

Four sediment samples were analyzed for inorganic contaminants. Calcium, magnesium, potassium, and sodium were detected frequently, but these inorganics are not retained as COPCs because they are considered essential nutrients.

Aluminum, antimony, chromium, and iron were detected in sediment samples at maximum concentrations that exceeded corresponding soil RBCs. Consequently, these analytes are retained as sediment COPCs. Barium, cobalt, copper, lead, manganese, vanadium, and zinc were detected in sediment samples at maximum concentrations less than corresponding soil COC screening values. Therefore, these inorganics were not retained as sediment COPCs.

6.2.2.6 Fish Tissue

Table 6-9 shows that four fillet fish tissue samples were analyzed for VOCs. Acetone was detected at a frequency of two in four samples. The maximum detected concentration was 7,900 µg/kg. It was not retained as a COPC since the maximum concentration is less than the fish tissue COC screening value.

No SVOCs were detected in the fillet fish tissue samples; therefore, none were retained as COPCs.

Four fillet fish tissue samples were analyzed for pesticides/PCBs. 4,4'-DDD was detected in one of four samples at a concentration of 5.7 µg/kg. This concentration is less than the fish COC screening value for 4,4'-DDD. Therefore, 4,4'-DDD was not retained as a fish tissue COPC.

Four fillet fish tissue samples were analyzed for inorganic contaminants. Copper, manganese, selenium, and zinc were detected at high frequencies, but in each case maximum concentrations are less than the fish tissue COC screening values. Aluminum and barium were detected in one out of four samples at concentrations less than the respective COC screening values. Calcium, magnesium, potassium, and sodium were found in all samples; however, these inorganics are not retained as COPCs because they are considered essential nutrients.

Mercury was detected in all four samples with concentrations ranging from 0.051 mg/kg to 0.3 mg/kg. All concentrations exceed the fish COC screening value for mercury. Thallium was detected in 3 of 4 sediment samples at a maximum concentration of 0.11 mg/kg, which exceeds the fish tissue COC screening value. Consequently, mercury and thallium are retained as fish tissue COPCs.

6.2.2.7 Summary of COPCs

Table 6-10 presents a detailed summary of COPCs identified in each environmental medium sampled at Site 65.

6.3 Exposure Assessment

This section addresses potential human exposure pathways at Site 65 and presents the rationale for their evaluation. Potential source areas and potential migration routes, in conjunction with contaminant fate and transport information, are combined to produce a site conceptual model. Exposure pathways to be retained for quantitative evaluation are subsequently selected, based on the conceptual site model.

6.3.1 Conceptual Site Model of Potential Exposure

A conceptual site model of potential sources, migration pathways and human receptors is developed to encompass all current and future routes for potential exposure at Site 65. Figure 6-1 presents the Site 65 conceptual model. Inputs to the conceptual model include qualitative descriptions of current and future land use patterns in the vicinity of Site 65. All available analytical data and meteorological data are considered, in conjunction with a general understanding of surrounding habitat demographics. The following list of receptors is developed for a quantitative health risk analysis:

- Future on-site residents (child and adult)
- Current military personnel in training
- Current military recreational user
- Current fisherman (child and adult)
- Future construction worker

Contaminants detected in surface and subsurface soils are discussed in Section 4.0 (Nature and Extent of Contamination) and in Section 6.2.2, selection of COPCs. Migration of COPCs from these sources can occur in the following ways:

- Vertical migration of contaminants from surface soil to subsurface soil.
- Leaching of contaminants from subsurface soil to water-bearing zones.
- Vertical migration from shallow water-bearing zones to deeper flow systems.
- Horizontal migration in groundwater in the direction of groundwater flow.
- Groundwater discharge into local streams.
- Wind erosion and subsequent deposition of windblown dust.

The potential for a contaminant to migrate and persist in environmental media is important in estimating exposure. A more detailed discussion of migration pathways is provided in Section 5.

6.3.2 Current and Future Scenarios

The Engineer Area Dump (Site 65) is a four- to five-acre, former, land-disposal site that is now primarily a wooded area due to heavy overgrowth. Immediately east of Site 65 is an equipment training area occupying the area between Site 65 and two small ponds located to the southeast. The Marine Corps Engineer School, which occupies property between Site 65 and Courthouse Bay, utilizes the training area to conduct heavy construction equipment (i.e., bulldozers, graders, etc.) training activities. There are wide, cleared trails between the school and the equipment training area used for movement of the construction equipment. Also, there is a circuit/fitness course with exercise stops (called Butler's Way) along the northern perimeter of the site. This course is used frequently by military base personnel for fitness training.

Current receptors are on-site military personnel. The military personnel are divided into two groups: those involved in training with heavy equipment (referred to as trainees) and those who use the fitness course (referred to as recreational users). The training maneuvers consist of such activities as digging up the soil and moving it around with the bulldozers, graders, etc. Consequently, it is necessary to consider exposure to both surface and subsurface soil through ingestion, dermal contact and inhalation of fugitive dust from vehicular traffic. Military personnel who use the fitness course for exercising are considered to be exposed to surface soil. Potential surface soil exposure pathways are incidental ingestion, dermal contact, and inhalation of fugitive dust.

Presently, the groundwater at the site is not used for potable purposes. Consequently, exposure to groundwater is not considered to be applicable to current scenarios at the site. Exposure to surface water and sediment is not expected for either military personnel group. However, fishing is allowed in the two small ponds, Courthouse Bay Pond and Power Line Pond, southeast of Site 65. Members of the public are allowed limited access to these ponds from 8:00 AM to 5:00 PM to fish. To be conservative, surface water and sediment exposure to adult and child fisherman receptors is assessed. The potential exposure pathways are ingestion and dermal contact of surface water and sediment. Fish were taken from Courthouse Bay Pond and Powerline Pond to obtain fish tissue for chemical analysis. Ingestion of fish tissue, the edible or fillet portion, is also evaluated.

It is unlikely that this site will be used for a residential area in the future. However, to be conservative future groundwater exposure to a child and adult residential receptor was assessed. It assumed that a private well could be installed on-site in the future case. The potential exposure pathways were ingestion, dermal contact, and inhalation while showering.

Similarly, it is anticipated that a residential child and adult may become exposed to surface soil. As a result, potential surface soil exposures via ingestion, dermal contact and inhalation were evaluated for the future residential child and adult receptor. While it is doubtful that surface water recreational facilities will be expanded in the future, a conservative exposure scenario was examined for a future residential population. The potential exposure pathways are ingestion and dermal contact of surface water and sediment.

Finally, potential subsurface soil exposures resulting from future excavation and construction activities were assessed. A future construction worker was evaluated for subsurface soil ingestion, dermal contact, and inhalation.

6.3.3 Exposure Pathways

This section presents exposure pathways, shown in Figure 6-1, associated with each environmental medium and each human receptor group. Each pathway is then qualitatively evaluated for further consideration in the quantitative risk analysis. Table 6-11 presents the matrix of human exposure at Site 65.

6.3.3.1 Surface Soil

Potential exposure to surface soil may occur by incidental soil ingestion, contaminant absorption through the skin and inhalation of airborne particulates. Surface soil exposure is evaluated for future residential children and adults, as well as current military trainees and recreational users.

6.3.3.2 Subsurface Soil

Subsurface soil is available for contact only during excavation activities, so potential exposure to subsurface soil is limited to current military personnel involved in heavy equipment training exercises and construction workers. Exposure pathways involving ingestion, dermal contact, and inhalation of airborne particulates are evaluated for current military personnel in training and future construction workers only.

6.3.3.3 Groundwater

Currently, shallow groundwater at Site 65 is not used as a potable supply for residents or base personnel. However, in the future, (albeit unlikely due to poor transmissivity, insufficient flow, and availability of other sources) shallow groundwater may be tapped for potable water. In this scenario, potential exposure pathways are ingestion, dermal contact and inhalation of volatile contaminants while showering. Groundwater exposure is evaluated for future residential children and adults.

6.3.3.4 Surface Water/Sediment

Access to surface water at Site 65 is limited to two freshwater ponds adjacent to the site - Courthouse Bay Pond and Power Line Pond. It is known that individuals fish in these ponds. In a current scenario, swimming and/or wading are unlikely due to the murky quality of the water. In a future scenario, it is possible that surface water recreational facilities may be expanded for residents. Surface water and sediment exposure pathways include ingestion and dermal contact. Exposure is evaluated for current fisherman (adult and child receptors) and future residential children and adults (although it will be a conservative estimate).

6.3.3.5 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 pathway for human receptors is fish ingestion. Exposure is evaluated for current fishermen, adult and child.

6.3.4 Quantification of Exposure

The concentrations used to estimate chronic daily intakes (CDIs) must represent the type of exposure evaluated. Exposure to groundwater, surface water and sediment can occur distinctly, at one sampling location, or collectively, from various locations. These media are transitory in that their contaminant concentrations change over time. Averaging transitory data obtained from multiple locations is difficult and requires many more data points than those existing at Site 65. Consequently, the existing RI groundwater, surface water and sediment contaminant concentrations, from an exposure standpoint, are considered to be the most representative exposure concentrations available.

Soils are less transitory than the aforementioned media, and in most cases, soil exposure occurs over a wider area (eg., residential exposure). For this reason, upper confidence intervals are used to represent soil contaminant concentrations.

The human health risk assessment for future groundwater use incorporates groundwater data collected from all monitoring wells at a given site. Because the RI data sets are assumed to originate from a skewed underlying distribution, lognormal distribution is used to represent relevant media. This ensures conservative CDI calculations.

In order to account for uncertainty and to be health protective, USEPA risk assessment guidance (USEPA, 1989a) requires that an upper bound estimate of the arithmetic mean concentration, be used to calculate CDI. This estimate, which should be in the high end of the concentration frequency distribution, is called the RME concentration. The RME concentration is defined as the highest concentration that could reasonably be expected to be contacted via a given pathway over a long-term exposure period.

Ninety-five percent upper confidence levels, (95 percent UCL) derived for lognormal data sets, produce concentrations in excess of the 95 percent confidence interval derived assuming normality. The 95 percent UCL for lognormal distribution, or RME, is used for each contaminant in a given data set, in order to quantify conservative exposure values. For exposure areas with limited amounts of data or extreme variability in measured data, the 95 percent UCL can be greater than the maximum detected concentration. In such cases, the maximum concentration is used instead. The true mean; however, may still be higher than this maximum value. In other words, the 95 percent UCL indicates that a higher mean is possible, especially if the most contaminated portion of the site, by chance, has not been sampled (USEPA, 1992c). Statistical summaries are presented in Appendix R.

The 95 percent UCL of the lognormal distribution was calculated using the following equation (USEPA, 1992c):

$$\mathit{Lognormal}\ 95\%\ \mathit{UCL} = e^{(\bar{x} + 0.5s^2 + sH/\sqrt{n-1})}$$

where:

UCL = upper confidence limit
e = constant (base of the natural log, equal to 2.718)
$\bar{x}$ = mean of the transformed data
s = standard deviation of the transformed data
H = H-statistic (Gilbert, 1987)
n = number of samples

In addition to the RME risk descriptor, which is represented by the maximum and/or 95% UCL concentration for the selected COPC, the central tendency (CT) risk descriptor was also used for data sets when the RME concentration term showed a potential risk to human health, specifically, to future on-site residential children. The CT concentration term utilized was the lognormal 95% UCL or the arithmetic mean (if the UCL was greater than the arithmetic mean) (USEPA, 1993). The CT concentrations were then utilized to calculate chemical intakes for the CT-case scenarios. The results of the CT calculations are presented in Section 6.6.6.

6.3.5 Calculation of Chronic Daily Intakes (CDI)

In order to numerically calculate risks for current and future human receptors at Site 65, a CDI must be computed for each COPC, in each relevant exposure pathway. Appendix U contains CDI equations for specific exposure scenarios (USEPA, 1989a).

The following paragraphs present the general equations and input parameters used to calculate CDIs. Input parameters are taken from USEPA's default exposure factors guidelines. USEPA promulgated exposure factors are used in conjunction with USEPA standard default exposure factors for both the CT and RME exposure scenarios; however, the CT exposure scenario was utilized only for future residential children. All inputs not defined by this source are derived either from other USEPA exposure documents or by using best professional judgment. All exposure assessments incorporate representative contaminant concentrations; only one exposure scenario is developed for each exposure route/receptor combination. The CT assumptions, though not discussed below, are presented in the tables in parentheses. Exposure assessment summaries are presented in Tables 6-12 through 6-22.

Carcinogenic risk is calculated as an incremental lifetime risk, and thereby involves exposure duration (years) over the course of a lifetime (70 years, or 25,550 days). Noncarcinogenic risk, on the other hand, involves average annual exposure. Exposure time and frequency represent the number of hours of exposure per day, and days of exposure per year, respectively. Generally, noncarcinogenic risk for certain exposure routes (e.g., soil ingestion) is greater for children, as the combination of a lower body weight and an exposure frequency equal to that of an adult increases their ingestion rates.

Future residential exposure scenarios address one to six-year old children weighing 15 kg, and adults weighing 70 kg, on average (USEPA, 1989a). An exposure duration of four years is used to estimate military residential exposure duration. A one year duration is used for future construction workers.

6.3.5.1 Incidental Ingestion of Soil

The equation for CDI, calculated for all human receptors potentially experiencing incidental soil ingestion, is as follows:

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

Where:

C = Contaminant concentration in soil (mg/kg)
IR = Ingestion rate (mg/day)
CF = Conversion factor (1E-6 kg/mg)
Fi = Fraction ingested from source (dimensionless)
EF = Exposure frequency (days/year)
ED = Exposure duration (years)
BW = Body weight (kg)
AT = Averaging time (days)

The following paragraphs explain the exposure assumptions used to evaluate the impact of COPCs in incidental soil ingestion. In each exposure scenario, the Fi value, indicating the portion of exposure from soils actually containing COPCs, is 100 percent.

Future On-Site Residents

Future on-site residents may be exposed to COPCs in surface soil, during outdoor activities around their homes. In addition, children and adults may be exposed to COPCs by incidental ingestion of surface soil through hand-to-mouth contact.

Ingestion rates (IR) for adults and children in this scenario are assumed to be 100 mg/day and 200 mg/day, respectively (USEPA, 1991a). The EF for both receptor groups is 350 days per year (USEPA, 1991a). Residential exposure duration (ED) is divided into two parts. First, a six-year ED, used for young children, represents the period of highest soil ingestion (200 mg/day). Second, a 24-year ED, used for older children and adults, represents a period of lower soil ingestion (100 mg/day) (USEPA, 1991a).

The BW of future residential children (age one to six years) is assumed to be 15 kg, and 70 kg is used as the BW for future residential adults (USEPA, 1989a).

AT values of 25,550 days (70 years x 365 days/year) (USEPA, 1989a) and 8,760 days (24 years x 365 days/year) (USEPA, 1989a) are assigned to potentially carcinogenic and noncarcinogenic constituents, respectively, to estimate adult CDIs. The AT used for children exposed to noncarcinogens is 2,190 days (6 years x 365 days/year) (USEPA, 1989a).

Military Personnel - Trainee

Military personnel may be exposed to COPCs by ingesting surface soil and subsurface soil, during the course of heavy construction equipment training activities conducted at Site 65.

The IR for military personnel exposed to surficial soils is assumed to be 100 mg/day (USEPA, 1989a). An EF of 260 days per year is used in conjunction with a four-year ED. The EF value, based on site-specific professional judgement, represents the reasonable worst case scenario of a training instructor present five days/week for 52 weeks over the course of a year.

Carcinogenic compounds have an AT 25,550 days (70 years x 365 days/year), and the AT for noncarcinogenic compounds is 1,460 days (four years ED x 365 days/year). Adult average body weight (BW) is 70 kg (USEPA, 1989a).

Military Personnel - Recreational User

Military personnel may be exposed to COPCs by ingesting surface soil while jogging and/or exercising on the fitness course, Butler's Way, located near Site 65.

The IR for military personnel exposed to surficial soils is assumed to be 100 mg/day (USEPA, 1989a). An EF of 260 days per year is used in conjunction with a four-year ED. The EF value, based on site-specific professional judgement, maintains a reasonable worst case scenario of an individual using the fitness course 5 days/week for 52 weeks/year.

AT (carcinogens and noncarcinogens) and BW values are the same as those used in the military trainee scenario.

Future Construction Worker

Construction workers may be exposed to COPCs through incidental ingestion of subsurface soil, during the course of excavation activities. An IR of 480 mg/day (USEPA, 1991a) is assigned to future construction workers. A 90-day per year EF is used in conjunction with a one-year ED, representing the estimated length of a typical construction job (USEPA, 1991a). AT_{nc} is 365 days (USEPA, 1989a). CF, Fi, BW and AT_c values are the same as those used for adults in the residential exposure scenarios. A summary of incidental soil ingestion exposure assessment input parameters is presented in Table 6-12.

6.3.5.2 Dermal Contact with Soil

The equation for CDI, calculated for all human receptors potentially experiencing dermal contact with soil, is as follows:

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

Where:

C = Contaminant concentration in soil (mg/kg)
CF = Conversion factor (kg/mg)
SA = Skin surface available for contact (cm^2)
AF = Soil to skin adherence factor (mg/cm^2)
ABS = Absorption factor (dimensionless)
EF = Exposure frequency (days/year)
ED = Exposure duration (years)
BW = Body weight (kg)
AT = Averaging time (days)

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

Future On-Site Residents

Future on-site residents may be exposed to COPCs through dermal contact with surface soil during outdoor activities near their homes. The SA values represent reasonable worst case scenarios for an individual wearing a short-sleeved shirt, shorts, and shoes. The exposed skin surface area is limited to the head, hands, forearms and lower legs. Twenty-five percent of the upper-bound total body surface area yields a default SA of 5,800 cm^2 for adults (USEPA, 1992a). The exposed skin surface for a child (2,300 cm^2) is estimated using an average of the 50th (0.866 m^2) and the 95th (1.06 m^2) percentile body surface for a six year old child, multiplied by 25 percent (USEPA, 1992a). ED, EF, BW and AT values are the same as those used in the incidental soil ingestion scenario. Data on AF is limited. A value of 1.0 mg/cm^2 is used in this assessment (USEPA, 1991b).

Military Personnel - Trainees

Base personnel in training may be exposed to COPCs through dermal contact with surface and subsurface soil, during the course of equipment training activities. It is assumed that military personnel taking part in training exercises near Site 65 wear military issue work clothes consisting of a short-sleeved shirt, fatigue trousers (long pants), and boots. Exposed body parts include the hands (840 cm^2), head (1,180 cm^2), and arms (2,280 cm^2) (USEPA, 1992a). The total SA for the military trainee is 4,300 cm^2. The ED, EF, BW and AT values are the same as those used in the incidental soil ingestion scenario.

Military Personnel - Recreational User

Military personnel may be exposed to COPCs through dermal contact with surface soil while using the fitness course (called Butler's Way) adjacent to Site 65. It is assumed that military personnel involved in recreational activities have approximately 5,800 cm^2 of skin surface (SA) available for contact with COPCs (USEPA, 1992a). Exposed body parts include the head, hands, forearms, and lower legs, and represent 25 percent of total body surface area (23,000 cm^2). The ED, EF, BW and AT values are the same as those used in the incidental soil ingestion scenario.

Future Construction Worker

Construction workers may be exposed to COPCs through dermal contact with subsurface soil, experienced during excavation activities. It is assumed that a construction worker wears a short-sleeved shirt, long pants and boots. Exposed skin surface area is then limited to the head, (1,180 cm^2) arms (2,280 cm^2) and hands (840 cm^2) (USEPA, 1992a). Total SA for the construction worker is 4,300 cm^2. ED and EF values are the same as those used in the incidental soil ingestion scenario. Data on AF is limited. A value of 1.0 mg/cm^2 is used in this assessment (USEPA, 1991b). A summary of dermal contact with soil exposure assessment input parameters is presented in Table 6-13.

6.3.5.3 Inhalation of Fugitive Particulates

The equation for CDI, calculated for future residents and base personnel potentially inhaling particulates, is as follows:

$$CDI = \frac{C \ x \ IR \ x \ EF \ x \ ED \ x \ 1/PEF}{BW \ x \ AT}$$

Where:

C = Contaminant concentration in soil (mg/kg)
IR = Inhalation rate (m^3/hr)
EF = Exposure frequency (days/year)
ED = Exposure duration (years)
1/PEF = Particulate emission factor (m^3/kg)
BW = Body weight (kg)
AT = Averaging time (days)

PEF relates contaminant concentrations in soil to concentrations of respirable particles in air, from surface soil fugitive dust emissions. A default PEF is used in this assessment (USEPA 1989b). Particulate emissions at contaminated sites occur vis-a-vis wind erosion, and thereby vary according to irritability of the surface material. PEF is 4.63E+09 m^3/kg for all receptors in this scenario (USEPA, 1989b).

The following paragraphs explain the exposure assumptions used to evaluate COPC impact in particulate inhalation.

Future On-Site Residents

Future on-site residents may be exposed to COPCs by inhaling fugitive dust during outdoor activities near their homes. The adult IR for residential exposure scenarios is 20 m^3/day (USEPA 1991a), and the IR for children is 15 m^3/day (USEPA, 1995). ED, EF, BW and AT values are the same as those used the incidental soil ingestion scenario.

Military Personnel - Trainee

During work related activities, military personnel may inhale COPCs emitted as fugitive dust from surface and subsurface soil. An inhalation rate of 20 m^3/day is used in this scenario (USEPA 1991a). ED, EF, BW and AT values are the same as those used in the incidental soil ingestion scenario.

Military Personnel - Recreational User

During fitness related activities, military personnel may inhale COPCs emitted as fugitive dust. An inhalation rate of 20 m^3/day is used in this scenario (USEPA 1991a). ED, EF, BW and AT values are the same as those used in the incidental soil ingestion scenario.

Future Construction Worker

Construction workers may be exposed to COPCs through inhalation of fugitive particulates in subsurface soil, during excavation activities. IR is 20 m^3/day (USEPA 1991a). ED, EF, BW and AT values are the same as those used in the incidental soil ingestion scenario. A summary of particulate inhalation exposure assessment input parameters is presented in Table 6-14.

6.3.5.4 Ingestion of Groundwater

Currently at Site 65, deep groundwater provides the potable water supply. Due to the generally low water quality and poor flow rates in the shallow aquifer, it is not likely that the shallow aquifer will be developed as a potable water supply. However, should residential housing be constructed in the future, shallow groundwater may be used to provide potable supplies. Currently, there are five supply wells within a one mile radius of this site. These supply wells utilize the Castle Hayne aquifer. If well contamination is reported, the wells are no longer used as potable water supplies.

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

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

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 explain the exposure assumptions used to calculate the impact of COPCs in groundwater ingestion.

Future On-Site Residents

Exposure to COPCs by groundwater ingestion is a possible future exposure pathway for children and adults. A six-year-old child weighing 15kg has an IR of 1.0 L/day (USEPA, 1989a). This rate provides a conservative exposure estimate, in terms of systemic health effects. This value assumes that children obtain all the tap water they drink from the same source, for 350 days/year (EF). ED for young children is six years (USEPA, 1991a). AT is 2,190 days (six years x 365 days/year) for noncarcinogenic compound exposure.

IR for a 70 kg adult is 2 L/day (USEPA 1989a). ED is 30 years, the national upper-bound (90th percentile) time spent at one residence (USEPA 1991a). AT for noncarcinogens is 10,950 days. An AT of 25,550 days (70 years x 365 days/year) is used to evaluate exposure to potential carcinogenic compounds, for children and adults. A summary of groundwater ingestion exposure assessment input parameters is presented in Table 6-15.

6.3.5.5 Dermal Contact with Groundwater

As stated previously, deep groundwater currently provides the potable water supply at Site 65. Due to the generally low water quality and poor flow rates in the shallow aquifer, it is not likely that the shallow aquifer will be developed as a potable water supply. However, should residential housing be constructed in the future, shallow groundwater may be used to provide potable supplies. Currently, there are five supply wells within a one mile radius of this site. These supply wells tap the Castle Hayne aquifer. If well contamination is reported, the wells are no longer used as potable water supplies.

The equation for CDI, calculated for all human receptors potentially experiencing dermal contact with groundwater, is as follows:

$$CDI = \frac{C \ x \ SA \ x \ PC \ x \ ET \ x \ EF \ x \ ED \ x \ CF}{BW \ x \ AT}$$

Where:

C = Contaminant concentration in groundwater (mg/L)
SA = Surface area available for contact (cm^2)
PC = Dermal permeability constant (cm/hr)
ET = Exposure time (hour/day)
EF = Exposure frequency (days/year)
ED = Exposure duration (years)
CF = Conversion factor (1 L/1000 cm^3)
BW = Body weight (kg)
AT = Averaging time (days)

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

Future On-Site Residents

Children and adults may be exposed to COPCs through dermal contact with groundwater while bathing or showering. It is assumed that bathing takes place 350 days/year (EF). The SA available for dermal absorption is estimated at 10,000 cm^2 for children and 23,000 cm^{2} for adults (USEPA, 1992a).

PC indicates the movement of a chemical through the skin and into the blood stream. The permeability of a chemical is an important property in evaluating actual absorbed dose; however, many compounds do not have published PC values. The permeability constant for water (1.55E-03 cm/hr) is used as a default value for those compounds without established PC values (USEPA 1992a). This value may, in fact, be a reasonable estimate of chemical absorption rates when COPC concentrations are in the part-per-billion range. ET for bathing or showering is 0.25 hours/day, a conservative estimate. ED, BW and AT values are the same as those used in the groundwater ingestion scenario. A summary of dermal contact with groundwater exposure assessment input parameters is presented in Table 6-16.

6.3.5.6 Inhalation of Volatile Organics While Showering

The Andelman Shower Model (1985) is applied in a qualitative assessment of inhaling VOCs released from shower water. Contaminant (VOC) concentrations in air while showering are estimated by a balance between the rate of chemical release from the shower and the rate of air exchange between the shower and the bathroom and the rest of the house. The calculations are based on the efficiency of the volatilization of trichloroethene from shower water as observed in model showers, as well as in several homes.

The equation for CDI, calculated for all human receptors potentially inhaling groundwater volatile contaminants while showering, is as follows:

$$CDI \; \frac{C \text{ x } IR \text{ x } ET \text{ x } EF \text{ x } ED}{BW \text{ x } AT}$$

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

The potential to inhale vaporized volatile organic COPCs while showering is considered for both children and adults. It is assumed that showering takes place 350 days/year (EF). IR for children and adults is 0.6 m^3/hr. ET is 0.25 hrs/day for both receptors (USEPA, 1989a). ED, BW, and AT values are the same as those used in the groundwater ingestion scenario. A summary of groundwater inhalation exposure assessment input parameters is presented in Table 6-17.

6.3.5.7 Incidental Ingestion of Surface Water

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

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

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

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

Future On-Site Residents

The IR, ET and EF values used for future residents apply to both children and adults. IR is 0.05 L/hr (USEPA, 1989a). ET is 2.6 hr/day (USEPA, 1992a). EF is 48 days/yr. This value represents a site-specific professional judgement, according to which exposure to surface water is estimated at eight days/month, for six months/year. ED values represent lifetime residential exposure durations. They are the same as those used for future children and adult residents in the groundwater exposure scenarios. BW and AT values are also the same as those used in groundwater exposure scenarios.

Fisherman

Individuals known to fish from Courthouse Bay Pond and Power Line Pond may be exposed to COPCs through surface water ingestion. Exposure to surface water through activities such as swimming or wading is considered unlikely due to the murky nature and high algae content of the pond water. However, a surface water ingestion scenario is included based on conservative professional judgement. The IR, ET, EF, ED, BW and AT values are the same as those given above for future resident adults and children. A summary of surface water ingestion exposure assessment input parameters is presented in Table 6-18.

6.3.5.8 Dermal Contact with Surface Water

The equation for CDI, for all residents potentially experiencing dermal contact with surface water, is as follows:

$$CDI = \frac{C \ x \ CF \ x \ SA \ x \ EF \ x \ ED \ x \ ET \ x \ PC}{BW \ x \ AT}$$

Where: C = Contaminant concentration in soil (mg/kg)
CF = Conversion factor (kg/mg)
SA = Surface available for contact (cm^2/event)
EF = Exposure frequency (days/year)
ED = Exposure duration (years)
ET = Exposure Time (hr/day
PC = Dermal Permeability Constant (cm/hr)
BW = Body weight (kg)
AT_c = Averaging time carcinogen (days)
AT_{nc} = Averaging time noncarcinogen (days)

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

Future On-Site Residents

SA values represent dermal surface area of hands, forearms and lower extremities exposed for contact with surface water. SA is 2,100 cm^2 for children and 8,300 cm^2 for adults (USEPA, 1992a). ET, EF, ED, BW and AT values are the same as those used for future children and adult residents in the surface water ingestion exposure scenario. PC values are chemical specific (USEPA, 1992a). They are provided on the CDI spreadsheets in Appendix U.

Fisherman

Although unlikely, an exposure scenario for individuals who may fish in the ponds adjacent to Site 65 is presented to evaluate the impact of COPCs in dermal contact with surface water. Values of 8,300 cm^2 for adults and 2,100 cm^2 for children are used for the surface area exposed for contact with surface water. ET, EF, ED, BW and AT values are the same as those used in the surface water ingestion exposure scenario. PC values are chemical-specific. A summary of surface water dermal contact exposure assessment input parameters is presented in Table 6-19.

6.3.5.9 Incidental Ingestion of Sediment

The equation for CDI, for all residents and fishermen potentially experiencing incidental ingestion of sediment, is as follows:

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

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

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

Future On-Site Residents

IR is 200 mg/day for children and 100 mg/day for adults (USEPA, 1989a). EF, ED, BW and AT values are the same as those used for future children and adult residents in the surface water exposure scenarios.

Fisherman

Contact with sediment by individuals who fish from the ponds on Site 65 is considered unlikely for the same reasons given in the surface water ingestion section. However, a conservative exposure scenario is presented in the event that exposure to sediment were to occur.

IR for the fisherman is 200 mg/day for an adult and 100 mg/day for a child. EF, ED, BW and AT values are the same as those for the fisherman in the surface water exposure scenario. CF is 1E-06 kg/mg (USEPA, 1989a). It is applied to sediment exposure analyses for both children and adults. A summary of sediment ingestion exposure assessment input parameters is presented in Table 6-20.

6.3.5.10 Dermal Contact with Sediment

The equation for CDI, for all residents potentially experiencing dermal contact with sediment, is as follows:

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

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

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

Future On-Site Residents

SA values are the same as those used for future residential children and adults in the dermal contact with surface water exposure scenario. AF is 1.0 mg/cm^2. It is used to evaluate dermal contact with sediment for both children and adults. ABS is 1.0 percent for organics and 0.1 percent for inorganics (USEPA, 1991b). EF, ED, BW, AT and CF values are the same as those used in the sediment ingestion exposure scenario.

Fisherman

The SA value is the same as that used for the fisherman (adult and child) in the dermal contact with surface water exposure scenario. EF, ED, BW, AT and CF values are the same as those used in the sediment ingestion exposure scenario. A summary of sediment dermal contact exposure assessment input parameters is presented in Table 6-21. Appendix U contains CDI calculation spreadsheets for specific exposure scenarios (USEPA 1989a).

6.3.5.11 Ingestion of Fish Tissue

The equation for CDI, for those individuals potentially ingesting edible fish tissue, is as follows:

$$CDI = \frac{C \ x \ IR \ x \ Fi \ x \ EF \ x \ ED}{BW \ x \ AT \ x \ DY}$$

Where:

C = Concentration of contaminant in fish (mg/kg)
IR = Ingestion rate (kg/meal)
Fi = Fraction ingested from source (dimensionless)
EF = Exposure frequency (meals/yr)
ED = Exposure duration (years)
BW = Body weight (kg)
AT = Averaging time (years)
DY = days per year (days/yr)

Fisherman

The IR and EF values used for the adult and child fisherman are 0.145 kg/meal (USEPA, 1993) and 48 meals/year (USEPA, 1989a), respectively. Due to the lack of site-specific information as well as a published IR value for children, 0.145 kg/meal was used to provide a conservative estimate. ED, BW, and AT values are the same as those used for future children and adult residents in the sediment ingestion exposure scenario. The Fi value, indicating the portion of exposure from fish tissue actually containing COPCs, is 100 percent. A summary of fish ingestion exposure assessment input parameters is presented in Table 6-22.

6.4 Toxicity Assessment

This section reviews toxicological information available for COPCs identified in Section 6.2.

6.4.1 Toxicological Evaluation

Toxicological evaluation addresses the inherent toxicity of chemical compounds. It consists of the review of scientific data to determine the nature and extent of the potential human health and environmental effects associated with exposure to various contaminants.

Because of uncertainties in exposure estimates and inherent difficulties in determining causal relationships established by epidemiological studies, human data from occupational exposures are often insufficient for determining quantitative indices of toxicity. For this reason, animal bioassays are conducted under controlled conditions, and results are extrapolated to humans. There are several stages in this extrapolation. First, to account for species differences, conversion factors are used to apply test animal data to human studies. Second, high dosages administered to test animals must be translated into lower dosages, more typical of human exposure. When developing acceptable human doses of noncarcinogenic contaminants, safety factors and modifying factors are applied to animal test results. When studying carcinogens, mathematical models are used to convert high dosage effects to effects at lower dosages. Epidemiological data can then be used to determine credibility of these experimentally derived indices.

Reference dose (RfD) is an experimentally derived exposure index for noncarcinogenic contaminants, and carcinogenic slope factor (CSF) is an experimentally derived exposure index for carcinogens. These values are addressed, within the context of dose-response evaluation, in the next section.

Available toxicological information indicates that many COPCs have both carcinogenic and noncarcinogenic health effects in humans and/or experimental animals. Although COPCs may cause adverse health and environmental effects, dose-response relationships and exposure must be evaluated before receptor risk can be determined. Dose-response relationships correlate dose magnitude with the probability of toxic effects, as discussed in the following section.

6.4.2 Dose-Response Evaluation

An important component in risk assessment is the relationship between the dose of a compound and the potential for adverse health effects resulting from the exposure to that dose. Dose-response relationships provide a means by which potential public health impacts may be evaluated. The published information on doses and responses is used in conjunction with information on the nature and magnitude of exposure to develop an estimate of risk.

6.4.2.1 Carcinogenic Slope Factor

CSFs are used to estimate upper-bound lifetime probability of developing cancer as a result of exposure to a particular dose of a potential carcinogen (USEPA, 1989a). This factor is generally reported in $(mg/kg/day)^{-1}$ CSF is derived by converting high dose-response values produced by animal studies to low dose-response values, and by using an assumed low-dosage linear multistage model. The value used in reporting the slope factor is the upper 95th percent confidence limit.

USEPA weight-of-evidence classifications accompany CSFs. They provide the weight of evidence according to which particular contaminants are defined as potential human carcinogens.

The USEPA's Human Health Assessment Group (HHAG) classifies carcinogenic potential by placing chemicals into one of the following groups, according to weight of evidence from epidemiological and animal studies:

Group A - Human Carcinogen (sufficient evidence of carcinogenicity in humans)

Group B - Probable Human Carcinogen (B1 - limited evidence of carcinogenicity in humans; B2 - sufficient evidence of carcinogenicity in animals with inadequate or lack of evidence in humans)

Group C - Possible Human Carcinogen (limited evidence of carcinogenicity in animals and inadequate or lack of human data)

Group D - Not Classifiable as to Human Carcinogenicity (inadequate or no evidence)

Group E - Evidence of Noncarcinogenicity for Humans (no evidence of carcinogenicity in adequate studies)

6.4.2.2 Reference Dose

RfD is developed for chronic and/or subchronic chemical exposure and is based solely on noncarcinogenic effects of chemical substances. It is defined as an estimate of the daily exposure level for a human population that is not likely to produce an appreciable risk of adverse effects during a lifetime. The RfD is usually expressed as dose (mg) per unit body weight (kg) per unit time (day). It is generally derived by dividing a no-observed-(adverse)-effect-level (NOAEL or NOEL) or a lowest observed-adverse-effect-level (LOAEL) for the critical toxic effect, by the appropriate "uncertainty factor (UF)". Effect levels are determined by laboratory or epidemiological studies. The UF is based on the availability of toxicity data.

UFs usually consist of multiples of 10, where each factor represents a specific area of uncertainty naturally present in the extrapolation process. These UFs are presented below and were taken from the Risk Assessment Guidance Document for Superfund, Volume I, Human Health Evaluation Manual (Part A) (USEPA, 1989a):

- A UF of 10 is to account for variation in the general population and is intended to protect sensitive populations (e.g., elderly; children).
- A UF of 10 is used when extrapolating from animals to humans. This factor is intended to account for the interspecies variability between humans and other mammals.
- A UF of 10 is used when a NOAEL derived from a subchronic instead of a chronic study is used as the basis for a chronic RfD.
- A UF of 10 is used when a LOAEL is used instead of a NOAEL. This factor is intended to account for the uncertainty associated with extrapolating from LOAELs to NOAELs.

In addition to UFs, a modifying factor (MF) is applied to each reference dose and is defined as:

- An MF ranging from >0 to 10 is included to reflect a qualitative professional assessment of additional uncertainties in the critical study and in the entire data base for the chemical not explicitly addressed by the preceding uncertainty factors. The default for the MF is 1.

Thus, the RfD incorporates the uncertainty of the evidence for chronic human health effects. Even if applicable human data exist, the RfD still maintains a margin of safety so that chronic human health effects are not underestimated.

Toxicity factors and the USEPA weight-of-evidence classifications are presented in Table 6-23. The hierarchy for choosing these values is as follows (USEPA, 1989a):

- Integrated Risk Information System (IRIS)
- Health Effects Assessment Summary Table (HEAST)
- USEPA National Center for Environmental Assessment (EPA-NCEA) (USEPA, 1997)

The IRIS database is updated monthly and contains both verified CSFs and RfDs. The USEPA has formed the Carcinogen Risk Assessment Verification Endeavor (CRAVE) Workgroup to review and to validate toxicity values used in developing CSFs. Once the slope factors have been verified with extensive peer review, they appear in the IRIS database. Like the CSF Workgroup, an RfD Workgroup has been formed by the USEPA to review existing data used to derive RfDs. Once RfDs have been verified, they also appear in IRIS.

HEAST, on the other hand, provides both interim (unverified) and verified CSFs and RFDs. This document is published quarterly and incorporates any applicable changes to its database.

6.5 Risk Characterization

This section presents estimated incremental lifetime cancer risks (ICRs) and hazard indices (HIs) for identified receptor groups possibly exposed to COPCs by the exposure pathways presented in Section 6.3.

Quantitative risk calculations for carcinogenic compounds estimate ICR levels for individuals in a given population. An ICR of 1E-06, for example, indicates that, within a lifetime of exposure to site-specific contamination, one additional case of cancer may occur per one million exposed individuals.

The following represents an individual's ICR:

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

where CDI_i is the chronic daily intake (mg/kg/day) for compound I, and CSF_I is the compound's carcinogenic slope factor [$(mg/kg/day)^{-1}$]. The CSF is defined as an upper 95th percentile confidence limit of the probability of a carcinogenic response, based on experimental animal data. The CDI defines exposure, expressed as a mass of a substance contracted per unit body weight per unit time, averaged over a period of time (i.e., six years to a lifetime). The above equation is derived assuming that cancer is a non-threshold process and that the potential excess risk level is proportional to the cumulative intake over a lifetime.

Quantitative noncarcinogenic risk calculations assume that noncarcinogenic compounds have threshold values for toxicological effects. Noncarcinogenic effect weighs CDI against threshold levels (RfDs). Noncarcinogenic effect is estimated by calculating the hazard index (HI), defined by the following equation:

$$HI = HQ_1 + HQ_2 + ...HQ_n$$

$$= \sum_{i=1}^{n} HQ_i$$

$$\gamma \text{ where } HQ_i = CDI_i / RfD_i$$

where HQi is the hazard quotient for contaminant I, CDI_i is chronic daily intake (mg/kg/day) and RfD_i is the reference dose (mg/kg/day) for contaminant I, over a prolonged period of exposure.

6.5.1 Human Health Risks

ICR and HI values associated with exposure to environmental media at Site 65 (soil, groundwater, surface water/sediment, and fish tissue) are presented in Tables 6-24, 6-25 and 6-26, respectively. Total carcinogenic and noncarcinogenic risks, per medium, for all relevant receptor groups, are provided in these tables. ICR and HI are also broken down to show risks from specific exposure pathways: ingestion, dermal contact and inhalation (where applicable).

The text in this section explains the calculated risk results for Site 65, presented in Tables 6-24, 6-25 and 6-26. A cancer risk range of 1E-04 to 1E-06 is used to evaluate calculated ICR levels. Any ICR value within this range is considered "acceptable"; an ICR greater than 1E-04 denotes an existing cancer risk. A noncarcinogenic risk of 1.0 is used as an upper limit to which calculated HI values are compared. Any HI exceeding 1.0 indicates an existing noncarcinogenic risk (USEPA 1989a).

6.5.1.1 Soil

As shown in Table 6-24, ICR values calculated for future residential children and adults, military personnel (both trainees and recreational users), and future construction workers fall within the USEPA's acceptable risk range. These receptors are then not at risk from carcinogens in Site 65 soil. HI values calculated for these receptors are less than 1.0, below the acceptable risk level. Adverse systemic health effects are then not likely to be caused by noncarcinogens in Site 65 soil.

6.5.1.2 Groundwater

As shown in Table 6-25, no carcinogenic contaminants were retained as COPCs in groundwater. Therefore, no ICR values were calculated. These receptors are then not at risk from carcinogens in Site 65 groundwater. The HI value calculated for future residential adults is less than 1.0, the acceptable risk level. However, the HI calculated for future residential children exceeded 1.0. The groundwater ingestion pathway contributed 100 percent of the elevated HI (1.9). Iron was the primary risk driver for this pathway.

6.5.1.3 Surface Water/Sediment

As shown in Table 6-26, no carcinogenic contaminants were retained as COPCs in surface water. Therefore, no ICR values were calculated. These receptors are then not at risk from carcinogens in Site 65 surface water/sediment. HI values calculated for future residential children and adults are less than 1.0, below the acceptable risk level. Adverse systemic health effects are then not likely to be caused by noncarcinogens in Site 65 surface water/sediment.

6.5.1.4 Fish Tissue

As shown in Table 6-26, no carcinogenic contaminants were retained as COPCs in fish tissue. Therefore, no ICR values were calculated. These receptors are then not at risk from carcinogens in Site 65 fish tissue.

The HI values calculated for the adult and child fisherman (HI=1.3 and 6.1, respectively) are above EPA's acceptable risk level of 1.0. It should be noted that the exposure parameters used to calculate the CDI for these receptors are very conservative. The IR value of 0.145 kg/meal, the RME for a 70 kg adult, was used for the child since there is no site-specific information available concerning the fish consumption rate of young children. This HI value, while very conservative, is considered protective of young children, as well as adults, for adverse systemic health effects.

6.6 Sources of Uncertainty

Uncertainties may arise during the risk assessment process. This section presents site specific sources of uncertainty in the risk assessment:

- Analytical data
- Exposure assessment
- Sampling strategy
- Toxicity assessment
- Compounds not qualitatively evaluated
- Results of CT calculations

6.6.1 Analytical Data

The credibility of the BRA relies on the quality of the analytical data available to the risk assessor. Analytical data are limited by the precision and accuracy of the analytical method. In addition, the statistical methods used to compile and analyze data (mean concentration, standard deviation, and detection frequencies) are subject to uncertainty in the ability to evaluate data. In general, increasing the number of data points reduces the statistical uncertainty.

Data validation serves to reduce some of the inherent uncertainty associated with analytical data by establishing the usability of the data to the risk assessor who may or may not choose to include the data point in risk estimation. Data can be qualified as "J" (estimated) for many reasons, including a slight exceedence of holding times, high or low surrogate recovery, or intra-sample variability. Data qualified with "J" were retained for risk assessment. Organic data qualified with "B" (detected in blank) or "R" (rejected/unreliable) were not applied to risk analysis. Because the sampling and analytical program at Site 65 was comprehensive, dismissing data points qualified with "B" or "R" did not significantly increase uncertainty in the risk assessment.

6.6.2 Exposure Assessment

When performing exposure assessments, uncertainties can arise from two main sources. First, the chemical concentration to which a receptor may be exposed must be estimated for every medium of interest. Second, uncertainties can arise in estimating contaminant intakes resulting from contact with a particular medium.

Estimating the contaminant concentration in a given medium to which a human receptor may be exposed can be as simple as deriving the 95th percent upper confidence limit of the mean for a given data set. More complex methods for deriving contaminant concentration are necessary when exposure to COPCs in a given medium occurs subsequent to contaminant release from another medium, or when analytical data are not available to characterize the release. In this case, modeling is usually employed to estimate potential human exposure.

Potential inhalation of fugitive dusts from affected soils is estimated by using USEPA's Rapid Assessment of Exposure to Particulate Emissions from Surface Contamination (Cowherd et al., 1985). The Cowherd model employs the use of a site-specific PEF for wind erosion based on source area and vegetative cover. A conservative PEF estimate was derived for Site 65 by assuming that the entire area was not covered with vegetation and was unlimited in its erosion potential.

Groundwater samples were analyzed for total (unfiltered) and dissolved (filtered) inorganic contaminants. These samples were obtained from wells which were constructed using USEPA Region IV monitoring well design specifications. Groundwater taken from monitoring wells cannot be considered representative of potable groundwater, or groundwater which is obtained from a domestic well at the tap. The use of total inorganic analytical results overestimates the potential human health risks associated with potable use scenarios. However, in order to produce the most conservative risk estimates, total organic results were used to calculate the potential intake associated with groundwater use.

As stated previously, the shallow groundwater at Camp Lejeune is currently not used as a potable source. Receptors are only exposed to groundwater drawn from the deep zone. For this reason, exposure to shallow groundwater is not evaluated for current receptors. Groundwater exposure is evaluated for future residents only, as there is a possibility that shallow groundwater may be tapped someday.

To estimate receptor intake, certain assumptions must be made about exposure events, exposure durations and the corresponding assimilation of contaminants by the receptor. Exposure factors have been created from a range of values generated by studies conducted by the scientific community, and have been reviewed by the USEPA. Conservative assumption for daily intakes are employed throughout the BRA when values are not available; they are designed to produce low error, to protect human health and to yield reasonable clean-up goals. In all instances, the values, conservative scientific judgments and conservative assumptions used in the risk assessment concur with USEPA guidelines.

6.6.3 Sampling Strategy

As an environmental medium, soil is available for direct contact exposure, and it is often the main source of contamination released to other media. Soil sampling intervals should be appropriate for the exposure pathways and contaminant transport routes of concern. Surface soil exposure assessment is based on samples collected from the shallowest depth, zero to one foot below the ground surface. Subsurface soil samples are necessary to generate data for exposure assessment when soil excavation is possible, or if leaching of chemicals to groundwater is likely. Subsurface soil samples are collected at depths greater than one foot below the ground surface.

6.6.4 Toxicity Assessment

In making quantitative estimates about the toxicity of varying chemical doses, uncertainties arise from two sources. First, existing data usually provide insufficient information about toxic exposure and subsequent effects. Human exposure data display inherent temporal variability and often lack adequate concentration estimates. Animal studies are often used to subsidize available human data. In the process of extrapolating animal results to humans; however, more uncertainties can arise. Second, in order to obtain visible toxic effects in experimental animals, high chemical doses are employed over short periods of time. Doses typical of human exposure; however, are much lower, relative to those doses administered to experimental animals. In order to apply animal test results to human exposure assessments, data must be adjusted to extrapolate from high dose effects to low dose effects.

In extrapolating effects from animal receptors to human receptors, and from high doses to low doses, scientific judgment and conservative assumptions are employed. In selecting animal studies for use in dose response calculations, the following factors are considered:

- Studies are preferred in which the animal closely mimics human pharmacokinetics
- Studies are preferred in which dose intake most closely mimics intake route and duration for humans
- Studies are preferred in which the most sensitive responses to the compound in question is demonstrated

In order to evaluate compounds that cause threshold effects, (i.e., noncarcinogens) safety factors are taken into account when experimental results are extrapolated from animals to humans, and from high to low doses. Employing conservative assumptions yields quantitative toxicity indices that are not expected to underestimate potential toxic effects, but may overestimate these effects by some magnitude.

6.6.5 Compounds Not Quantitatively Evaluated

The following contaminants detected at Site 65 were not quantitatively evaluated in the BRA, as there is no toxicity information promulgated by the USEPA:

- lead.

6.6.6 Results of CT Calculations

There was an unacceptable HI calculated for the future residential child under the groundwater ingestion RME exposure scenario. CT exposure scenarios for the future residential child were then applied to all media and pathways and carcinogenic and noncarcinogenic risks were recalculated. Under the CT exposure scenarios, the total site HI for the future residential child (0.66) was less than the acceptable risk level of 1.0. Specifically, the HI calculated for the groundwater ingestion pathway was 0.3. In addition, the total site ICR for the future residential child fell below USEPA's acceptable risk range (1.0E-06<ICR<1.0E-04). Therefore, it is unlikely that under a CT (or average) exposure scenario, adverse huma health effects would occur. The CDI calculations for the CT exposure scenarios can be found in Appendix T.

6.7 BRA Conclusions

The BRA evaluates environmental media at Site 65, in terms of human health risk. Potential receptors at the site include future residential children and adults, current military personnel (trainees and recreational users), fisherman (adult and child), and future construction workers. Total site ICR and HI per receptor group are estimated by combining ICRs and HIs associated with specific exposure pathways. The following algorithms define total site risk:

1. Future Residents (Children and Adults)
   a. Incidental ingestion of COPCs in surface soil + dermal contact with COPCs in surface soil + inhalation of COPCs in particulates
   b. Ingestion of COPCs in groundwater + dermal contact with COPCs in groundwater + inhalation of volatile COPCs
   c. Ingestion of COPCs in surface water + ingestion of COPCs in sediment + dermal contact with COPCs in surface water + dermal contact with COPCs in sediment
2. Current Military Personnel - Trainees
   a. Incidental ingestion of COPCs in surface soil + dermal contact with COPCs in surface soil + inhalation of airborne COPCs
   b. Incidental ingestion of COPCs in subsurface soil + dermal contact with COPCs in subsurface soil + inhalation of airborne COPCs
3. Military Personnel - Recreational User
   a. Incidental ingestion of COPCs in surface soil + dermal contact with COPCs in surface soil + inhalation of airborne COPCs
4. Fisherman (Adult and Child)
   a. Ingestion of COPCs in surface water + ingestion of COPCs in sediment + dermal contact with COPCs in surface water + dermal contact with COPCs in sediment
   b. Ingestion of COPCs in fish tissue

5. Future Construction Worker

    a. Incidental ingestion of COPCs subsurface soil + dermal contact with COPCs in subsurface soil + inhalation of airborne COPCs

6.7.1 Total Site Risk

The text below addresses total site risks by receptor group. Total site ICR and HI values are presented in Table 6-27.

6.7.1.1 Future Residential Children

Total ICR for future residential children, 3.7E-06, is within the USEPA acceptable cancer risk range. Total HI, 3.0, is above 1.0. This elevated HI value is primarily a result of iron detected in the groundwater. However, it should be noted that iron is still considered an essential nutrient. Also, toxicity criteria, which have not been finalized by the USEPA, have only recently been introduced for iron. Finally, as noted in Section 6.6.6, the CT exposure scenarios calculated for the future residential child showed no unacceptable risk.

6.7.1.2 Future Residential Adults

Total ICR for future residential adults at, 2.8E-06, is within the USEPA acceptable cancer risk range. Total HI, 0.25, is less than 1.0. It can then be concluded that COPCs in environmental media at Site 65 generate no health risks in excess of acceptable levels.

6.7.1.3 Current Military Personnel - Trainee

Total ICR for current military personnel involved in heavy equipment training activities near Site 65, 7.3E-07, is below the USEPA acceptable risk range. Total HI, 0.2, is less than 1.0. It can then be concluded that COPCs in environmental media at Site 65 generate no health risks in excess of acceptable levels.

6.7.1.4 Current Military Personnel - Recreational User

Total ICR for current military personnel involved in physical fitness/recreational activities through the use of Butler's Way adjacent to Site 65, 3.5E-07, is below the USEPA acceptable risk range. Total HI, less than 0.05, is well below the USEPA limit of 1.0. It can then be concluded that COPCs in environmental media at Site 65 generate no health risks in excess of acceptable levels.

6.7.1.5 Adult Fisherman

There were no carcinogens selected as COPCs for surface water, sediment, or fish tissue. Therefore, a carcinogenic risk was not calculated for the adult fisherman. It can then be concluded that COPCs in environmental media at Site 65 generate no carcinogenic health risks in excess of acceptable levels.

The total HI, 1.3, is above 1.0. The elevated HI is primarily due to the presence of mercury in fish tissue (69% of the total fish tissue HI). It should be noted that the HQ for mercury (0.82) was less than 1.0. In addition, several factors indicate that the presence of mercury is not site related. The mercury was detected only in the fish tissue. It was not detected in any other media sampled at

Site 65. The location of the ponds from the heavy equipment training area prevents them from being affected by surface run-off. Finally, Courthouse Bay Pond and Powerline Pond are stocked with fish. It can be concluded that there may be potential non-carcinogenic risks above the acceptable level from the ingestion of fish tissue, but that it is not related to Site 65.

6.7.1.6 Child Fisherman

There were no carcinogens selected as COPCs for surface water, sediment, or fish tissue. Therefore, a carcinogenic risk was not calculated for the child fisherman. It can then be concluded that COPCs in environmental media at Site 65 generate no carcinogenic health risks in excess of acceptable levels.

The total HI, 6.1, is above 1.0. The elevated HI is primarily due to the presence of mercury in fish tissue (69% of the total fish tissue HI). As stated previously in Section 6.5.1.4, the fish tissue ingestion HI calculated for the child fisherman is very conservative. In addition, several factors indicate that the presence of mercury is not site related. The mercury was detected only in the fish tissue. It was not detected in any other media sampled at Site 65. The location of the ponds from the heavy equipment training area prevents them from being affected by surface run-off. Finally, Courthouse Bay Pond and Powerline Pond are stocked with fish. It can be concluded that there may be potential non-carcinogenic risks above the acceptable level from the ingestion of fish tissue, but that it is not related to Site 65.

6.7.1.7 Future Construction Workers

Total ICR for future construction workers at Site 65, 1.3E-07, is less than 1.0E-06; it is within the USEPA acceptable risk range. Total HI, 0.2, is less than 1.0. It can then be concluded that COPCs in environmental media at Site 65 generate no health risks in excess of acceptable levels. Total site ICR and HI values are presented in Table 6-27.

6.8 References

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TABLES

TABLE 6-1

SUMMARY OF BLANK CONTAMINANT RESULTS
SITE 65 - ENGINEER AREA DUMP
REMEDIAL INVESTIGATION, CTO-0312
MCB, CAMP LEJEUNE, NORTH CAROLINA

Constituent	Maximum Concentration Detected in Blank (μg/L)	Medium Associated with Maximum Concentration Detected in Blank	Type of Blank with Maximum Detected Value	Concentration for Comparison$^{(1)}$ (Aqueous -μg/L)	Concentration for Comparison$^{(2)}$ (Solid - μg/kg)
Volatiles					
Methylene Chloride	1J	Soil	Trip	10	10
Acetone	93	Soil	Rinsate	930	930
2-Butanone	7J	Soil	Rinsate	70	70
Toluene	4J	Soil	Trip	40	40
Semivolatiles					
Di-n-butylphthalate	1J	Soil	Field	10	330
Bis(2-ethylhexyl)phthalate	2J	Soil	Field	20	660
Pesticide/PCBs					
4,4'-DDT	0.3	Soil	Rinsate	1.5	49.5
Inorganics					
Aluminum	73.6	Soil	Field	368	368
Barium	2.7	Soil	Field	13.5	13.5
Calcium	138	Soil	Field	690	690
Copper	16.1	Soil	Field	80.5	80.5
Iron	20.4	Soil	Field	102	102
Zinc	20.3	Soil	Field	101.5	101.5
Volatiles					
Methylene Chloride	1J	Groundwater	Trip	10	NA
Acetone	12	Groundwater	Field	120	NA
1,2-Dichloroethane	2J	Groundwater	Trip	20	NA
Semivolatiles					
Di-n-butylphthalate	1J	Groundwater	Field	10	NA
Bis(2-ethylhexyl)phthalate	2J	Groundwater	Field	20	NA
Inorganics					
Aluminum	73.6	Groundwater	Field	368	NA
Barium	2.7	Groundwater	Field	15	NA
Calcium	138	Groundwater	Field	2,990	NA
Copper	16.1	Groundwater	Field	80.5	NA
Iron	20.4	Groundwater	Field	102	NA
Zinc	20.3	Groundwater	Field	140	NA

TABLE 6-1 (Continued)

SUMMARY OF BLANK CONTAMINANT RESULTS
SITE 65 - ENGINEER AREA DUMP
REMEDIAL INVESTIGATION, CTO-0312
MCB, CAMP LEJEUNE, NORTH CAROLINA

Constituent	Maximum Concentration Detected in Blank (µg/L)	Medium Associated with Maximum Concentration Detected in Blank	Type of Blank with Maximum Detected Value	Concentration for Comparison[(1)] (Aqueous -µg/L)	Concentration for Comparison[(2)] (Solid - µg/kg)
Volatiles					
Methylene Chloride	10	Surface Water/ Sediment	Trip	10	10
Acetone	44	Surface Water/ Sediment	Rinsate	440	440
1,2-Dichloroethane	2J	Surface Water/ Sediment	Trip	10	10
Toluene	4J	Surface Water/ Sediment	Trip	40	40
Inorganics					
Aluminum	65.2	Surface Water/ Sediment	Rinsate	326	326
Calcium	598	Surface Water/ Sediment	Rinsate	2,990	2,990
Magnesium	120	Surface Water/ Sediment	Rinsate	600	600
Sodium	290	Surface Water/ Sediment	Rinsate	1,450	1,450

Notes:

(1) Concentration is five or ten times (for common laboratory blank contaminants) the maximum detected concentration in a blank.

(2) Concentration is five or ten times the maximum detected concentration in a blank; converted to µg/kg.

(3) Semivolatile blank concentrations are multiplied by 33 or 66 to account for matrix difference.

NA - Not applicable

TABLE 6-2

ORGANIC DATA SUMMARY - SURFACE SOIL
SITE 65 - ENGINEER AREA DUMP
REMEDIAL INVESTIGATION, CTO-0312
MCB, CAMP LEJEUNE, NORTH CAROLINA

	Contaminant Range/Frequency		Region III Criteria	Comprison to Criteria
Contaminant	Range of Positive Detections (µg/kg)	No. of Positive Detects/ No. of Samples	Residential COC Value (µg/kg)	Positive Detects Above Residential COC Value
Volatiles				
Methylene Chloride	2J - 2J	2/13	85,000	0
Acetone	10J	1/13	780,000	0
Trichloroethene	1J	1/13	58,000	0
Toluene	1J - 2J	3/13	1,600,000	0
Ethylbenzene	1J	1/13	780,000	0
Xylenes (Total)	3J - 5J	2/13	16,000,000	0
Semivolatiles				
Acenaphthene	130J	1/13	470,000	0
2,4-Dinitrophenol	150J	1/13	16,000	0
Dibenzofuran	58J	1/13	31,000	0
Fluorene	100J	1/13	310,000	0
Phenanthrene	59J - 860	3/13	230,000(1)	0
Anthracene	190J	1/13	230,000	0
Carbazole	180J	1/13	32,000	0
Di-n-butylphthalate	260J - 390J	2/13	780,000	0
Fluoranthene	130J - 830	3/13	310,000	0
Pyrene	150J - 850	3/13	230,000	0
Benzo(a)anthracene	76J - 510	3/13	880	0
Chrysene	70J - 470	3/13	88,000	0
bis(2-Ethylhexyl)phthalate	48J - 87J	9/13	46,000	0
Benzo(b)fluoranthene	89J - 360J	3/13	880	0
Benzo(k)fluoranthene	120J - 510	2/13	8,800	0
Benzo(a)pyrene	100J - 400	2/13	88	2
Indeno(1,2,3-cd)pyrene	88J - 310J	2/13	880	0
Dibenzo(a,h)anthracene	45J - 150J	2/13	88	1
Benzo(g,h,i)perylene	70J - 250J	2/13	230,000	0
Pesticide/PCBs				
Heptachlor Epoxide	2.3	1/13	70	0
4,4'-DDE	4.3 - 83J	6/13	1,900	0
Endosulfan II	3.8NJ - 3.9NJ	2/13	47,000	0
4,4'-DDD	3.8NJ - 59J	7/13	2,700	0
4,4'-DDT	25 - 56J	3/13	1,900	0
Aroclor-1260	52J	1/13	319	0

Notes:

Shaded areas indicate contaminant selected as a risk-based COPC.
J - Estimated value
N - Indicates presumptive evidence of a compound.
(1) USEPA Region III COC value for pyrene used as a surrogate.

TABLE 6-3

INORGANIC DATA SUMMARY - SURFACE SOIL
SITE 65 - ENGINEER DUMP AREA
REMEDIAL INVESTIGATION, CTO-0312
MCB, CAMP LEJEUNE, NORTH CAROLINA

	Range/Frequency		Comparison to Criteria			
Inorganic	Range of Positive Detections (mg/kg)	No. of Positive Detects/ No. of Samples	Twice the Average Base Specific Background(1) Concentration (mg/kg)	No. of Times Exceeded Twice the Average Background Concentration	Residential COC Value (mg/kg)	Positive Detects Above Residential COC Value
Aluminum	656 - 5,040	13/13	5,940.594	0	7,800	0
Barium	2.7 - 36.3	13/13	17.36	3	550	0
Calcium+	79.3 - 3,460	13/13	1,396.788	1	NE	NA
Chromium	2.3 -8.6	11/13	6.693	2	39	0
Copper	2.5 - 55.6	9/13	7.2	6	290	0
Iron+	509 - 16,400	13/13	3,755.063	2	2,300	3
Lead	2 - 178J	13/13	23.749	4	400(2)	0
Magnesium+	28.5 - 187	13/13	205.751	0	NE	NA
Manganese	2.9 - 163J	13/13	18.497	5	180	0
Nickel	4.6 - 5.7	2/13	3.434	2	160	0
Potassium+	248	1/13	199.610	1	NE	NA
Sodium+	51.3 - 56.3	2/13	59.298	0	NE	NA
Thallium	2.3	1/13	0.899	1	0.63(3)	1
Vanadium	2.8 - 12	9/13	11.628	1	55	0
Zinc	3.7 - 377J	11/13	13.880	6	2,300	0

Notes:

Shaded areas indicate contaminant selected as a risk-based COPC.
+ = Essential Nutrient
NE = Not Established
NA = Not Applicable
(1) Soil background concentrations are based on reference background soil samples collected from MCB Camp Lejeune investigations.
(2) Action Level for residential soils (USEPA, 1994).
(3) Value for thallium carbonate used as a surrogate.
J = Estimated Value

TABLE 6-4

ORGANIC DATA SUMMARY - SUBSURFACE SOIL
SITE 65 - ENGINEER AREA DUMP
REMEDIAL INVESTIGATION, CTO-0312
MCB, CAMP LEJEUNE, NORTH CAROLINA

Contaminant	Contaminant Range/Frequency		Region III Criteria	Comparison to Criteria
	Range of Positive Detections (μg/kg)	No. of Positive Detects/ No. of Samples	Residential COC Value (μg/kg)	Positive Detects Above Residential COC Value
Volatiles				
Acetone	7J - 380	13/19	780,000	0
Carbon Disulfide	2J	1/19	780,000	0
2-Butanone	2J - 29	3/19	4,700,000	0
Trichloroethene	2J	1/19	58,000	0
Toluene	1J	1/19	1,600,000	0
Xylenes (Total)	1J - 3J	5/19	16,000,000	0
Semivolatiles				
Naphthalene	55J	1/19	310,000	0
2-Methylnaphthalene	60J	1/19	310,000	0
Acenaphthene	94J - 97J	2/19	470,000	0
Fluorene	110J	1/19	310,000	0
Dibenzofuran	42J	1/19	31,000	0
Phenanthrene	150J - 1,200	2/19	230,000$^{(1)}$	0
Anthracene	290J	1/19	2,300,000	0
Carbazole	120J	1/19	32,000	0
Di-n-butylphthalate	160J - 340J	8/19	780,000	0
Fluoranthene	230J - 1,900	2/19	310,000	0
Pyrene	190J - 1,400	2/19	230,000	0
Benzo(a)anthracene	100J - 900	2/19	880	1
Chrysene	110J - 800	2/19	88,000	0
bis(2-Ethylhexyl)phthalate	37J - 370	15/19	46,000	0
Benzo(b)fluoranthene	96J - 710	2/19	880	0
Benzo(k)fluoranthene	110J - 620	2/19	8,800	0
Benzo(a)pyrene	69J - 680	2/19	88	1
Ideno(1,2,3-cd)pyrene	480J	1/19	880	0
Benzo(g,h,i)perylene	67J - 360J	1/19	230,000	0
Pesticide/PCBs				
Endosulfan I	3.1NJ	1/19	47,000	0
4,4'-DDE	4.6 - 45J	8/19	1,900	0
4,4'-DDD	4.4J - 340J	8/19	2,700	0
4,4'-DDT	9.6 - 40	4/19	1,900	0
Endrin Aldehyde	9.4J	1/19	2,300	0
alpha-Chlordane	8.3J	1/19	490	0
gamma-Chlordane	3J - 7.5J	3/19	490	0

Notes:

Shaded areas indicate contaminant selected as a risk-based COPC.
J = Estimated value
N = Indicates presumptive evidence of a compound
(1) USEPA Region III COC value for pyrene used as a surrogate.

TABLE 6-5

INORGANIC DATA SUMMARY - SUBSURFACE SOIL
SITE 65 - ENGINEER AREA DUMP
REMEDIAL INVESTIGATION, CTO-0312
MCB, CAMP LEJEUNE, NORTH CAROLINA

Inorganic	Range/Frequency		Comparison to Criteria			
	Range of Positive Detections (mg/kg)	No. of Positive Detects/ No. of Samples	Twice the Average Base Specific Background(1) Concentration (mg/kg)	No. of Times Exceeded Twice the Average Background Concentration	Region III Residential COC Value (mg/kg)	Positive Detects Above Residential COC Value
Aluminum	1,020 - 10,600	19/19	7,375.302	1	7,800	1
Antimony	11.8	1/19	6.409	1	3.1	1
Arsenic	2.6 - 3.3	3/19	1.968	3	0.37	3
Barium	2.7 - 38.3	19/19	14.204	7	550	0
Cadmium	1.3 - 1.3	2/19	0.712	2	3.9	0
Calcium+	49.8 - 1,350	18/19	391.509	9	NE	NA
Chromium	2.6 - 17.3	16/19	12.562	1	39	0
Cobalt	11.5	1/19	1.504	1	470	0
Copper	7.7 - 672	8/19	2.416	8	290	2
Iron+	236J - 31,300	19/19	7,252.076	5	2,300	9
Lead	1.6 - 539	19/19	8.327	8	400(2)	1
Magnesium+	23.8 - 410	19/19	260.718	2	NE	NA
Manganese	2 - 471	19/19	7.919	10	180	2
Nickel	4.8 - 243	3/19	3.714	3	160	1
Potassium+	253 - 453	4/19	347.236	1	NE	NA
Selenium	1.5	1/19	0.801	1	39	0
Silver	4.2	1/19	0.866	1	39	0
Sodium+	50.8 - 130	5/19	52.676	4	NE	NA
Thallium	4.2	1/19	0.955	1	0.63(3)	1
Vanadium	3.1 - 27.2	15/19	13.454	1	55	0
Zinc	2.5J - 764	16/19	6.662	12	2,300	0

Notes:

Shaded areas indicate contaminant selected as a risk-based COPC.

(1) Soil background concentrations are based on reference background soil samples collected from MCB Camp Lejeune investigations.

(2) Action Level for residential soils (USEPA, 1994).

(3) Value for thallium carbonate used as a surrogate.

\+ = Essential Nutrient

NE = Not Established
NA = Not Applicable
J = Estimated Value

TABLE 6-6

GROUNDWATER DATA SUMMARY
SITE 65 - ENGINEER AREA DUMP
REMEDIAL INVESTIGATION, CTO-0312
MCB, CAMP LEJEUNE, NORTH CAROLINA

	Groundwater Criteria					Frequency/Range		Comparison to Criteria				
				Federal Health Advisories[3] (µg/L)							No. of Detects Above Health Advisories	
Contaminant	NCWQS[1] (µg/L)	MCL[2] (µg/L)	Region III Tap Water COC Value (µg/L)	10 kg Child	70 kg Adult	No. of Positive Detects/ No. of Samples	Concentration Range (µg/L)	No. of Detects Above NCWQS	No. of Detects Above MCL	No. of Detects Above COC	10 kg Child	70 kg Adult
Volatiles												
Methylene Chloride	5	NE	4.1	NE	NE	6/11	1J - 2J	0	NA	0	NA	NA
Acetone	700	NE	370	NE	NE	7/11	5J - 7J	0	NA	0	NA	NA
Carbon Disulfide	NE	NE	2.1	NE	NE	1/11	5J	NA	NA	1	NA	NA
1,2-Dichloroethane	0.38	5	0.12	700	2,600	8/11	2J - 2J	8	0	8	0	0
2-Butanone	NE	NE	190	NE	NE	3/11	1J - 1J	NA	NA	0	NA	NA
Semivolatiles												
Naphthalene	210	NE	150	400	1,000	1/11	3J	0	NA	0	0	0
Di-n-butylphthalate	700	NE	370	NE	NE	3/11	2J - 6J	0	NA	0	NA	NA
bis(2-Ethylhexyl)phthalate	3.0	6.0	4.8	NE	NE	5/11	1J - 6J	2	0	~~0~~ 1	NA	NA
Inorganics												
Aluminum	NE	50/200[4]	3,700	NE	NE	7/11	40.3 - 421	6/3	NA	0	NA	NA
Barium	2,000	2,000	260	NE	NE	10/11	17.9 - 151	0	0	0	NA	NA
Calcium	NE	NE	NE	NE	NE	11/11	2,700 - 146,000	NA	NA	NA	NA	NA
Chromium	50	100	18	200	800	2/11	10 - 10.2	0	0	0	0	0
Cobalt	NE	NE	220	NE	NE	4/11	20.1 - 52.4	NA	NA	0	NA	NA
Iron	300	300[4]	1,100	NE	NE	10/11	41.9 - 6,580	5	5	4	NA	NA
Lead	15	15[5]	NE	NE	NE	1/11	3.4	0	0	NA	NA	NA
Magnesium	NE	NE	NE	NE	NE	11/11	1,200 - 16,200	NA	NA	NA	NA	NA
Manganese	50	50[4]	84	NE	NE	11/11	3 - 186	6	6	4	NA	NA
Nickel	100	100	73	500	1,700	2/11	53.1 - 59.6	0	0	0	0	0
Potassium	NE	NE	NE	NE	NE	10/11	1,200 - 7,940	NA	NA	NA	NA	NA
Sodium	NE	NE	NE	NE	NE	11/11	5,620 - 16,400	NA	NA	NA	NA	NA
Zinc	2,100	5,000[4]	1,100	3,000	10,000	10/11	11 - 58.9	0	0	0	0	0

Notes:

Shaded areas indicate contaminant selected as a risk-based COPC.

(1) NCWQS = North Carolina Water Quality Standards for Groundwater.

(2) MCL = Safe Drinking Water Act Maximum Contaminant Level

(3) Longer Term Health Advisories for a 10 kg Child and 70 kg Adult.

(4) SMCL = Secondary Maximum Contaminant Level.

(5) Action Level.

\+ = Essential Nutrient

NE = Not Established

NA = Not Applicable

J = Estimated value

TABLE 6-7

SURFACE WATER DATA SUMMARY
SITE 65 - ENGINEER AREA DUMP
REMEDIAL INVESTIGATION, CTO-0312
MCB, CAMP LEJEUNE, NORTH CAROLINA

	Surface Water Criteria			Contaminant Frequency/Range		Comparison to Criteria		
		Federal Health AWQCs(2) (µg/L)					Positive Detects Above AWQC	
Contaminant	NCWQS(1) (µg/L)	Water & Organisms	Organisms Only	No. of Positive Detects/ No. of Samples	Contaminant Range (µg/L)	Positive Detects Above NCWQS	Water & Organisms	Organisms Only
Volatiles								
Acetone	NE	NE	NE	1/2	5J	NA	NA	NA
1,2-Dichloroethane	NE	0.38	99	2/2	1J - 1J	NA	2	0
Inorganics								
Aluminum	NE	NE	NE	1/2	25,800	NA	NA	NA
Barium	NE	1,000	NE	2/2	36.7 - 69.3	NA	0	NA
Calcium+	NE	NE	NE	2/2	12,000 - 26,800	NA	NA	NA
Chromium	50	170(3)	3,400(3)	1/2	27.6	0	0	0
Copper	7	1,300(3)	NE	1/2	41.1	1	0	NA
Iron	1,000	NE	NE	2/2	348 - 7,890	1	NA	NA
Lead	25	NE	NE	1/2	45.8	1	NA	NA
Magnesium+	NE	NE	NE	2/2	2,060 - 2,520	NA	NA	NA
Manganese	NE	NE	100	2/2	57.3 - 88.4	NA	NA	0
Potassium+	NE	NE	NE	1/2	2,970	NA	NA	NA
Sodium+	NE	NE	NE	2/2	3,330 - 6,320	NA	NA	NA
Vanadium	NE	NE	NE	1/2	26.2	NA	NA	NA
Zinc	50	NE	NE	2/2	33.6 - 144	1	NA	NA

Notes:

Shaded areas indicate contaminant selected as a risk-based COPC.
(1) NCWQS = North Carolina Water Quality Standards for Surface Water, surface water classification C.
(2) AWQC = Ambient Water Quality Standard.
(3) Recalculated values using IRIS, as of 9/90.
+ = Essential Nutrient
NE = Not Established
NA = Not Applicable
J = Estimated value

TABLE 6-8

SEDIMENT DATA SUMMARY
SITE 65 - ENGINEER AREA DUMP
REMEDIAL INVESTIGATION, CTO-0312
MCB, CAMP LEJEUNE, NORTH CAROLINA

Contaminant	Region III Criteria	Range/Frequency		Comparison to Criteria
	Residential COC Value	Range of Positive Detections	No. of Positive Detects/ No. of Samples	Positive Detects Above COC
Volatiles (µg/kg)				
Acetone	780,000	190J - 450J	4/4	0
Chloroform	100,000	79J	1/4	0
2-Butanone	4,700,000	72J - 94J	4/4	0
Carbon Tetrachloride	4,900	13J - 18J	2/4	0
Tetrachloroethene	12,000	6J - 15J	2/4	0
Toluene	1,600,000	3J - 7J	3/4	0
Semivolatiles (µg/kg)				0
Di-n-butylphthalate	780,000	940J - 1,600J	4/4	0
Pesticide/PCBs (µg/kg)				0
beta-BHC	350	8.3NJ	1/4	0
4,4'-DDE	2,700	18J - 19NJ	2/4	0
4,4'-DDD	1,900	76J - 84J	2/4	0
Inorganics (mg/kg)				
Aluminum	7,800	394 - 37,500J	4/4	2
Antimony	3.1	46.6J	1/4	1
Barium	550	13.6 - 110	4/4	0
Calcium+	NE	322 - 4,640	4/4	1
Chromium	39	9.8J - 43.6J	2/4	0
Cobalt	470	36.3	1/4	0
Copper	290	8.2 - 100J	3/4	0
Iron	2,300	414 - 14,600J	4/4	2
Lead	400$^{(1)}$	23.9 - 176J	3/4	0
Magnesium+	NE	94.8 - 1,140	3/4	NA
Manganese	180	25.6 - 126J	4/4	0
Potassium+	NE	1,410	1/4	NA
Sodium+	NE	139 - 203	3/4	NA
Vanadium	55	40.5	1/4	0
Zinc	2,300	7.9 - 280J	4/4	0

Notes:

Shaded areas indicate contaminant seleceted as a risk-based COPC.
ER-L = Effects Range-Low
ER-M = Effects Range-Medium
(1) Action level for soils (USEPA, 1994).
+ = Essential Nutrient
NA = Not Applicable
NE = Not Established
J = Estimated value
N = Indicates presumptive evidence of a compound

TABLE 6-9

FISH TISSUE(1) DATA SUMMARY
SITE 65 - ENGINEER AREA DUMP
REMEDIAL INVESTIGATION, CTO-0312
MCB, CAMP LEJEUNE, NORTH CAROLINA

	Contaminant Frequency/Range		Region III Criteria	Comprison to Criteria
Contaminant	Range of Positive Detections	No. of Positive Detects/ No. of Samples	Fish COC Value	Positive Detects Above Fish COC Value
Volatiles (µg/kg)				
Acetone	5,600J - 7,900J	2/4	14,000	0
Pesticide/PCBs (µg/kg)				
4,4'-DDD	5.7J	1/4	13	0
Inorganics (mg/kg)				
Aluminum	0.99	1/4	140	0
Barium	0.21J	1/4	9.5	0
Calcium+	385J - 2,100J	4/4	NE	NA
Copper	0.46 - 0.49	2/4	5	0
Magnesium+	290J - 299J	4/4	NE	NA
Manganese	0.092J - 0.45J	4/4	0.68	0
Mercury	0.051J - 0.3J	4/4	0.014	4
Potassium+	2,700J - 3,540J	4/4	NE	NA
Selenium	0.14 - 0.22	4/4	0.68	0
Sodium+	441 - 869	4/4	NE	NA
Thallium	0.11 - 0.11	3/4	0.011(2)	NA
Zinc	5.8J - 8.4J	4/4	41	0

Notes:

(1) Fillet (or edible) portion of fish tissue was analyzed for human health BRA.
(2) Value for thallium carbonate used as a surrogate.
Shading indicates contaminant selected as a risk-based COPC.
NA = Not Applicable
NE = Not Established
\+ = Essential Nutrient
J = Estimated value

TABLE 6-10

SUMMARY OF COPCs IN ENVIRONMENTAL MEDIA OF CONCERN
SITE 65 - ENGINEER AREA DUMP
REMEDIAL INVESTIGATION, CTO-0312
MCB, CAMP LEJEUNE, NORTH CAROLINA

Contaminant	Surface Soil		Subsurface Soil		Groundwater		Surface Water		Sediment		Fish Tissue	
Volatiles												
Methylene Chloride	●				●							
Acetone	●		●		●		●		●		●	
Carbon disulfide			●		●	X						
Chloroform									●			
1,2-Dichloroethane					●		●					
2-Butanone			●		●				●			
Carbon Tetrachloride									●			
Trichloroethene	●		●									
Tetrachloroethene									●			
Toluene	●		●						●			
Ethylbenzene	●											
Xylenes (Total)	●		●									
Semivolatiles												
Naphthalene			●		●							
2-Methylnaphthalene			●									
Acenaphthene	●		●									
2,4-Dinitrophenol	●											
Dibenzofuran	●		●									
Fluorene	●		●									
Phenanthrene	●		●									
Anthracene	●		●									
Carbazole	●		●									
Di-n-butylphthalate	●		●		●				●			
Fluoranthene	●		●									
Pyrene	●		●									
Benzo(a)anthracene	●		●	X								
Chrysene	●		●									
bis(2-Ethylhexyl)phthalate	●		●		●							
Benzo(b)fluoranthene	●		●									
Benzo(k)fluoranthene	●		●									
Benzo(a)pyrene	●	X	●	X								
Ideno(1,2,3-cd)pyrene	●		●									
Dibenzo(a,h)anthracene	●	X										
Benzo(g,h,i)perylene	●		●									
Pesticide/PCBs												
beta-BHC									●			
Heptachlor Epoxide	●											
Endosulfan I			●									

TABLE 6-10 (Continued)

SUMMARY OF COPCs IN ENVIRONMENTAL MEDIA OF CONCERN
SITE 65 - ENGINEER AREA DUMP
REMEDIAL INVESTIGATION, CTO-0312
MCB, CAMP LEJEUNE, NORTH CAROLINA

Contaminant	Surface Soil		Subsurface Soil		Groundwater		Surface Water		Sediment		Fish Tissue	
4,4'-DDE	●		●						●			
Endosulfan II	●											
4,4'-DDD	●		●						●		●	
4,4'-DDT	●		●									
Endrin Aldehyde			●									
Alpha Chlordane			●									
Gamma Chlordane			●									
Aroclor-1260	●											
Inorganics												
Aluminum	●		●	X	●		●	X	●	X	●	
Antimony			●	X					●	X		
Arsenic			●	X								
Barium	●		●		●		●	X	●		●	
Beryllium												
Cadmium			●									
Calcium	●		●		●		●		●		●	
Chromium	●		●		●		●	X	●	X		
Cobalt			●		●				●			
Copper	●		●	X			●	X	●		●	
Iron	●	X	●	X	●	X	●		●	X		
Lead	●		●	X	●		●	X	●			
Magnesium	●		●		●		●		●		●	
Manganese	●	X	●	X	●	X	●	X	●		●	
Mercury											●	X
Nickel	●		●	X	●							
Potassium	●		●		●		●		●		●	
Selenium			●								●	
Silver			●									
Sodium	●		●		●		●		●		●	
Thallium	●	X	●	X							●	X
Vanadium	●		●				●	X	●			
Zinc	●		●		●		●	X	●		●	

Notes:

● = Detected in media; compared to relevant criteria and standards.
X = Selected as a COPC for human health risk assessment.

TABLE 6-11

MATRIX OF POTENTIAL HUMAN EXPOSURE
SITE 65 - ENGINEER AREA DUMP
REMEDIAL INVESTIGATION, CTO-0312
MCB, CAMP LEJEUNE, NORTH CAROLINA

Exposure Medium/ Exposure Route	Current Military Personnel	Current Military Recreational User	Future Construction Worker	Future Residential Population	Current Fisherman
Soil Incidental Ingestion	M	A	NA	A,C	NA
Dermal Contact	M	A	NA	A,C	NA
Subsurface Soil Incidental Ingestion	M	NA	W	NA	NA
Dermal Contact	M	NA	W	NA	NA
Groundwater Ingestion	NA	NA	NA	A,C	NA
Dermal Contact	NA	NA	NA	A,C	NA
Surface Water Ingestion	NA	NA	NA	A,C	A, C
Dermal Contact	NA	NA	NA	A,C	A, C
Sediment Incidental Ingestion	NA	NA	NA	A,C	A, C
Dermal Contact	NA	NA	NA	A,C	A, C
Fish Tissue Incidental Ingestion	NA	NA	NA	NA	A, C
Air Inhalation of Vapor Phase Chemicals Indoor	NA	NA	NA	A,C	NA
Inhalation of Particulates Outdoor	M	A	W	A,C	NA

Notes:

A = Exposure - adults
C = Exposure - children
M = Military exposure during training
W = Construction duration exposure
NA = Not applicable to receptor group

TABLE 6-12

EXPOSURE ASSESSMENT SUMMARY
INCIDENTAL INGESTION OF SOIL CONTAMINANTS
SITE 65 - ENGINEER AREA DUMP
REMEDIAL INVESTIGATION, CTO-0312
MCB, CAMP LEJEUNE, NORTH CAROLINA

Future Residential Child and Adult, Current Military Personnel - Trainee and Recreational User, Future Construction Worker			
Input Parameter	Description	Value$^{(1)}$	Reference
C	Exposure Concentration	95% UCL$^{(2)}$ (mg/kg)	USEPA, 1992b
IR	Ingestion Rate	Child 200 mg/day (100 mg/day) Adult 100 mg/day Military Personnel 100 mg/day Construction Worker 480 mg/day	USEPA, 1989a USEPA, 1991a
CF	Conversion Factor	1E-6 kg/mg	USEPA, 1989a
Fi	Fraction Ingested from Contaminated Source	100%	Conservative Professional Judgement
EF	Exposure Frequency	Child 350 days/yr (234 days/yr) Adult 350 days/yr Military Personnel Trainee 260 days/yr Recreational User 260 days/yr Construction Worker 90 days/yr	USEPA, 1989a USEPA, 1991a Site specific professional judgement (5 days/week x 52 weeks/year)
ED	Exposure Duration	Child 6 years Adult 24 years Military Personnel 4 years Construction Worker 1 year	USEPA, 1991a USEPA, 1989a
BW	Body Weight	Child 15 kg Adult 70 kg Military Personnel 70 kg Construction Worker 70 kg	USEPA, 1989a
AT_c	Averaging Time Carcinogen	All 25,550 days	USEPA, 1989a
AT_{nc}	Averaging Time Noncarcinogen	Child 2,190 days Adult 8,760 days Military Personnel 1,460 days Construction Worker 365 days	USEPA, 1989a

Note:

(1) Values in parentheses represent CT exposure assumptions.

(2) Maximum detected soil concentrations will be used in situations where the 95% UCL exceeds the maximum.

TABLE 6-13

EXPOSURE ASSESSMENT SUMMARY
DERMAL CONTACT WITH SOIL CONTAMINANTS
SITE 65 - ENGINEER AREA DUMP
REMEDIAL INVESTIGATION, CTO-0312
MCB, CAMP LEJEUNE, NORTH CAROLINA

Future Residential Child and Adult, Current Military Personnel - Trainee and Recreational User, Future Construction Worker

Input Parameter	Description	Value[(1)]		Reference
C	Exposure Concentration	95% UCL[(2)]	(mg/kg)	USEPA, 1992b
CF	Conversion Factor	1E-6 kg/mg		USEPA, 1989a
SA	Exposed Surface Area of Skin Available for Contact	Child Adult Military Personnel Trainee[(3)] Recreational User Construction Worker[(3)]	$2,300\ cm^2$ $(1,745\ cm^2)$ $5,800\ cm^2$ $4,300\ cm^2$ $5,800\ cm^2$ $4,300\ cm^2$	USEPA, 1992a Reasonable worst case: individual skin area limited to head, hands, forearms, lower legs
AF	Soil-to-Skin Adherence Factor	$1.0\ mg/cm^2$ $(0.2\ mg/cm^2)$		USEPA, 1991b
ABS	Fraction Absorbed (unitless)	Organics Inorganics	1.0% 0.1%	USEPA, 1991b
EF	Exposure Frequency	Child Adult Military Personnel Trainee Recreational User Construction Worker	350 days/yr (234 days/yr) 350 days/yr 260 days/yr 260 days/yr 90 days/yr	USEPA, 1989a USEPA, 1991a
ED	Exposure Duration	Child Adult Military Personnel Construction Worker	6 years 24 years 4 years 1 year	 USEPA, 1989a USEPA, 1991a
BW	Body Weight	Child Adult Military Personnel Construction Worker	15 kg 70 kg 70 kg 70 kg	USEPA, 1989a
AT_c	Averaging Time Carcinogen	All	25,550 days	USEPA, 1989a

TABLE 6-13 (Continued)

EXPOSURE ASSESSMENT SUMMARY
DERMAL CONTACT WITH SOIL CONTAMINANTS
SITE 65 - ENGINEER AREA DUMP
REMEDIAL INVESTIGATION, CTO-0312
MCB, CAMP LEJEUNE, NORTH CAROLINA

Future Residential Child and Adult, Current Military Personnel - Trainee and Recreational User, Future Construction Worker			
Input Parameter	Description	Value(1)	Reference
AT_{nc}	Averaging Time Noncarcinogen	Child 2,190 days Adult 8,760 days Military Personnel 1,460 days Construction Worker 365 days	USEPA, 1989a

Notes:

(1) Values in parentheses represent CT exposure assumptions.
(2) Maximum detected soil concentrations will be used in situations were the 95% UCL exceeds the maximum.
(3) Exposed surface area limited to head, hands, and arms.

TABLE 6-14

EXPOSURE ASSESSMENT SUMMARY
INHALATION OF FUGITIVE PARTICULATES
SITE 65 - ENGINEER AREA DUMP
REMEDIAL INVESTIGATION, CTO-0312
MCB, CAMP LEJEUNE, NORTH CAROLINA

Future Residential Child and Adult, Current Military Personnel - Trainee and Recreational User, Future Construction Worker				
Input Parameter	Description	Value(1)		Reference
C	Exposure Concentration	95% UCL(2)	(mg/kg)	USEPA, 1992b
EF	Exposure Frequency	Child Adult Military Personnel Trainee Recreational User Construction Worker	350 days/yr (234 days/yr) 350 days/yr 260 days/yr 260 days/yr 90 days/yr	USEPA, 1989a Site specific professional judgement (5 days/week x 52 weeks)
ED	Exposure Duration	Child Adult Military Personnel Construction Worker	6 years 24 years 4 years 1 year	USEPA, 1991a
IR	Inhalation Rate	Child Adult Military Personnel Construction Worker	15 m^3 20 m^3 20 m^3 20 m^3	USEPA, 1991a USEPA, 1989b
BW	Body Weight	Child Adult Military Personnel Construction Worker	15 kg 70 kg 70 kg 70 kg	USEPA, 1989a
AT$_c$	Averaging Time Carcinogen	All	25,550 days	USEPA, 1989a
AT$_{nc}$	Averaging Time Noncarcinogens	Child Adult Military Personnel Construction Worker	2,190 days 8,760 days 1,460 days 365 days	USEPA, 1989a
PEF	Site-Specific Particulate Emission Factor	4.63E+09 m^3/kg		USEPA, 1989b

Note:

(1) Values in parentheses represent CT exposure assumptions.

(2) Maximum detected soil concentrations will be used in situations where the 95% UCL exceeds the maximum.

TABLE 6-15

EXPOSURE ASSESSMENT SUMMARY
INGESTION OF GROUNDWATER CONTAMINANTS
SITE 65 - ENGINEER AREA DUMP
REMEDIAL INVESTIGATION, CTO-0312
MCB, CAMP LEJEUNE, NORTH CAROLINA

Future Residential Child and Adult			
Input Parameter	Description	Value(1)	Reference
C	Exposure Concentration	95% UCL(2) (mg/L)	USEPA, 1992b
IR	Ingestion Rate	Child 1 L/day Adult 2 L/day	USEPA, 1991a USEPA, 1989a
EF	Exposure Frequency	Child 350 days/yr (234 days/yr) Adult 350 days/yr	USEPA, 1989a
ED	Exposure Duration	Child 6 years Adult 30 years	USEPA, 1991a
BW	Body Weight	Child 15 kg Adult 70 kg	USEPA, 1989a
AT_c	Averaging Time Carcinogen	All 25,550 days	USEPA, 1989a
AT_{nc}	Averaging Time Noncarcinogen	Child 2,190 days Adult 10,950 days	USEPA, 1989a

Note:

(1) Values in parentheses represent CT exposure assumptions.
(2) Maximum detected aqueous concentrations will be used in situations where the 95% UCL exceeds the maximum.

TABLE 6-16

EXPOSURE ASSESSMENT SUMMARY
DERMAL CONTACT WITH GROUNDWATER CONTAMINANTS
SITE 65 - ENGINEER AREA DUMP
REMEDIAL INVESTIGATION, CTO-0312
MCB, CAMP LEJEUNE, NORTH CAROLINA

Future Residential Child and Adult				
Input Parameter	Description	Value(1)		Reference
C	Exposure Concentration	95% UCL(2)	(mg/L)	USEPA, 1992b
SA	Exposed Surface Area of Skin Available for Contact	Child Adult	10,000 cm^2 (6,978 cm^2) 23,000 cm^2	USEPA, 1992a
PC	Permeability Constant	Chemical Specific		USEPA, 1992a
ET	Exposure Time	All	0.25 hr/day	USEPA, 1992a
EF	Exposure Frequency	Child Adult	350 days/yr (234 days/yr) 350 days/yr	USEPA, 1991a
ED	Exposure Duration	Child Adult	6 years 30 years	USEPA, 1989a
CF	Conversion Factor	1 L/1000 cm^3		USEPA, 1989a
BW	Body Weight	Child Adult	15 kg 70 kg	USEPA, 1989a
AT_c	Averaging Time Carcinogen	All	25,550 days	USEPA, 1989a
AT_{nc}	Averaging Time Noncarcinogen	Child Adult	2,190 days 10,950 days	USEPA, 1989a

Note:

(1) Values in parentheses represent CT exposure assumptions.

(2) Maximum detected aqueous concentrations will be used in situations where the 95% UCL exceeds the maximum.

TABLE 6-17

EXPOSURE ASSESSMENT SUMMARY
INHALATION OF GROUNDWATER VOLATILE CONTAMINANTS
SITE 65 - ENGINEER AREA DUMP
REMEDIAL INVESTIGATION, CTO-0312
MCB, CAMP LEJEUNE, NORTH CAROLINA

Future Residential Child and Adult				
Input Parameter	Description	Value(1)		Reference
C	Exposure Concentration	95% UCL(2)	(mg/m^3)	USEPA, 1992b
IR	Inhalation Rate	Child Adult	$0.6\ m^3/hr$ $0.6\ m^3/hr$	USEPA, 1989a
ET	Exposure Time	All	0.25 hr/day	USEPA, 1992a
EF	Exposure Frequency	All	350 day/yr (234 days/yr)	USEPA, 1989a
ED	Exposure Duration	Child Adult	6 years 30 years	USEPA, 1989a
BW	Body Weight	Child Adult	15 kg 70 kg	USEPA, 1989a
AT_c	Averaging Time Carcinogen	All	25,550 days	USEPA, 1989a
AT_{nc}	Averaging Time Noncarcinogens	Child Adult	2,190 days 10,950 days	USEPA, 1989a

Note:

(1) Values in parentheses represent CT exposure assumptions.

(2) Maximum detected concentrations will be used in situations where the 95% UCL exceeds the maximum.

TABLE 6-18

EXPOSURE ASSESSMENT SUMMARY
INGESTION OF SURFACE WATER
SITE 65 - ENGINEER AREA DUMP
REMEDIAL INVESTIGATION, CTO-0312
MCB, CAMP LEJEUNE, NORTH CAROLINA

Future Residential Child and Adult, Fisherman - Adult and Child				
Input Parameter	Description	Value		Reference
C	Exposure Concentration	95% UCL[1]	(mg/L)	USEPA, 1992b
IR	Ingestion Rate	Child Adult	0.05 L/hr 0.05 L/hr	USEPA, 1989a
ET	Exposure Time	Child Adult	2.6 hr/day 2.6 hr/day	USEPA, 1992a
EF	Exposure Frequency	Child Adult	48 events/yr 48 events/yr	Site-Specific Professional Judgement (8 days/month x 6 months/year)
ED	Exposure Duration	Child Adult	6 years 30 years	USEPA, 1989a
BW	Body Weight	Child Adult	15 kg 70 kg	USEPA, 1989a
AT_c	Averaging Time Carcinogen	All	25,550 days	USEPA, 1989a
AT_{nc}	Averaging Time Noncarcinogens	Child Adult	2,190 days 10,950 days	USEPA, 1989a

Note:

(1) Maximum detected aqueous concentrations will be used in situations where the 95% UCL exceeds the maximum.

TABLE 6-19

EXPOSURE ASSESSMENT SUMMARY
DERMAL CONTACT WITH SURFACE WATER
SITE 65 - ENGINEER AREA DUMP
REMEDIAL INVESTIGATION, CTO-0312
MCB CAMP LEJEUNE, NORTH CAROLINA

Future Residential Child and Adult, Fisherman - Adult and Child				
Input Parameter	Description	Value[1]		Reference
C	Exposure Concentration	95% UCL[2]	(mg/L)	USEPA, 1992b
SA	Exposed Surface Area of Skin Available for Contact	Child Adult	2,100 cm^2 (1,745 cm^2) 8,300 cm^2	USEPA, 1992a Individual skin area limited to hands, forearms, lower extremities
ET	Exposure Time	Child Adult	2.6 hr/day 2.6 hr/day	USEPA, 1992a
EF	Exposure Frequency	Child Adult	48 days/yr 48 days/yr	Site-Specific Professional Judgement (8 days/month x 6 months/year)
ED	Exposure Duration	Child Adult	6 years 30 years	USEPA, 1989a
CF	Volumetric Conversion Factor for Water	1 L/1000 cm^3		USEPA, 1989a
BW	Body Weight	Child Adult	15 kg 70 kg	USEPA, 1989a
AT_c	Averaging Time Carcinogen	All	25,550 days	USEPA, 1989a
AT_{nc}	Averaging Time Noncarcinogen	Child Adult	2,190 days 10,950 days	USEPA, 1989a
PC	Permeability Constant	Chemical-Specific		USEPA, 1992a

Note:

(1) Values in parentheses represent CT exposure assumptions.
(2) Maximum detected aqueous concentrations will be used in situations where the 95% UCL exceeds the maximum.

TABLE 6-20

EXPOSURE ASSESSMENT SUMMARY
INGESTION OF SEDIMENT
SITE 65 - ENGINEER AREA DUMP
REMEDIAL INVESTIGATION, CTO-0312
MCB, CAMP LEJEUNE, NORTH CAROLINA

Future Residential Child and Adult, Fisherman - Adult and Child				
Input Parameter	Description	Value(1)		Reference
C	Exposure Concentration	95% UCL(2)	(mg/kg)	USEPA, 1992b
IR	Sediment Ingestion Rate	Child Adult	200 mg/day (100 mg/day) 100 mg/day	USEPA, 1989a
EF	Exposure Frequency	Child Adult	48 days/yr 48 days/yr	Site-Specific Professional Judgement (8 days/month x 6 months/year)
ED	Exposure Duration	Child Adult	6 years 30 years	USEPA, 1989a
BW	Body Weight	Child Adult	15 kg 70 kg	USEPA, 1989a
AT_c	Averaging Time Carcinogen	All	25,550 days	USEPA, 1989a
AT_{nc}	Averaging Time Noncarcinogen	Child Adult	2,190 days 10,950 days	USEPA, 1989a
CF	Conversion Factor	1E-06 kg/mg		USEPA, 1989a

Notes:

(1) Values in parentheses represent CT exposure assumptions.
(2) Maximum detected sediment concentrations will be used in situations where the 95% UCL exceeds the maximum.

TABLE 6-21

EXPOSURE ASSESSMENT SUMMARY
DERMAL CONTACT WITH SEDIMENT
SITE 65 - ENGINEER AREA DUMP
REMEDIAL INVESTIGATION, CTO-0312
MCB, CAMP LEJEUNE, NORTH CAROLINA

Future Residential Child and Adult, Fisherman - Adult and Child			
Input Parameter	Description	Value(1)	Reference
C	Exposure Concentration	95% UCL(2) (mg/kg)	USEPA, 1992b
SA	Surface Area of Skin Available for Contact	Child $2,100\ cm^2$ $(1,745\ cm^2)$ Adult $8,300\ cm^2$	USEPA, 1992a Individual skin area limited to hands, forearms, lower extremities
AF	Sediment Adherence Factor	$1.0\ mg/cm^2$ $(0.2\ mg/cm^2)$	USEPA, 1991b
ABS	Absorption Factor (dimensionless)	Organics 1.0% Inorganics 0.1%	USEPA, 1991b
EF	Exposure Frequency	Child 48 events/yr Adult 48 events/yr	Site-Specific Professional Judgement (8 days/month x 6 months/year)
ED	Exposure Duration	Child 6 years Adults 30 years	USEPA, 1989a
BW	Body Weight	Child 15 kg Adult 70 kg	USEPA, 1989a
AT_c	Averaging Time Carcinogen	All 25,550 days	USEPA, 1989a
AT_{nc}	Averaging Time Noncarcinogen	Child 2,190 days Adult 10, 950 days	USEPA, 1989a
CF	Conversion Factor	1E-06 kg/mg	USEPA, 1989a

Note:

(1) Values in parentheses represent CT exposure assumptions.

(2) Maximum detected sediment concentrations will be used in situations where the 95% UCL exceeds the maximum.

TABLE 6-23

TOXICITY FACTORS
ENGINEER AREA DUMP
SITE 65 - ENGINEER AREA DUMP
REMEDIAL INVESTIGATION, CTO-0312
MCB, CAMP LEJEUNE, NORTH CAROLINA

	RfD	RfC	CSF	CSFI	WOE	Reference
Volatiles						
Acetone	1.00E-01	ND	ND	ND	D	IRIS, 1997
Chloroform	1.00E-02	ND	6.10E-03	8.05E-02	B2	IRIS, 1997
2-Butanone	6.00E-01	2.86E-01	ND	ND	ND	IRIS, 1997
Carbon Disulfide	1.00E-01	2.86E-05	ND	ND	ND	IRIS, 1997
Carbon Tetrachloride	7.00E-04	5.71E-04	1.30E-01	5.25E-02	B2	IRIS, 1997
Tetrachloroethene	1.00E-02	ND	5.20E-02	2.03E-03	ND	IRIS, 1997
Semivolatiles						
Benzo(a)anthracene	ND	ND	7.30E-01	6.10E-01	B2	EPA-NCEA, 1997
Benzo(a)pyrene	ND	ND	7.30E+00	6.10E+00	B2	IRIS, 1997
Dibenzo(a,h)anthracene	ND	ND	7.30E+00	6.10E+00	B2	EPA-NCEA, 1997
Di-n-butylphthalate	1.00E-01	ND	ND	ND	D	IRIS, 1997
Pesticides/PCBs						
beta-BHC	ND	ND	1.80E+00	1.80E+00	C	IRIS, 1997
4,4'-DDE	ND	ND	3.40E-01	ND	B2	IRIS, 1997
4,4'-DDD	ND	ND	2.40E-01	ND	B2	IRIS, 1997
Inorganics						
Aluminum	1.00E+00	ND	ND	ND	ND	EPA-NCEA, 1997
Antimony	4.00E-04	ND	ND	ND	D	IRIS, 1997
Arsenic	3.00E-04	ND	1.50E+00	1.51E+01	A_I	IRIS, 1997
Barium	7.00E-02	1.43E-04	ND	ND	D	IRIS, 1997, HEAST Alternate, 1997
Chromium	5.00E-03	ND	ND	4.20E+01	D	IRIS, 1997
Cobalt	6.00E-02	ND	ND	ND	ND	EPA-NCEA, 1997
Copper	3.71E-02	ND	ND	ND	D	EPA-NCEA, 1997
Iron	3.00E-01	ND	ND	ND	D	EPA-NCEA, 1997
Lead	ND	ND	ND	ND	B2	IRIS, 1997
Manganese	1.4E-01	1.43E-05	ND	ND	D	IRIS, 1997
Mercury	3.00E-04	8.57E-05	ND	ND	D	HEAST, 1997
Thallium (carbonate)	8.00E-05	ND	ND	ND	ND	IRIS, 1997
Vanadium	7.00E-03	ND	ND	ND	D	HEAST, 1997
Zinc	3.00E-01	ND	ND	ND	D	IRIS, 1997

Notes:

RfD	Oral Reference Dose (mg/kg - day)
RfC	Inhalation Reference Concentration (mg/cu m)
CSF	Oral Cancer Slope Factor $(mg/kg\text{-}day)^{-1}$
CSFI	Inhalation Cancer Slope Factor $(mg/kg\text{-}day)^{-1}$
WOE	Weight of Evidence
IRIS	Integrated Risk Information System
HEAST	Health Effects Assessment Summary Tables
USEPA	United States Environmental Protection Agency
ND	Not Determined
PDG	Pending
A	Human Carcinogen

B1	Probable Human Carcinogen - Limited Evidence
B2	Probable Human Carcinogen - Sufficient Evidence
C	Possible Human Carcinogen
D	Not Classifiable as to Human Carcinogenicity
I	Ingestion

TABLE 6-24

TOTAL INCREMENTAL LIFETIME CANCER RISKS (ICRs) AND HAZARD INDICES (HIs) ASSOCIATED WITH SOIL
SITE 65 - ENGINEER AREA DUMP
REMEDIAL INVESTIGATION, CTO-0312
MCB, CAMP LEJEUNE, NORTH CAROLINA

	Future Residential Child		Future Residential Adult		Current Military Personnel - Trainee		Current Military Personnel - Recreational User		Construction Worker	
	ICR	HI	ICR	HI	ICR	HI	ICR	HI	ICR	HI
Incidental Ingestion of Soil	3.0E-06	0.54	1.3E-06	0.06	4.5E-07	0.2	1.6E-07	0.04	1.2E-07	0.2
Dermal Contact with Soil	7.0E-07	0.03	1.5E-06	0.02	2.8E-07	0.04	1.9E-07	0.01	1.2E-08	0.01
Inhalation of Soil Particulates	2.7E-11	NA	4.7E-11	NA	7.4E-11	<0.01	5.8E-12	NA	5.8E-12	<0.01
Total	3.7E-06	0.6	2.8E-06	0.08	7.3E-07	0.2	3.5E-07	0.05	1.3E-07	0.2

Notes:

NA = Not Applicable. Toxicity criteria not available.

TABLE 6-25

TOTAL INCREMENTAL LIFETIME CANCER RISKS (ICRs) AND HAZARD INDICES (HIs) ASSOCIATED WITH GROUNDWATER
SITE 65 - ENGINEER AREA DUMP
REMEDIAL INVESTIGATION, CTO-0312
MCB, CAMP LEJEUNE, NORTH CAROLINA

	Future Residential Child		Future Residential Adult	
	ICR	HI	ICR	HI
Incidental Ingestion of Groundwater	NA	1.9	NA	0.8
Dermal Contact with Groundwater	NA	0.03	NA	0.01
Inhalation - Shower	NA	<0.01	NA	<0.01
Total	NA	1.9	NA	0.08

Note:

NA = Not Applicable (no carcinogenic contaminants selected as COPCs).

TABLE 6-26

TOTAL INCREMENTAL LIFETIME CANCER RISKS (ICRs) AND HAZARD INDICES (HIs) ASSOCIATED WITH SURFACE WATER/SEDIMENT AND INGESTION OF FISH TISSUE
SITE 65 - ENGINEER AREA DUMP
REMEDIAL INVESTIGATION, CTO-0312
MCB, CAMP LEJEUNE, NORTH CAROLINA

	Future Residential Child		Future Residential Adult		Fisherman Child		Fisherman Adult	
	ICR	HI	ICR	HI	ICR	HI	ICR	HI
Incidental Ingestion of Surface Water	--	0.07	--	0.02	--	0.07	--	0.02
Dermal Contact with Surface Water	--	0.02	--	0.01	--	0.02	--	0.01
Incidental Ingestion of Sediment	--	0.35	--	0.04	--	0.35	--	0.04
Dermal Contact with Sediment	- -	0.02	--	0.02	--	0.02	--	0.02
Ingestion of Fish Tissue	NA	NA	NA	NA	--	5.6	--	1.2
Total	--	0.5	--	0.09	--	6.1	--	1.3

Notes:

NA = Not applicable to receptor group
-- = No carcinogenic COPCs selected

TABLE 6-27

TOTAL SITE RISK
SITE 65 - ENGINEER AREA DUMP
REMEDIAL INVESTIGATION, CTO-0312
MCB, CAMP LEJEUNE, NORTH CAROLINA

Receptors	Soil		Groundwater		Surface Water/Sediment		Fish Tissue		Total	
	ICR	HI	ICR	HI	ICR	HI	ICR	HI	ICR	HI
Current Military Personnel - Trainee	7.3E-07 (100)	0.2 (100)	NA	NA	NA	NA	NA	NA	7.3E-07	0.2
Current Military Personnel - Recreational User	3.5E-07 (100)	<0.05 (100)	NA	NA	NA	NA	NA	NA	3.5E-07	0.05
Future Child Resident	3.7E-06 (100)	0.6 (20)	--	1.9 (63)	--	0.5 (17)	NA	NA	3.7E-06	3.0
Future Adult Resident	2.8E-06 (100)	0.08 (32)	--	0.08 (32)	--	0.09 (36)	NA	NA	2.8E-06	0.25
Future Construction Worker	1.3E-07 (100)	0.8 (100)	NA	NA	NA	NA	NA	NA	1.3E-07	0.2
Fisherman - Child Receptor	NA	NA	NA	NA	--	0.5 (7)	--	5.6 (93)	--	6.1
Fisherman - Adult Receptor	NA	NA	NA	NA	--	0.09 (8)	--	1.2 (92)	--	1.3

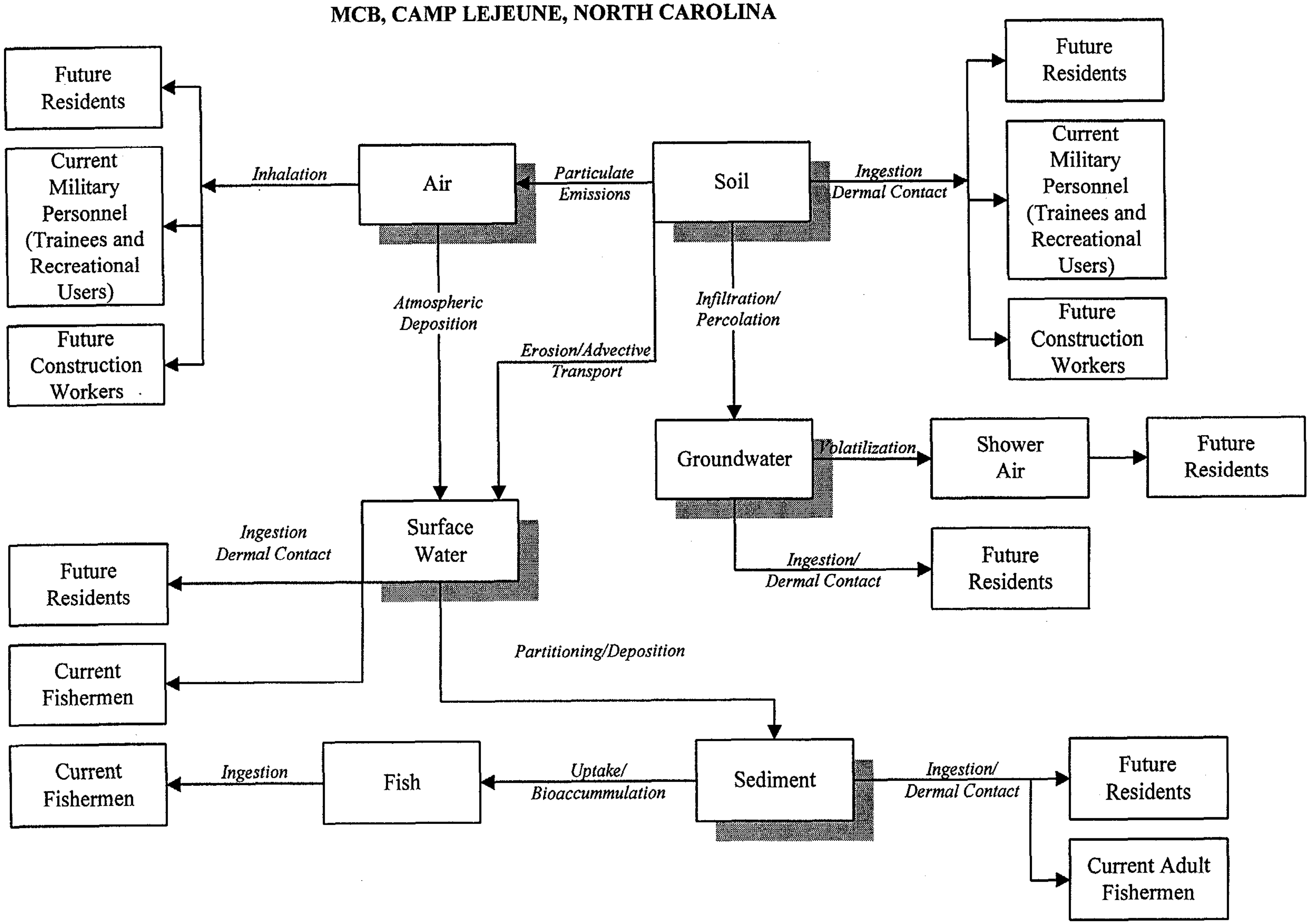
Notes:

ICR = Incremental Lifetime Cancer Risk
HI = Hazard Index
( ) = Approximate percent contribution to the total ICR or HI values
Total = Soil + Groundwater + Surface Water/Sediment + Fish Tissue
NA = Not Applicable
-- = No carcinogenic COPCs selected

FIGURES

FIGURE 6-1

CONCEPTUAL SITE MODEL
FOR CURRENT AND FUTURE HUMAN RECEPTORS
SITE 65 - ENGINEER AREA DUMP
REMEDIAL INVESTIGATION, CTO-0312
MCB, CAMP LEJEUNE, NORTH CAROLINA



7.0 ECOLOGICAL RISK ASSESSMENT

The Comprehensive Environmental Response, Compensation, and Liability Act of 1980 (CERCLA) as amended by the Superfund Amendments and Reauthorization Act (SARA) of 1986, directs USEPA to protect human health and the environment with respect to releases or potential releases of contaminants from abandoned hazardous waste sites (USEPA, 1989a). This section of the report presents the ecological risk assessment (ERA) conducted at Operable Unit No. 9 (Site 65) that assesses the potential impacts to ecological receptors from contaminants detected at this site.

7.1 Objectives, Scope, and Organization of the Ecological Risk Assessment

The objective of this ERA is to evaluate if past reported disposal practices at Site 65 are potentially adversely impacting the terrestrial and aquatic communities on, or adjacent to, the site. This assessment also evaluates the potential effects of contaminants related to Site 65 on sensitive environments including wetlands and protected species. The conclusions of the ERA are used in conjunction with the human health risk assessment to evaluate the appropriate remedial action for this site for the overall protection of public health and the environment. If potential risks are characterized for the ecological receptors, further ecological evaluation of the site and surrounding areas may be warranted.

This ERA evaluates and analyzes the results from the Remedial Investigation (RI) including chemical analysis of the soil, groundwater, surface water, and sediment. In addition, fish were collected and chemically analyzed and benthic macroinvertebrate samples were collected and identified.

Information used to evaluate sensitive environments is obtained from historical data and previous studies obtained in the literature, or through conversations with appropriate state, federal, and local personnel.

The risk assessment methodologies used in this evaluation are consistent with those outlined in the Ecological Risk Assessment Guidance for Superfund: Process for Designing and Conducting Ecological Risk Assessments (USEPA, 1994) and Framework for Ecological Risk Assessment (USEPA, 1992a). In addition, information found in the following documents was used to supplement the USEPA guidance document:

- USEPA Supplemental Risk Assessment Guidance for Superfund, Volume II, Environmental Evaluation Manual (USEPA, 1989b)
- Ecological Assessment of Hazardous Waste Sites: A Field and Laboratory Reference (USEPA, 1989c)
- Macroinvertebrate Field and Laboratory Methods for Evaluating the Biological Integrity of Surface Waters (USEPA, 1990)
- Fish Field and Laboratory Methods for Evaluating the Biological Integrity of Surface Waters (USEPA, 1993a)

Based on the USEPA Framework for Ecological Risk Assessment, an ERA consists of three main components: 1) Problem Formulation; 2) Analysis; and, 3) Risk Characterization (USEPA, 1992a). The problem formulation section includes a preliminary characterization of exposure and effects of the stressors to the ecological receptors. During the analysis, the data are evaluated to determine the exposure and potential effects on the ecological receptors from the stressors. Finally, in the risk characterization, the likelihood of adverse effects occurring as a result of exposure to a stressor are evaluated. This section also evaluates the potential impact on the ecological integrity at the site from the contaminants detected in the media. This ERA is organized to parallel these three components.

7.2 Problem Formulation

Problem formulation is the first step of an ERA and includes a preliminary characterization of exposure and effects (USEPA, 1992a). The problem formulation of this ERA includes sections 7.3 through 7.7 of this report. Chemical analyses were performed on samples collected from the soil, groundwater, surface water, sediment, and fish to evaluate the presence, concentrations, and variabilities of the contaminants. Ecological surveys and a habitat characterization also were conducted as part of the field activities. Based on these observations, potential ecological receptors were identified. Finally, toxicological information for the contaminants detected in the media was obtained from available references and literature and used to evaluate the potential adverse ecological effects to the ecological receptors.

The components of the problem formulation include identifying the stressors and their potential ecological effects, identification of ecosystems potentially at risk, defining ecological endpoints and presenting a conceptual model. The following sections discuss each of these components, and how they are evaluated in this ERA.

7.3 Contaminants of Potential Concern

One of the initial steps in the problem formulation stage of an ERA is identifying the stressors and their potential ecological effects. For this ERA, the stressors that are evaluated include contaminants detected in the surface soil, surface water, sediment, and fish.

Contaminants in the subsurface soil and groundwater are not evaluated in this ERA. Some terrestrial species burrow in the subsurface soil, and microorganisms most likely exist in the groundwater. However, current guidance does not provide sufficient information to evaluate risk to these receptors.

The nature and extent of contaminants detected in the environmental media at Site 65 are presented in Section 4.0 of this report. Sample locations are based on available historical site information and a site visit to evaluate potential ecosystems and ecological receptors.

7.3.1 Criteria for Selecting Contaminants of Potential Concern

Quantifying risk for all positively identified contaminants may distract from the dominant risk-driving contaminants at the site. Therefore, the data set was reduced to a list of contaminants of potential concern (COPCs). COPCs are site-related contaminants used to quantitatively estimate ecological exposures and associated potential ecological effects.

The criteria used in selecting the COPCs from the contaminants detected during the field sampling and analytical phase of the investigation are:

- Historical information
- Prevalence
- Toxicity
- Comparison to federal and state criteria and standards
- Comparison to investigation associated field and laboratory blank data
- Comparison to background or naturally occurring levels
- Comparison to anthropogenic levels

7.3.1.1 Historical Information

Using historical information to associate contaminants with site activities, when combined with the following selection procedures, helps determine contaminant retention or elimination. To be conservative, contaminants detected in the surface soil, surface water, sediment, and fish that may not have been historically used at a site are retained as COPCs to evaluate risk, but may be eliminated in the ecological significance section as not being site-related.

7.3.1.2 Prevalence

The frequency of positive detections in sample sets and the level at which a contaminant is detected in a given medium are factors that determine a chemical's prevalence. Prevalence is discussed in more detail in Section 6.2. Contaminants that were detected infrequently are not retained as COPCs.

7.3.1.3 Toxicity

The potential toxicity of a contaminant is an important consideration when selecting COPCs for further evaluation in the ERA. Several of the contaminants detected in the media at Site 65 are prevalent; however, their inherent toxicity to aquatic and terrestrial receptors is low (e.g., calcium, magnesium, potassium, and sodium). Therefore, they are not retained as COPCs. In addition, several the contaminants have not been adequately studied to develop published toxicity values, or even accepted toxicological data with which to assess the contaminants. Contaminants that fall into this category are retained as COPCs (if they are not eliminated due to other criteria); however, they are not quantitatively evaluated in the ERA.

7.3.1.4 State and Federal Criteria and Standards

North Carolina Water Quality Standards (NCWQS) for surface water have been developed (NC DEHNR, 1994). These are the only enforceable surface water standards. In addition to the NCWQS, Water Quality Screening Values (WQSVs) have been developed by USEPA Region IV (USEPA, 1995a), USEPA Region III (USEPA, 1995b), and Oak Ridge National Laboratory (ORNL) (Suter and Mabrey, 1994). The NCWQS and WQSVs will be herein referred to as Surface Water Screening Values (SWSVs).

Sediment quality standards have not been developed for North Carolina. However, Sediment Screening Values (SSVs) are available for many contaminants. These SSVs include: Sediment Screening Levels (SSLs) (Long et.al. 1995; Long and Morgan, 1991; and, USEPA, 1995b), calculated sediment quality criteria (SQC) (USEPA, 1993b), Apparent Effect Threshold values (Tetra-Tech, Inc., 1986), and Wisconsin Department of Natural Resources interim guidance criteria for in-water disposal of dredged sediments (Sullivan, et.al., 1985).

The SWSVs and SSVs are used for comparative purposes to infer potential ecological risks. Contaminants that were detected at concentrations less than these screening values are not retained as COPCs for aquatic receptors since contaminants detected at concentrations less than these values are not expected to pose a significant risk to the aquatic receptor population. However, the contaminants in the surface water may be retained as COPCs for the terrestrial receptors. None of the contaminants in the sediment are retained as COPCs for the terrestrial receptors because current guidance does not exist to evaluate this pathway.

There are no state or federal soil screening values that can be used to evaluate potential ecological risks to terrestrial receptors (other than plants or invertebrates). Therefore, toxicity of contaminants in the surface soil to terrestrial receptors is not used as a criteria for retaining COPCs except for calcium, magnesium, potassium, and sodium, which are not retained as COPCs in any of the media.

There are no state or federal fish tissue screening values that can be used to evaluate potential ecological risks to fish. Therefore, toxicity of contaminants in the tissue samples to aquatic receptors is not used as a criteria for retaining COPCs except for calcium, magnesium, potassium, and sodium, which are not retained as COPCs in any of the media.

A brief explanation of the standards, criteria, and screening values used for the evaluation of the COPCs is presented below.

North Carolina Water Quality Standards (Surface Water) - NCWQS are the concentrations of toxic substances that will not result in chronic toxicity to aquatic life (NC DEHNR, 1994). NCWQS are provided for both freshwater and saltwater aquatic systems.

USEPA Water Quality Screening Values (WQSVs) - WQSVs are non-enforceable regulatory guidelines and are of primary utility in assessing acute and chronic toxic effects in aquatic systems. WQSVs are provided for both freshwater and saltwater aquatic systems and are reported as acute and/or chronic values (USEPA, 1995a,b). Most of the WQSVs are the same as the USEPA Ambient Water Quality Criteria (AWQC) (USEPA, 1991b); however, some of the WQSVs are based on more current studies.

Oak Ridge National Laboratory (ORNL) Aquatic Benchmarks - ORNL Aquatic Benchmarks are developed for many contaminants, including those that do not have NCWQS or WQSVs (Suter and Mabrey, 1994). The ORNL aquatic benchmarks include secondary acute values and secondary chronic values that are calculated using the Tier II method described in the EPA's Proposed Water Quality Guidance for the Great Lakes System (USEPA, 1993c). Tier II values are developed so that aquatic benchmarks could be established with fewer data than are required for the USEPA AWQC. The benchmarks are limited to contaminants in freshwater.

Sediment Screening Levels - Sediment Screening Levels (SSLs) have been compiled to evaluate the potential for contaminants in sediments to cause adverse biological effects (Long, et.al, 1995; Long and Morgan 1991; and, USEPA, 1995b). The lower ten percentile (Effects Range-Low [ER-L]) and the median percentile (Effects Range-Median [ER-M]) of biological effects have been developed for several contaminants. The concentration below the ER-L represents a minimal-effects range (adverse effects would be rarely observed). The concentration above the ER-L but below the ER-M represents a possible-effects range (adverse effects would occasionally occur). Finally, the concentration above the ER-M represents a probable-effects range (adverse effects would probable occur).

In addition to the SSLs, Apparent Effects Threshold Sediment Quality Values have been developed by Tetra Tech Inc., (1986) for the Puget Sound. These values are the concentrations of contaminants above which statistically significant biological effects would always be expected. Finally, the Wisconsin Department of Natural Resources has developed interim criteria for in-water disposal of dredged sediments (Sullivan, et.al., 1985). However, these criteria are established using background data and are not based on aquatic toxicity.

Sediment Quality Criteria - Currently, promulgated sediment quality criteria (SQC) only exist for a few contaminants. However, SQC for nonionic organic compounds can be calculated using the procedures in the Technical Basis for Deriving Sediment Quality Criteria for Nonionic Organic Contaminants for the Protection of Benthic Organisms by using Equilibrium Partitioning (USEPA, 1993b) as follows:

SQC = (Foc)(Koc)(FCV)/1,000,000

Where:

SQC = sediment quality criteria (µg/kg)
Foc = sediment organic carbon content (mg/kg)
Koc = chemical organic carbon partition coefficient (mL/g)
FCV = final chronic water quality value (µg/L)

7.3.1.5 Field and Laboratory Blank Data

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

In accordance with the National Functional Guidelines for Organics (USEPA, 1991a), common lab contaminants (i.e., acetone, 2-butanone, methylene chloride, toluene, and phthalate esters) should be regarded as a direct result of site activities only when sample concentrations exceed 10 times the maximum blank concentration. For other contaminants not considered common in a lab, concentrations exceeding 5 times the maximum blank concentration indicate contamination resulting from site activities (USEPA, 1991a). Maximum concentrations of contaminants detected in blanks are presented in Section 6.0, Table 6.1.

Contract Required Quantitation Limits (CRQLs) and percent moisture are employed when evaluating contaminant concentrations in soil, in order to correlate solid and aqueous detection limits. For example, the CRQL for semivolatiles in soil is 33 to 66 times that of aqueous samples, depending on the contaminant. In order to assess semivolatile contaminant levels in soil using aqueous blanks, the blank concentration must then also be multiplied by 33 or 66 to account for variance from the CRQL (common lab contaminants must first be multiplied by 5 or 10, as explained in the paragraph above). The final value is divided by the sample percent moisture.

Eliminating a sample result correlates directly to a reduction in the contaminant prevalence in that medium. Consequently, if elimination due to blank concentration reduces the prevalence of a contaminant to less than 5 percent, a contaminant that may have been included according to its prevalence is eliminated as a COPC.

7.3.1.6 Background or Naturally Occurring Levels

Contaminants that were detected in the surface soil at concentrations less than two-times the average Base background concentration are not retained as COPCs. As is presented in Section 4.0, off-site surface water and sediment samples were collected from several waterbodies in the White Oak River water basin. The contaminant in the off-site samples and the site stations are compared to each other to determine if contaminants concentrations in the site stations are below naturally occurring regional levels.

The two water bodies sampled at Site 65 were Courthouse Bay Pond and Powerline Pond. Since both ponds are freshwater, the freshwater off-site background surface water and sediment samples are compared to the Site 65 samples to determine if contaminant concentrations are within background concentrations. Contaminants that were detected in the Site 65 surface water or sediment samples at concentrations less than the average background concentrations are not retained as COPCs.

7.3.1.7 Anthropogenic Levels

Ubiquitous anthropogenic background concentrations result from non-site related sources such as combustion of fossil fuels (i.e., automobiles), plant synthesis, natural fires and factories. Examples of ubiquitous, anthropogenic chemicals are polycyclic aromatic hydrocarbons (PAHs). Anthropogenic chemicals are typically not eliminated as COPCs without considering other selection criteria. It is difficult to determine that such chemicals are present at the site due to operations not related to the site or the surrounding area. Omitting anthropogenic background chemicals from the risk assessment may result in the loss of important information for those potentially exposed.

The following sections apply the aforementioned selection criteria beginning with the prevalence of detected analytical results in each medium of interest to establish a preliminary list of COPCs for Site 65. Once this task has been completed, a final list of media-specific COPCs will be selected based on the remaining criteria.

7.3.2 Selection of Contaminants of Potential Concern

The following sections present an overview of the analytical data obtained for each medium during the RI and the subsequent retention or elimination of COPCs using the aforementioned selection criteria. Contaminants that were not eliminated due to the above criteria were retained as COPCs. The primary reasons for retaining contaminants as COPCs include, but may not be limited to the following: (1) frequently detected, (2) detected at concentrations above the screening values (if available) and/or (3) detected at concentrations above background (if available). In addition, some common laboratory contaminants (i.e., phthalates, acetone, 2-butanone) are retained as COPCs if they were detected frequently and were detected at levels slightly less than 10 times the concentration in the blank samples. Calcium, magnesium, potassium, and sodium are not retained as COPCs in any of the media because they are common naturally occurring chemicals, are not related to the site, and no published toxicity data was identified to assess potential impacts to aquatic or terrestrial life.

Table 7-1 presents the comparison of the surface water contaminant concentrations to the SWSVs and the off-site background sample contaminant concentrations. Table 7-2 presents the comparison of the sediment contaminant concentrations to applicable SSVs and the off-site background sample contaminant concentrations. A comparison of the surface soil contaminant concentrations to Base background concentrations is presented in Section 6.0, Table 6-3. A summary of the COPCs in each media are presented in Table 7-3 . All of the media samples were analyzed for TCL volatile organic compounds (VOCs), semivolatile organic compounds (SVOC), pesticides and PCBs, and TAL metals.

7.3.2.1 Surface Soil

Thirteen surface soil samples were collected at Site 65. Six VOCs (methylene chloride, acetone, trichloroethene, toluene, ethylbenzene, and xylenes) were detected in the surface soil. Methylene chloride, acetone, and toluene are not retained as COPCs because they are common laboratory contaminants and they were detected at less than 10 times the concentration in the blank samples. Trichloroethene, ethylbenzene, and xylenes are retained as COPCs.

Nineteen SVOCs were detected in the surface soil. Acenaphthene, 2,4-dinitrophenol, anthracene, benzo(a)anthracene, benzo(b)fluoranthene, benzo(k)fluoranthene, benzo(a)pyrene, ideno(1,2,3-cd)pyrene, benzo(g,h,i)perylene, carbazole, chrysene, dibenzo(a,h)anthracene, dibenzofuran, fluorene, phenanthrene, di-n-butylphthalate, fluoranthene, pyrene, and bis(2-ethylexyl)phthalate are retained as COPCs.

Five pesticides were detected in the surface soil. Endosulfan II, 4,4'-DDE, 4,4'-DDT, 4,4'-DDD, and heptachlor epoxide are retained as COPCs. Aroclor 1260 was detected in one of the surface soil samples and is retained as a COPC.

Fifteen metals were detected in the surface soil. As presented above, calcium, magnesium, potassium, and sodium are not retained as a COPCs. Copper is not retained as a COPC because it was detected at a concentration of less than five times the concentration in the blank sample. Aluminum is not retained as COPC because it was detected at concentrations of less than twice base background. Barium, chromium, iron, lead, manganese, nickel, thallium, vanadium and zinc are retained as COPCs.

7.3.2.2 Surface Water

Two surface water samples were collected at Site 65. Two VOCs (acetone, and 1,2-dichloroethane) were detected in the surface water. Neither contaminant is retained as a COPC for the aquatic and terrestrial receptors because they are common laboratory contaminants and were detected at a concentration of less than 10 times the concentration in the blank sample. No SVOCs, pesticides, or PCBs were detected in the surface water samples.

Thirteen metals were detected in the surface water samples. As presented above, calcium, magnesium, potassium, and sodium are not retained as COPCs for the aquatic or terrestrial receptors. Chromium is not retained as a COPC for the aquatic receptors because detected concentrations do not exceed the SWSV. However, chromium is retained as a COPC for terrestrial receptors. Aluminum, barium, copper, iron, lead, manganese, vanadium, and zinc are retained as COPCs for both the aquatic and terrestrial receptors.

7.3.2.3 Sediment

Four sediment samples were collected at Site 65. At each station sediment samples were collected from two depths, zero to six inches and six to 12 inches. Six VOCs were detected in the sediment. Acetone, chloroform, and toluene are not retained as COPCs because they are common laboratory contaminants and were detected at a concentration of less than 10 times the concentration in the blank sample. Carbon tetrachloride, 2-butanone, and tetrachloroethene are not retained as COPCs because they were detected at concentrations below the SSVs.

One SVOC (di-n-butylphthalate) was detected and retained as COPC in the sediment. Three pesticides were detected in the sediment. Beta-BHC, 4,4'-DDE, and 4,4'-DDD are all retained as COPCs.

Fifteen metals were detected in the sediment. As presented above, calcium, magnesium, potassium, and sodium are not retained as COPCs. Barium, chromium, iron, and manganese are not retained as COPCs because they did not exceed their respective SSVs. Aluminum, antimony, cobalt, copper, lead, vanadium, and zinc are retained as COPCs.

7.3.2.4 Tissue Samples

Four, fish-fillet samples and five, whole-body fish samples were chemically analyzed for Site 65.

Fish Fillet Samples

Four, fish-fillet samples were collected for tissue analysis at Site 65. One VOC (acetone) was detected and retained as a COPC in the fish fillet tissue. No SVOCs were detected in the fish fillet samples. One pesticide (4,4'-DDD) was detected and retained as a COPC.

Twelve metals were detected in the fish fillet tissue. As presented above, calcium, magnesium, potassium, and sodium are not retained as COPCs. Aluminum, barium, copper, manganese, mercury, selenium, thallium, and zinc are retained as COPCs.

Fish Whole Body Samples

Five, whole-body fish samples were collected for tissue analysis at Site 65. Four VOCs were detected in the fish, whole-body tissue. Acetone, 2-butanone, methylene chloride, and toluene are retained as COPCs. No SVOCs were detected in the fish, whole-body samples. Two pesticides were detected in the fish, whole-body tissue. Pesticides 4,4'-DDD and 4,4'-DDE are retained as COPCs.

Seventeen metals were detected in the fish, whole-body tissue. As presented above, calcium, magnesium, potassium, and sodium are not retained as COPCs. The remaining thirteen metals (aluminum, antimony, arsenic, barium, beryllium, copper, iron, lead, manganese, mercury, selenium, thallium, and zinc) are retained as COPCs.

7.3.3 Physical/Chemical Characteristics of COPCs

Physical and chemical characteristics of contaminants may affect their mobility, transport, and bioavailability in the environment. These characteristics include bioconcentration factors (BCFs), organic carbon partition coefficient (K_{oc}), octanol water partition coefficient (K_{ow}), and biotransfer factors (Bv, Bb, Br). Table 7-4 summarizes these values for the COPCs detected in the surface soil, surface water, sediment, and fish tissue samples. Information from this table is used to assess the fate and transport of the constituents and the potential risks to the environmental receptors at each site. The following paragraphs discuss the significance of each parameter included in the table.

Bioconcentration factors measure the tendency for a chemical to partition from the water column or sediment and concentrate in aquatic organisms. Bioconcentration factors are important for ecological receptors because chemicals with high BCFs could accumulate in lower-order species and subsequently accumulate to toxic levels in species higher up the food chain. The BCF is the concentration of the chemical in the organism at equilibrium divided by the concentration of the chemical in the water. Therefore, the BCF is unitless. The BCF used to determine if a contaminant has a high potential to bioaccumulate in aquatic or terrestrial organisms.

K_{oc} 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 K_{oc} is used to calculate sediment quality criteria.

K_{ow} 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 K_{ow} is used to calculate the plant biotransfer factors that are used to estimate the COPC concentration in plants that would potentially be ingested by the terrestrial receptors in the intake model.

The plant biotransfer factors (Bv or Br) measures the potential for a chemical to accumulate in a plant. These factors are used to calculate the concentration of the COPCs in either the leafy part of the plant (Bv) or the fruit of the plant (Br). The factors for inorganics are obtained from Baes et.al., 1984, while the factors for organics are calculated according to Travis and Arms, 1988. The Bv and Br values for the organics are assumed to be same value.

Finally, the beef biotransfer factors (Bb) measures the potential for a chemical to accumulate in an animal. This factor is used to calculate the COPC concentration in the small mammal that is ingested by the red fox. The factors for inorganics are obtained from Baes et.al., 1984, while the factors for organics are calculated according to Travis and Arms, 1988.

7.4 Ecosystems Potentially at Risk

Ecological receptors that might be potentially at risk from contaminants at Site 65 were identified during the field investigations and the habitat evaluation. The regional and site-specific ecology are presented in Section 3.0. Based on the results of the field investigations and the habitat evaluation, potential receptors of contaminants in surface water and sediment include: fish, benthic macroinvertebrates, other aquatic flora and fauna and some terrestrial faunal species. Potential receptors of contaminants in soil include: deer, rabbits, foxes, raccoons, birds and other terrestrial flora and fauna.

7.5 Ecological Endpoints

The information compiled during the first stage of problem formulation (stressor characteristics and ecosystems potentially at risk) is used to select the ecological endpoints for this ERA. The following section presents the ecological endpoints selected for this ERA, and the reasons they are selected.

There are two primary types of ecological endpoints: assessment endpoints and measurement endpoints. Assessment endpoints are explicit expressions of the actual environmental values that are to be protected (USEPA, 1994). Measurement endpoints are measurable responses to a stressor that are related to the valued characteristics chosen as the assessment endpoints (USEPA, 1994). Measurement endpoints may be identical to assessment endpoints (e.g., measurement of abundance of fish), or they may be used as surrogates for assessment endpoints (e.g., toxicity test endpoints). Both types of endpoints are used in the ecological risk evaluation and are presented in the following sections.

A measurement endpoint, or "ecological effects indicator" as it is sometimes referred, is used to evaluate the assessment endpoint. Therefore, measurement endpoints must correspond to, or be predictive of, assessment endpoints. In addition, they must be readily measurable, preferably quickly and inexpensively, using existing techniques. Measurement endpoints must take into consideration the magnitude of the contamination and the exposure pathway. The measurement endpoint should be an indicator of effects that are temporally distributed. Low natural variability in the endpoint is preferred to aid in attributing the variability in the endpoint to the contaminant. Measurement endpoints should be diagnostic of the pollutants of interest, as well as broadly applicable to allow comparison among sites and regions. Also, measurement endpoints should be standardized (e.g., standard procedures for toxicity tests). Finally, it is desirable to use endpoints that already are being measured (if they exist) to determine baseline conditions.

7.5.1 Aquatic Endpoints

The assessment endpoints for the aquatic receptors are changes in the structure (i.e., density, diversity) of benthic macroinvertebrate communities attributable to site-related contaminants and the protection of benthic macroinvertebrates and fish due to exposure of site-related contaminants in the surface water and sediment. Measurement endpoints for the first aquatic assessment endpoint include: 1) lower benthic macroinvertebrate species diversity and richness when compared to an ecologically similar background location; 2) the dominance of contaminant-tolerant species (opportunistic) over contaminant sensitive species (equilibrium); 3) elevated levels of contaminants in the biota tissue samples as compared to tissue samples collected at off-site background stations or in the literature; and, 4) contaminant levels in the tissue samples that exceed toxicity values in the literature (where available). The measurement endpoints for the second aquatic assessment endpoint include exceedences of contaminant-specific surface water and sediment effect concentrations (i.e., SWSVs, and SSVs).

Species diversity, richness, and change in species dominance are evaluated by comparing the type of species, the species diversity, and community similarity of the benthic macroinvertebrates collected at Site 65 to the appropriate off-site background stations. The dominance of contaminant-tolerant species over contaminant sensitive species is evaluated by comparing the Macroinvertebrate Biotic Index (MBI) of the benthic macroinvertebrates collected at Site 65 to the MBI from the appropriate off-site background stations. The following paragraphs present how the species diversity, community similarity, and MBI are calculated and interpreted.

7.5.1.1 Species Diversity

The benthic macroinvertebrate community was examined using a mathematical expression of community structure called a diversity index. Diversity data are useful because they condense a substantial amount of data into a single value. The Shannon-Wiener diversity index and Brillouin diversity index both were calculated for the benthic macroinvertebrate species.

The Shannon-Wiener (H^1) function is one of the more commonly used formulas for calculating species diversity. Species diversity was calculated in logarithmic base 10 using the following equation (Brower and Zar, 1977):

$$H^1 = \sum (p_i * \log(p_i)).$$

H^1 = mean species diversity
p_i = proportion of the total number of individuals occurring in species i.

Brillouin's diversity (H) is used if a data set is not considered to be a random sample. This situation arises when data comprising an entire population are available or for data that are from a sample obtained non-randomly from a population. Brillouin's diversity is calculated using the following equation (Brower and Zar, 1977):

$$H = \frac{(\log n! - \sum (\log(f_i!))}{n}.$$

H = species diversity
n = the sample size
f = the number of observations in category i

The operative assumption in the interpretation of diversity values is that relatively undisturbed environments tend to support communities that consist of a large number of species with no single species present in overwhelming abundance. Many forms of stress tend to reduce diversity by producing an environment that is less desirable for some taxa and, therefore, giving a competitive advantage to other taxa.

7.5.1.2 Community Similarity

Community similarity between benthic macroinvertebrate stations was measured using two qualitative indices of community similarity, the Jaccard coefficient (S_J) and the SΦrenson index (S_S). The indices use two possible attributes of the ecosystem, that is whether a species was or was not present in the collected sample. Because these coefficients are based on the number of species collected and not the number of individuals, a few organisms from several taxa could significantly change the similarity value, whereas there may not be an overall significant difference between the communities.

The S_J is better than the S_S at discriminating between highly similar collections and has been used widely in stream pollution investigations. The S_J ranges from 0.0 (dissimilar) to 1.0 (similar) and is calculated using the following equation (Brower and Zar, 1977):

$$S_j = \frac{a}{a + b + c}$$

a = number of species common to both collections
b = number of species in the first collection but not the second
c = number of species in the second collection but not in the first

The S_S places more emphasis on common attributes, and is better than the S_J at discriminating between highly dissimilar collections. The S_S ranges from 0.0 (dissimilar) to 1.0 (similar) and is calculated using the following equation (Brower and Zar, 1977):

$$S_s = \frac{2a}{2\,a + b + c}$$

Where a, b, and c are as described above.

These indices are used to detect changes in the community structure. Stressed communities presumably have different species than relatively non-stressed communities, given that all other factors are equal. Several factors determine the type of benthic population that will inhabit an area including salinity fluctuations, sediment type, size of water body, and time of collection. Although the community similarity indices will give some indication as to the similarities of the communities, more weight will be placed on the types of species that were collected, the relative densities, and the species diversities of the site stations as compared to the reference stations.

7.5.1.3 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, 1990). 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 species Latin name, order, biotic index (BI), and feeding group. However, BI have not been developed 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, USEPA lists many common benthic macroinvertebrate species along with their tolerance to organic wastes, heavy metals, and acids (USEPA, 1990)

The MBI was developed to provide a rapid stream quality assessment. North Carolina had a data set of over 2,000 stream macroinvertebrate samples that 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 pollution regardless of the source. The index is an average of the BIs weighed by individual abundance, and is calculated as follows:

$$MBI = \frac{\Sigma(n_i * BI)}{N}$$

Where:

MBI = Macroinvertebrate Biotic Index
n_i = Number of individuals occurring in the i^{th} taxa
BI = Biotic Index assigned to the i^{th} taxa
N = Total number of individuals in the sample

The sample benthic macroinvertebrate populations were assigned a general stream/water quality condition based on the MBI value. The five classes and their corresponding MBI values are presented 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.

7.5.2 Terrestrial Endpoints

The assessment endpoint for the terrestrial receptors as follows: 1) the protection of terrestrial herbivore and carnivore mammals from ingesting plants, soil, surface water, fish, and/or small mammals that contain site-related contaminants; 2) the protection of terrestrial herbivore avian species from ingesting plants, soil, and surface water that contain site-related contaminants; and 3) the protection of terrestrial plants and invertebrates from direct exposure to site-related contaminants in the soil.

The measurement endpoints for the terrestrial ERA include: 1) exceedences of contaminant-specific soil effect concentrations (i.e., SSSVs); 2) CDI exceedences of contaminant-specific effect doses (TRVs); and, 3) tissue sample concentration exceedences of proposed criteria for piscivorous wildlife.

7.6 Conceptional Model

This section of the ERA presents each potential exposure pathway via soil, groundwater, surface water, sediment, and air, and the likelihood that an exposure will occur through these pathways. Figure 7-1 presents the flowchart of potential exposure pathways and ecological receptors.

To determine if ecological exposure via these pathways may occur in the absence of remedial actions, an analysis is conducted including the identification and characterization of the exposure pathways. The following four elements are examined to determine if a complete exposure pathway is present:

- A source and mechanism of chemical release
- An environmental transport medium

- A receptor exposure route
- A receptor exposure point

7.6.1 Soil Exposure Pathway

Potential release sources to be considered in evaluating the soil pathway are surface or buried wastes and contaminated soil. The release mechanisms to be considered are fugitive dust, leaching, tracking, and surface runoff. The transport medium is the soil. The potential routes to be considered for ecological exposure to the contaminated soil are ingestion and dermal contact. Potential exposure points for ecological receptors include species living in, or coming in contact with, the soil. COPCs were detected in the surface soil demonstrating a release from a source to the surface soil transport medium. Potential receptors that may be exposed to contaminants in surface soil at/or around surface soil in the areas of detected COPCs including: deer, fox, raccoon, rabbits, birds, plants, and other terrestrial life.

Terrestrial receptors potentially are exposed to contaminants in the soil through ingestion, dermal contact, and/or direct uptake (for flora). The magnitude of the exposure depends on their feeding habits and the amount of time they reside in the contaminated soil. In addition, terrestrial species may ingest organisms that have bioconcentrated contaminates from the soil. This exposure pathway is likely to occur at Site 65 and is retained for further analysis.

7.6.2 Groundwater Exposure Pathway

The potential release source to be considered in evaluating the groundwater pathway is contaminated soil. The release mechanism to be considered is leaching. The routes to be considered for ecological exposure to the contaminated groundwater are ingestion and dermal contact. Groundwater discharge to area surface waters may represent a pathway for contaminant migration.

Subsurface biota (i.e., microorganisms) are the only ecological receptors expected to be directly exposed to groundwater. Potential impacts to these biota are not assessed in this ERA because current guidance does not provide sufficient information to evaluate risk. In addition, since the receptors of concern are not directly exposed to groundwater at Site 65, the groundwater to surface water exposure is accounted for in the surface water section of the ERA.

7.6.3 Surface Water and Sediment Exposure Pathway

Potential release sources to be considered in evaluating the surface water and sediment pathways are contaminated surface soil and groundwater. The release mechanisms to be considered are groundwater seepage and surface runoff. The potential routes to be considered for ecological exposure to the contaminated surface water/sediment are ingestion and dermal contact. Potential exposure points for ecological receptors include species living in, or coming in contact with, the surface water/sediment on-site. COPCs were detected in the surface water and sediment demonstrating a release from a source to the surface water or sediment transport medium. Potential receptors that may be exposed to contaminants in surface water and sediment include: fish, benthic macroinvertebrates, deer, birds, and other aquatic and terrestrial life.

Aquatic receptors are exposed to contaminants in the surface water and sediment by ingesting water while feeding and by direct contact while feeding or swimming. This exposure pathway is likely to occur at Site 65 and is evaluated in the ERA. In addition, aquatic organisms may ingest other aquatic flora and fauna that have bioaccumulated chemicals from the surface water and sediment. This potential exposure pathway is not evaluated in the ERA because current guidance does not provide sufficient information to evaluate risk.

Terrestrial faunal receptors potentially are exposed to contaminants in the surface water and sediment through ingestion and dermal contact. The magnitude of the exposure depends on their feeding habits and the amount of time they reside in the contaminated waters. In addition, terrestrial species may ingest organisms (e.g., fish, small mammals, invertebrates, and plants) that have bioconcentrated contaminates from the surface water and sediment. These exposure pathways are likely to occur at Site 65. However, only the surface water and surface soil ingestion pathway is evaluated in the ERA. Current guidance does not exist to evaluate the sediment pathway, sub-surface soil pathway, or dermal contact pathway for terrestrial receptors, therefore, these pathways are not evaluated in the ERA.

7.6.4 Air Exposure Pathway

There are two potential release mechanisms to be considered in evaluating the atmospheric pathway: release of contaminated particulates and volatilization from surface soil, groundwater and surface water. The potential exposure points for receptors are areas on or adjacent to the site. The air exposure pathway is not evaluated in this ERA because air sampling was not conducted, and current guidance does not provide sufficient information to evaluate risk.

7.7 Exposure Assessment

The next phase after the problem formulation is the exposure assessment that consists of quantifying the potential exposure of the stressors (COPCs) to the ecological receptors. The RI included collecting samples for analytical analysis from five media; soil, groundwater, surface water, sediment, and tissue (fish). As presented earlier in the ERA, contaminants in the subsurface soil and groundwater are not evaluated. The analytical results for the data used in ERA are presented in Section 4.0 of this report.

The regional ecology, site ecology, and habitat characterization in the areas surrounding Site 65 are presented in Section 3.0 of this report. Information on sensitive environments and endangered species also is included in this section.

Exposure of contaminants in the surface soil to terrestrial flora and fauna (invertebrates and microorganisms) are assumed to be equal to the contaminant concentration in the surface soil. It is noted in the uncertainty section of this ERA that all the contaminants in the surface soil may not be bioavailable to the terrestrial flora or fauna. Exposure of contaminants in the surface water and sediment to aquatic receptors are assumed to be equal to the contaminant concentration in the surface water and sediment. Exposure of contaminants in the surface soil and surface water to other terrestrial fauna (mammals, birds) are estimated using the chronic daily intake models presented in the next section of this ERA.

The following sections presents the results of the ecosystem characterization including the biological sampling, abiotic habitat, and biotic habitat.

7.7.1 Surface Water, Sediment, and Biological Sampling

Biological samples collected at Site 65 included fish to obtain tissue samples, and benthic macroinvertebrates to obtain population statistics. Water quality measurements were collected during the sampling event prior to the surface water and sediment sample collection. These measurements consisted of temperature, pH, specific conductance, salinity, and dissolved oxygen. Site specific descriptions, and field water quality measurements were recorded on field data sheets (see Appendix V). The station locations and sampling procedures for collecting each of the environmental media are presented in Section 2.0 of this report.

7.7.1.1 Abiotic Habitat

The abiotic habitat consists of the description of the stations with regard to size of the ponds, depth of the water, substrate type, water chemistry and other such non-biological descriptors. The following sections present the abiotic habitat for the sampling stations at Site 65.

Table 7-5 presents the sampling station characterization summary that includes the dimensions of the ponds including depth, canopy cover, sediment type, and sediment odor of the Site 65 stations and the upstream stations. Courthouse Bay Pond has a perimeter of 750 feet and encompasses an area of 26,000 square feet. The canopy cover is open. The sediment was primarily, a silty-sand with organic material below the three inch depth, with a decaying organic odor. Powerline Pond has a perimeter of 630 feet and encompasses an area of 27,900 square feet. The canopy cover is open. Finally, the sediment was primarily a silty-sand with large amounts of organic material, with an anaerobic odor.

Table 7-6 presents the results of the field chemistry including the temperature, pH, dissolved oxygen concentration, conductivity, and salinity. The temperature ranged from 17.3 to 30.4 °C; the pH ranged from 6.32 to 7.62 standard units; the dissolved oxygen ranged from 2.0 to 10.6 mg/L; the conductivity ranged from 12 to 214 umhos/cm; and the salinity for both ponds was 0.0 parts per thousand. The field chemistry at these stations appear to be typical of surface waters at MCB, Camp Lejeune based on previous sampling experience.

7.7.1.2 Biotic Habitat

The biotic habitat consists of the description of the stations with regard to the biological community. The following sections present the results of the benthic macroinvertebrate community for the sampling stations at Site 65.

Fish Community

Fish were collected from both ponds at Site 65, the results of the fish sampling effort at these ponds are summarized on Table 7-7. The fish distribution and characterization summary is presented in Table 7-8. Appendix W presents the lengths and weights of the individual fish collected at each station. One bluegill that was collected from Courthouse Bay Pond had an enlarged dorsal end in front of the dorsal fin. The remaining fish did not have any visible signs of abnormalities. In general, the fish collected from Courthouse Bay Pond were not as brilliant in color as those collected from Powerline Pond.

Two fish species (i.e., bluegill [*Lepomis macrochirus*, 32 individuals] and redear sunfish [*L. microlophus,* 8 individuals]) were collected from Courthouse Bay Pond (65-FS04). Three fish species (i.e., largemouth bass [*Micropterus salmoides,* nine individuals], bluegill [30 individuals], and redear sunfish, [31 individuals]) were collected from Powerline Pond (65-FS05). Fish from Courthouse Bay Pond were collected by setting a series of hoop nets within the pond. Fish from Powerline Pond were collected via electrofishing and hoop nets. Hoop nets were deployed at

Powerline Pond due to the extremely high amounts of aquatic vegetation inhibiting the stunned fish from surfacing during electroshocking operations. Electroshocking was not performed at Courthouse Bay Pond due to the low visibility (less than one inch) caused by an excessive amount of suspended solids.

Benthic Macroinvertebrate Community

Table 7-9 presents the benthic macroinvertebrates collected from both of the Site 65 stations. Appendix X presents the benthic macroinvertebrates collected from the off-site reference station (WC02). Table 7-10 presents the tolerance values of each species to organic pollution and metals, and the North Carolina Biotic Index. Table 7-11 presents all the samples summary statistics.

A total of one benthic macroinvertebrate specie consisting of 6 individuals was collected at Courthouse Bay Pond (65-BN04), and a total of six species consisting of 14 individuals was collected at Powerline Pond (65-BN05). At the off-site reference station (WC02), 20 species consisting of 286 individuals were collected. It should be noted that benthic macroinvertebrate locations at the Site 65 were within the ponds, while the off-site reference station was a small ponded area through which a creek flowed.

The arthropod *Chaborus sp.* comprised the total percentage (100 %) of the individuals collected at 65-BN04. The arthropod *Ablabesmyia ramphe gr.* comprised the majority (35.7 %) of the individuals collected at 65-BN05.

Only one specie (*Chaborus sp.*) was identified within Courthouse Bay Pond. Six species were identified within Powerline Pond. Two of the species (*A. ramphe gr.*), and (*Chrysops sp.*) were quantified at the highest percentages, 36% and 21% respectively. Species densities for Courthouse Bay Pond and Powerline Pond were 38 and 89 individuals/square meter, respectively. The Shannon-Wiener and Brillouin's specie diversities for Courthouse Bay Pond were both zero. These diversities for Powerline Pond were 0.71 and 0.53, respectively. Diversities for the off-site reference station were 0.80 and 0.76, respectively. The MBI value for Powerline Pond was 7.1 and the off-site reference station was 7.8. The MBI was not calculated for Courthouse Bay Pond since the one benthic macroinvertebrate species collected in this pond did not have a biotic index value. Finally, Table 7-12 presents the community similarity for the benthic macroinvertebrates between the two Site 65 stations, and between the Site 65 stations and the off-site reference station. The similarities between all the stations are very low.

7.8 Ecological Effects Characterization

The ecological effects data that were used to assess potential risks to aquatic and/or terrestrial receptors in this ERA include aquatic and terrestrial screening values as presented in Section 7.3.4.1 to aid in the selection of the COPCs. The following sections present a summary of the ecological effects comparison.

7.8.1 Surface Water

Contaminant concentrations detected in the surface water at Site 65 were compared to the freshwater SWSVs to determine if there were any exceedences of the published values (see Table 7-1).

In summary, aluminum, barium, copper, iron, lead, manganese, vanadium, and zinc are the only contaminants detected in the surface water that exceeded any of the SWSVs. The SWSVs for barium (69.1 µg/L-acute, 3.8 µg/L-chronic) were the ORNL aquatic benchmarks (Suter and Mabrey, 1994). These values appear to be overly conservative since the lowest chronic value for aquatic organisms (daphnids) was 5,800 µg/L (Suter and Mabrey, 1994). In addition, it is reported in the Quality Criteria for Water-1986 that soluble barium concentrations in fresh waters generally would have to exceed 50,000 µg/L before toxicity to aquatic life would be expected (USEPA, 1987). Therefore, the maximum barium concentration in the surface water sample (69.3 µg/L) is below the concentrations that are expected to cause adverse impacts to aquatic life.

The SWSVs for manganese (1,470 µg/L-acute, 80.3 µg/L-chronic) were the ORNL aquatic benchmarks (Suter and Mabrey, 1994). These values also appear to be overly conservative since the lowest chronic value for aquatic organisms (daphnids) was <1,100 µg/L, while the lowest chronic value for fish was 1,770 µg/L (Suter and Mabrey, 1994). In addition, it is reported in the Quality Criteria for Water-1986 that the tolerance values for aquatic life in freshwaters range from 1500 µg/L to 1,000,000 µg/L (USEPA, 1987). Therefore, the maximum manganese concentration in the surface water sample (88.4 µg/L) is below the concentrations that are expected to cause adverse impacts to aquatic life.

The SWSVs for vanadium (284 µg/L-acute, 19.1 µg/L-chronic) were the ORNL aquatic benchmarks (Suter and Mabrey, 1994). These values also appear to be overly conservative since the lowest chronic value for aquatic organisms (fish) was 80 µg/L (Suter and Mabrey, 1994). Therefore, the maximum vanadium concentration in the surface water sample (26.2 µg/L) is below the concentration that is expected to cause adverse impacts to aquatic life.

Finally, NCWQS for turbidity is less than 25 Nephelometric Turbidity Units (NTU) (NC DEHNR, 1994), while the USEPA AWQC for turbidity is the "settleable and suspended solids should not reduce the depth of the compensation point for photosynthesis activity by more than 10 percent from the seasonally established norm for aquatic life" (USEPA, 1987). Turbidity was not measured in Courthouse Bay Pond. However, based on Baker's previous sampling experience, it is assumed that the turbidity in Courthouse bay Pond is greater than 25 NTU, and that the compensation point for photosynthesis activity is reduced by more than 10 percent. It is reported in the Quality Criteria for Water-1986, that suspended solids have four effects on fish and fish food populations: 1) by acting directly on the fish swimming in water in which solids are suspended, and either killing them or reducing their growth rate, resistance to disease, etc.; 2) by preventing the successful development of fish eggs and larvae; 3) by modifying natural movements and migration; and, 4) by reducing the abundance of food available to fish (USEPA, 1987). Largemouth bass are considered intolerant of suspended solids that may interfere with reproductive processes and reduce growth (USDI, 1982). It also is reported that largemouth bass are more sensitive to turbidity than are redear sunfish and bluegills (USEPA, 1977). Finally, suspended solids also are harmful to many aquatic invertebrates that cannot tolerate appreciable concentrations of inorganic particulate matter, and may significantly reduce organism density by smothering bottom invertebrates (Wetzel and Likens, 1991 and USEPA, 1987).

7.8.2 Sediment

Contaminant concentrations detected in the sediment at Site 65 were compared to SSVs and calculated SQC values to determine if there were any exceedences of the published values (see Table 7-2). Di-n-butylphthalate, beta-BHC, 4,4'-DDE, and 4,4'-DDD are the only organics that exceeded the SSVs.

A few of the organics only exceeded either the ER-L or the SQC. However, only 4,4'-DDD exceeded ER-M value. The di-n-butylphthalate SSV is an apparent effect threshold value (Tetra Tech, Inc, 1986), and is placed only in the ER-M column.

Antimony, copper, lead , and zinc are the only inorganics that exceeded the SSVs. The copper, lead, and zinc SSVs are sediment screening levels (USEPA, 1995a, Long et.al., 1995), and have both ER-L and ER-M values. All of these inorganics exceeded the ER-L. Antimony was the only inorganic that exceeded the ER-M. Aluminum, cobalt, and vanadium do not have associated SSVs, and therefore, their potential effects on aquatic life can not be evaluated.

7.8.3 Fish Tissue

The following sections discuss the chemical concentrations detected in the tissue samples collected from Site 65. The fish tissue samples were divided into two groups for discussion: fillet and whole body. Table 7-13 presents a summary of the fish sent to the laboratory for analysis along with their trophic level. Positive detection tables for the tissue samples collected at Site 65 are presented in Section 4.0. The statistical summaries for these samples are presented in Appendix R.

The individuals in each sample that are retained for chemical analysis are presented in Appendix W. The appendix lists the length and weight of all the individuals in each composite, along with the new sample number, and how the sample should be prepared for analysis (i.e., fillet, or whole body). In accordance with the Guidance for Assessing Chemical Contaminant Data for use in Fish Advisories, Volume I, Fish Sampling and Analysis (USEPA, 1993d), the smallest fish in a composite should be no less than 75 percent of the total length of the largest individual. As is presented in Appendix W, the minimum to maximum ratio is greater than 75 percent in all but two of the samples. The two samples with ratios less then 75 percent are 65-FS04-BG01F (67 percent), and 65-FS04-RS01W (69 percent). Both of these samples were collected from Courthouse Bay Pond. Samples 65-FS04-BG01F and 65-FS04-RS01W were less than 75 percent because a greater size variety of individuals had to be used to ensure adequate sample volume for analysis.

The Site 65, fish-fillet contaminant concentrations were compared to the tissue contaminant concentrations in an off-site tissue study Baker conducted in the White Oak River Basin in 1993 (Baker, 1994a). This background study was limited to the fillet portion of the fish (see Appendix N). The Site 65, fish, whole-body, tissue, contaminant concentrations were compared to the tissue contaminant concentrations in an fish survey conducted in Albermarl and Pamlico Sounds in North Carolina (NC Study) (Benkert, 1992). This background study was limited to the whole-body portion of the fish. Table 7-14 presents these comparisons. Contaminant concentrations in the fish also were compared to various proposed criteria values for piscivorous wildlife (see Table 7-15) (Newell et.al., 1987).

7.8.3.1 Fish Tissue Organics

Acetone, 2-butanone, methylene chloride, and toluene are the only VOCs retained as COPCs in the fish tissue. Only acetone was detected in the off-site background tissue samples. The remaining VOCs were not detected in either study.

Two pesticides (4,4'-DDD, and 4,4'-DDE) are retained as COPCs in the whole body fish tissue. Both pesticides were detected within their respective range of the NC Study. The pesticide 4,4'-DDD was detected in the fillet fish tissue but not in the off-site background tissue samples.

Table 7-15 presents a comparison of the maximum fish tissue concentrations to New York State proposed fish tissue criteria for the diet of piscivorous wildlife (Newell et.al., 1987). No COPCs were detected at concentrations above either the proposed non-carcinogenic or 10^{-2} carcinogenic criteria for the diet of piscivorous wildlife.

7.8.3.2 Fish Tissue Inorganics

Toxicity data for metals in fish tissue were located for arsenic, mercury, and zinc. Therefore, toxicological impacts to aquatic and piscivorous wildlife only could be evaluated for these elements. The comparison of tissue concentrations to other studies was conducted for remaining metals (aluminum, antimony, barium, beryllium, copper, iron, lead, manganese, and selenium).

Diminished growth and survival have been reported in immature bluegills (Lepomis macrochirus) when total arsenic residues in muscle was greater than 1.3 mg/kg fresh weight, or greater than 5 mg/kg in adults (Eisler, 1988). In addition, depending on the chemical form of arsenic, certain marine teleosts may be unaffected at muscle total arsenic residues of 40 mg/kg (Eisler, 1988). Prescribed limits for arsenic in feedstuff (fishmeals) of domestic livestock is less than 10 mg/kg. Arsenic was not detected in the fillet samples, and was detected at a maximum concentration of 0.15 mg/kg in the whole body samples. Therefore, arsenic is less than the 5 mg/kg reported to cause diminished growth and survival in adult fish, and was detected at a concentration less than the prescribed limits for arsenic in feedstuff.

To protect sensitive species of mammals and birds that regularly consume fish and other aquatic organisms, total mercury concentrations in these food items should probably not exceed 0.1 mg/kg for avian protection and 1.1 mg/kg for small mammals (Eisler, 1987). The maximum mercury tissue concentration at Site 65 whole body samples (0.11 mg/kg) is just slightly above the avian protection value but it is within the range of mercury detected in the NC Study. The concentration of mercury in the fillet samples are slightly higher than the mercury concentration in the off-site background fish samples.

Bird diets should contain 93 to 120 mg/kg of zinc for adequate to optimal growth, and it should be less than 178 mg/kg to prevent marginal sublethal effects (Eisler, 1993). Dietary loadings that optimally prevent zinc deficiency for the mink is 150 mg/kg (Eisler, 1993). The maximum zinc concentration in the Site 65 whole body fish tissue samples (31.5 mg/kg) is below this concentration. The whole body sample concentrations are within the NC Study sample concentrations, while the concentration of zinc in the fillet samples are slightly higher than the zinc concentration in the off-site background fish samples.

With the exception of copper, all the metals detected in the Site 65 whole body samples were detected within the range of the fish analyzed in the NC Study (where analyzed). Copper in the Site 65 whole body samples just slightly exceeded the range in the NC Study. With the exception of barium, selenium, and thallium, which were not detected in the off-site background samples, the remaining metals in the Site 65 fillet samples were detected within the range, or slightly above the range in the off-site background samples.

7.8.4 Surface Soil

Although promulgated standards do not exist, Surface Soil Screening Values (SSSVs) that may be used to evaluate potential ecological risks to terrestrial flora and fauna have been developed by the

Ditch (Richardson, 1987), USEPA Region III (USEPA, 1995b) and Oak Ridge National Laboratory (ORNL) (Will and Suter, 1994a, 1994b). The contaminant concentrations in the surface soils are compared to the SSSVs to determine if potential impacts to terrestrial flora and fauna invertebrates may be expected (see Table 7-16).

Several of the SVOCs and metals were detected in the surface soil samples at concentrations above the SSSVs. One pesticide and one PCB were detected in the surface soil samples at concentrations above the SSSVs. The SVOCs with the highest number of exceedences were pyrene, fluoranthrene, and chrysene with three exceedences, and benzo(k)fluoranthene and benzo(a)anthracene with two exceedences. The inorganics with the highest number of exceedences were iron (13), chromium (11), copper (3) and lead (3). Pesticide 4,4'-DDT had the highest number of exceedences for the pesticides (3), followed by Aroclor 1260 with one exceedence. Most of the inorganic SSSVs were developed by ORNL, while most of the organic SSSVs were developed by USEPA Region III.

7.8.5 Terrestrial Chronic Daily Intake Model

In addition to comparing the soil concentrations to toxicity values for terrestrial invertebrates and plants, a terrestrial Chronic Daily Intake (CDI) Model is used to estimate the exposure of the COPCs to terrestrial receptors. The following describes the procedures used to evaluate the potential soil exposure to terrestrial fauna at Site 65 by both direct and indirect exposure to COPCs via surface water, soil, and foodchain transfer.

Based on the regional ecology and potential habitat at the site, the indicator species used in this analysis were white-tailed deer, cottontail rabbit, red fox, the bobwhite quail, and the raccoon. It is realized that all the terrestrial species may not exist at the site, and that other species may exist at the site. The species were chosen based on the most likely exposure scenarios and the availability of exposure data (i.e., ingestion rates, body weights). The white-tailed deer represents a large mammal ingesting vegetation. The cottontail rabbit represents a small mammal ingesting vegetation. The red fox represents a small mammal ingesting vegetation and other small mammals. The bobwhite quail represents a bird ingesting vegetation. The raccoon represents a small mammal ingesting vegetation and fish. The exposure points for these receptors were the surface soil and biota transfers. The routes for terrestrial exposure to the COPCs in the soil were incidental soil ingestion, vegetation (leafy plants, seeds and berries) ingestion, and ingestion of small mammals.

7.8.5.1 Derivation of Terrestrial Reference Value

Total exposure of the terrestrial receptors to the COPCs in the soil and surface waters is determined by estimating the CDI dose and comparing this dose to Terrestrial Reference Values (TRVs) representing acceptable daily doses in mg/kg/day. The TRVs were developed from No-Observed-Adverse-Effect-Levels (NOAELs) or Lowest-Observed-Adverse-Effect-Levels (LOAELs) obtained from the Integrated Risk Information System (IRIS), Agency for Toxic Substances and Disease Registry Toxicological Profiles, mineral tolerance levels of domestic animals (NAS, 1992) or other toxicological data in the literature. Appendix U presents the methodology used in deriving the TRVs and the animals that were used to derive each TRV.

7.8.5.2 Calculation of Chronic Daily Intake

Potential impacts of the terrestrial receptors to the COPCs in the soil and surface water is determined by estimating the CDI dose and comparing this dose to TRVs representing acceptable daily doses in mg/kg/day. The estimated CDI dose of the bobwhite quail, cottontail rabbit, white-tailed deer and small mammal, to soil, surface water, and vegetation was determined using the following equation:

$$CDI = \frac{(Cw)(Iw)+[(Cs)(Bv)(Iv)+(Cs)(Is)][H]}{BW}$$

Where:

CDI = Chronic Daily Intake, mg/kg/d
Cw = Contaminant concentration in the surface water, mg/L
Iw = Rate of drinking water ingestion, L/d
Cs = Contaminant concentration in soil, mg/kg
Bv = Soil to plant transfer coefficient (leaves, stems, straw, etc.), unitless
Iv = Rate of vegetation ingestion, kg/d
Is = Incidental soil ingestion, kg/d
H = Contaminated area/Home area range area ratio, unitless
BW = Body weight, kg

To calculate the contaminant concentration in the small mammal (meadow vole), the resulting CDI from the above equation is multiplied by the biotransfer factor for beef (Bb) for organics (Travis and Arms, 1988) and metals (Baes et.al., 1984).

The estimated CDI dose of the raccoon is determined using the following equation.

$$CDI = \frac{(Cw)(Iw)+(Cf)(If)+[(Cs)(Br)(Iv)+(Cs)(Is)][H]}{BW}$$

where:

CDI = Chronic Daily Intake, mg/kg/d
Cw = Contaminant concentration in the surface water, mg/L
Iw = Rate of drinking water ingestion, L/d
Cf = Contaminant concentration in the fish, mg/kg
If = Rate of fish ingestion, kg/d
Cs = Contaminant concentration in soil, mg/kg
Br = Soil to plant transfer coefficient (fruit, seeds, tubers, etc.), unitless
Iv = Rate of vegetation ingestion, kg/d
Is = Incidental soil ingestion, kg/d
H = Contaminated area/Home area range area ratio, unitless
BW = Body weight, kg

The contaminant concentration in the fish is the whole body fish concentration from the samples collected at Site 65.

The estimated CDI dose of the red fox is determined using the following equation:

$$CDI = \frac{(Cw)(Iw)+[(Cs)(Bv)(Iv)+(Cs)(Is)+(Cm)(Im)][H]}{BW}$$

where:

CDI = Chronic Daily Intake, mg/kg/d
Cw = Contaminant concentration in the surface water, mg/L
Iw = Rate of drinking water ingestion, L/d
Cs = Contaminant concentration in soil, mg/kg
Bv = Soil to plant transfer coefficient (leaves, stems, straw, etc.), unitless
Iv = Rate of vegetation ingestion, kg/d
Is = Incidental soil ingestion, kg/d
Cm = Contaminant concentrations in small mammals, mg/kg
Im = Rate of small mammal ingestion, kg/d
H = Contaminated area/Home area range area ratio, unitless
BW = Body weight, kg

Bioconcentration of the COPCs to plants is calculated using the soil to plant transfer coefficient (Bv or Br) for organics (Travis and Arms, 1988) and metals (Baes et.al., 1984). The concentrations of the COPCs used in the models were the lower of the upper 95 percent confidence limit or the maximum concentration detected of each COPC. The exposure parameters used in the CDI calculations are presented in Table 7-17.

7.9 Risk Characterization

The risk characterization is the final phase of a risk assessment. It is at this phase that the likelihood of adverse effects occurring as a result of exposure to a stressor are evaluated. This section evaluates the potential decrease in aquatic and terrestrial populations at Site 65 from contaminants identified at the site.

A Quotient Index (QI) approach is used to characterize the risk to aquatic receptors from exposure to surface water and sediments and terrestrial receptors from exposure to surface soil, surface water, and biota. This approach characterizes the potential effects by comparing exposure levels of COPCs in the surface water and sediments to the aquatic reference values presented in Section 7.8, Ecological Effects Characterization. The QI is calculated as follows:

$$\mathrm{QI} = \frac{(\ EC,\ CDI)}{(SWSV,\ SSV,\ TRV)}$$

Where:

QI = Quotient Index
EC = Exposure Concentration, µg/L, µg/kg or mg/kg
CDI = Chronic Daily Intake, mg/kg/day
SWSV = Surface Water Screening Value, µg/L
SSV = Sediment Screening Value, µg/kg or mg/kg
TRV = Terrestrial Reference Value, mg/kg/day

A QI greater than "unity" (one) is considered to be indicative of potential risk. Such values do not necessarily indicate that an effect will occur but only that a lower threshold has been exceeded. However, it is important to determine which contaminants are posing the highest risks, in order to evaluate the significance of those contaminants to the site. Therefore, the evaluation of the significance of the QI has been judged as follows: (Menzie et.al., 1993)

- QI exceeds one but less than 10: some small potential for environmental effects
- QI exceeds 10: significant potential that greater exposures could result in effects based on experimental evidence
- QI exceeds 100: effects may be expected since this represents an exposure level at which effects have been observed in other species

The risks characterized above provide insight into general effects upon animals and plants in the local population. However, depending on the endpoint selected, they may not indicate if population-level effects will occur.

7.9.1 Surface Water

Table 7-18 present the surface water QIs. This table only presents the COPCs with QIs greater than one. The QIs for the hardness dependent metals are calculated using a sample specific hardness value. Figure 7-2 graphically displays the QIs that exceed one.

A hardness of 38.45 mg/L calcium carbonate ($CaCO_3$) was used to calculate the hardness-dependent SWSVs for the metals (copper, lead, and zinc) in Section 7.3.2, since this was the lowest hardness detected at any of the stations. The hardness ranged from 38.45 to 77.30 mg/L $CaCO_3$ in the two surface water samples. Copper, lead, and zinc exceeded a SWSV after adjusting the hardness for the specific sample. All three of these metals were collected from Courthouse Bay Pond (65-SW04) where large amounts of silt and suspended solids were present during the time of sampling. In summary, aluminum (QI = 297) was the only surface water COPC that had a QI greater than 100. Barium (QI = 18) and lead (QI = 49) were the only surface water COPCs that had QIs greater than 10. The remaining metals COPCs (barium, copper, iron, manganese, vanadium, and zinc) had QIs greater than one, but less than eight. With the exception of one barium sample, all the metals with QIs greater than one were collected in Courthouse Bay Pond.

As presented in the Ecological Effects section of this ERA, the SWSVs for barium, manganese, and vanadium appear to be extremely conservative based on other literature sources. Therefore, the concentrations of these contaminants are not expected to significantly decrease the population of aquatic receptors. Based on the high QIs for aluminum and lead, there is a probable potential for these contaminants to decrease the population of aquatic receptors. The remaining inorganics (copper, iron, and zinc) have a slight potential in decreasing the population of aquatic receptors.

7.9.2 Sediment

Table 7-19 presents the sediment QIs. This table only presents the COPCs with QIs greater than one. Figure 7-2 graphically displays the QIs that exceed one.

Di-n-butylphthalate was the only SVOC with an ER-M QI that exceeded one. The pesticides, 4,4'-DDD, and 4,4'-DDE are the only organics detected in the sediment with ER-L QIs that exceed one. The pesticide 4,4'-DDD was the only organic with a ER-L QI greater than 10; however, the ER-M and

SQC QIs were less than five. Therefore, there is only a very slight potential for decreasing the aquatic receptor population from organics in the sediment.

Antimony, copper, lead, and zinc are the only metals detected in the sediment with ER-L QIs that exceed one. Antimony, which had a ER-L QI value of 23, was the only metal detected in the sediment with an ER-M QI that exceeds one. Therefore there is only a slight potential for metals in the sediment to cause a decrease in the aquatic receptor population.

7.9.3 Terrestrial Chronic Daily Intake Model

Table 7-20 presents the QI for the terrestrial CDI model. Appendix U contains the CDI spreadsheets. The red fox, and white-tail deer had QIs that range from 0.627 to 0.847. The QI for the bobwhite quail was 4.77. The QIs for the cottontail rabbit and raccoon are 11.4 and 25.6, respectively. A significant portion of the QI values are due to metals, namely, aluminum, antimony, iron, and vanadium. In addition, acetone did contribute to a relatively high QI (8.6) in the raccoon model. The majority of the individual QIs were less than one, with a maximum QI of 2 for aluminum in the bobwhite quail and rabbit models. Iron, manganese, and vanadium also had QIs above one for the cottontail rabbit model. Aluminum and antimony had QIs above one for the raccoon model.

7.10 Ecological Significance

This section essentially summarizes the overall risks to the ecology at the site. It addresses potential impacts to the ecological receptors at Site 65 from the COPCs detected in the media, and determines which COPCs are impacting the site to the greatest degree. This section also describes if these contaminants appear to be site-related based on historical use or disposal of the contaminants, and/or if the contaminants were detected in other media (i.e., groundwater). This information, to be used in conjunction with the human health risk assessment, supports the selection of remedial action(s) for Site 65 that are protective of public health and the environment.

Figure 1-2 presents the locations of the two ponds in relationship to Site 65. The burn area and debris areas associated with Site 65 are located nearly 1,000 feet west of the ponds, and are separated by the heavy equipment training area. Potential contamination from Site 65 to the ponds could result from two release mechanisms, surface soil runoff and/or groundwater recharge. Initially, it was thought that some surface soil from Site 65 may have been pushed into the heavy equipment training area, and could subsequently work its way into Courthouse Bay Pond. However, based on the analytical results presented in Section 4.0 of this report, it does not appear that contaminants in the surface soil at Site 65 are migrating to Courthouse Bay Pond. It also was determined from the RI that groundwater at Site 65 flows in a southwesterly direction. Therefore, site-related contaminants in the groundwater will not be discharging to the ponds. In summary, it does not appear that any of the contaminants detected in the surface water or sediment in either pond are related to Site 65.

7.10.1 Aquatic Endpoints

Based on the risk characterization, there is a slight potential for organic compounds (di-n-butylphthalate, 4,4'-DDE and 4,4'-DDD) detected in the sediments to cause a decrease in the aquatic life population. Based on the risk characterization, there is a probable potential for (aluminum and lead) and a slight potential for (copper, iron, and zinc) in the surface water to decrease in the population of aquatic life.

In general, the pesticides 4,4'-DDE and 4,4'-DDD were detected at similar concentrations in Courthouse Bay Pond and Powerline Pond. These pesticides were detected at similar concentrations inside and outside of the site boundaries and are most likely attributable to the historical pesticide applications that have taken place at Camp Lejeune over the years.

The majority of inorganics that exceeded either SWSVs or SSVs were detected in Courthouse Bay Pond that is directly east and downgradient of the heavy equipment training area. Evidence of surface water runoff from the heavy equipment training area into this pond was apparent during the time of sampling. The suspended solids in the Courthouse Bay Pond are due to this runoff. It has been reported that for ambient waters, typically 30 to 80 percent of the copper, nickel, and zinc, and 90 to 95 percent of the lead may be in a particulate phase measured by the total recoverable method but not the dissolved method (USEPA, 1992). Therefore, the suspended solids probably are significantly contributing to the elevated inorganic concentrations in the surface water. This is important because it is generally supported by the scientific community within and outside USEPA that dissolved metal more closely approximates the bioavailable fraction of metal in the water column than does total recoverable metal (USEPA, 1993h). Since dissolved inorganics were not collected, the actual impacts to the aquatic life (based on dissolved inorganics), could not be evaluated. It should be noted; however, that as presented above, none of the inorganics in the surface water or sediment are thought to be site-related.

The bluegill and redear sunfish collected at Courthouse Bay Pond were not as brilliant in color as the same species collected from Powerline Pond. It has been reported that environmental background and light intensity are important factors in determining color changes in fish (Chavin, 1973). Therefore, the apparent color difference in the Courthouse Bay Pond fish is probably due to color difference of the water, and the decreased intensity of light penetration due to the turbidity.

No largemouth bass were collected in Courthouse Bay Pond. However, small fish resembling the shape of largemouth bass were observed swimming on the surface of this pond during the sampling investigation. The contaminants in the surface water and sediment may be reducing the fish population in Courthouse Bay Pond. As presented in the Ecological Effects section of this report, high turbidity is associated with adverse effects on fish, especially largemouth bass. Therefore, the reason for the decrease in numbers and types of fish collected in Courthouse Bay Pond also may be the large amount of suspended solids in the surface water.

As presented in the Ecological Effects section of this report, high turbidity is associated with adverse effects on benthic macroinvertebrates. The only species that was collected in Courthouse Bay Pond was *Chaborus* sp. This species is reportedly able to exist in turbid and anaerobic conditions (Hackney et.al., 1992). The absence of other benthic macroinvertebrate species may be due to the contaminants detected in the surface water and sediments. However, the high turbidity (>25 NTU) and low dissolved oxygen concentration (2.0 ppm) is most likely contributing significantly to the absence of other species.

In general, the summary statistics for the benthic macroinvertebrates collected in Powerline Pond were lower than those for the benthic macroinvertebrates collected in the off-site reference station. However, several of the species identified in Powerline Pond are sensitive to pollution and organic wastes. In addition, barium in the surface water, and 4,4'-DDE and 4,4'-DDD in the sediment were the only COPCs that exceeded screening values. As presented earlier in this ERA, the SWSV for barium appears to be overly conservative in the surface water and the pesticides in the sediment are not thought to be site-related. Therefore, the benthic macroinvertebrate population in Powerline Pond does not appear to adversely impacted by site-related contaminants.

7.10.2 Terrestrial Endpoints

Several contaminants were detected in the surface soil at concentrations that exceeded the SSSVs. Therefore, there is the potential for a decrease in the population of terrestrial plants and invertebrates in these areas. It is noted that no visible signs of stressed or dead vegetation in these areas were observed during the field investigations.

The CDI versus the TRV for the bobwhite quail, cottontail rabbit, raccoon, and whitetail deer all exceeded one. For the whitetail deer, none of the individual QIs exceeded "1". For the bobwhite quail, vanadium caused the high QI value, while aluminum, iron, and vanadium caused the high QI in the rabbit. Aluminum was detected in the surface soil at concentrations below the base-background concentration, and therefore is not expected to be site-related. In addition, vanadium was detected at a maximum concentration of 12 mg/kg in the Site 65 surface soil, which just slightly exceeded twice the average base background concentration (11.6 mg/kg). Therefore, it is unlikely that the vanadium is site-related. Iron, which may be site-related, had a QI value of 1.43. Based on the model being very conservative and the fact the heavy equipment training area (which would not be inhabitated by rabbits) is factored into the model, there does not appear to be an actual risk to the rabbit. Acetone and aluminum in the fish caused most of the high QI value in the raccoon. Acetone is not expected to bioconcentrate to the concentration detected in the fish due to its low bioconcentration factor, and the fact that it was detected at low concentrations (less than ten times the concentration in the blank samples) in the surface water (5 µg/L). Therefore, the acetone in the fish is most likely due to laboratory activities. In addition, aluminum in not thought to be related to site activities since it was detected below the base-background concentration in the surface soil, which would be the only pathway from Site 65 to the ponds.

7.10.3 Threatened and Endangered Species

Presently, no threatened or endangered species are known to reside at Site 65 or the immediately surrounding areas. However, a natural heritage resources survey conducted at Camp Lejeune (Leblond, 1991), identified the plant specie, blackfruit spikerush (*Eleocharis melanocarpa*) as being located in the vicinity of the ponds at Site 65. This specie presently has a state candidate status. The exact location of the plant is not known at this time, because of the large scale used on the survey map. Since the surface soil near the ponds does not contain contaminants related to Site 65, any potential impacts to this plant would not be site related.

7.10.4 Wetlands

National Wetland Inventory (NWI) maps identify both Courthouse Bay Pond and Powerline Pond as wetlands. Contaminants that exceeded screening values were present in the surface soil, surface water, and sediment. These contaminants may be effecting the wetland areas. It should be noted that no areas of stressed or dead vegetation were observed during the field investigations. Also, since the ponds do not contain contaminants related to Site 65, any potential impacts to wetlands are not site related.

7.11 Uncertainty Analysis

The procedures used in this evaluation to assess risks to ecological receptors, as in all such assessments, are subject to uncertainties. The following discusses some of the uncertainty in this ERA.

The chemical sampling program at Site 65 consisted of two surface water samples and four sediment samples. Because there were less than twenty samples, contaminants could not be eliminated because of infrequency. Therefore, contaminants not related to the site may have been retained as COPCs and thus carried through the ERA.

There is uncertainty in the ecological endpoint comparison. The SWSVs (NCWQS and AWQC) are established to be protective of a majority of the potential receptors. However, there will be some species will not be protected by the values because of their increased sensitivity to the chemicals. In addition, most of the values are established using laboratory tests, where the concentrations of certain water quality parameters (pH, hardness, total organic carbon) that may influence toxicity are most likely at different concentrations in the site water.

Potential adverse impacts to aquatic receptors from contaminants in the sediments were evaluated by comparing the COPC concentration in the sediments to SSVs. These SSVs have more uncertainty associated with them than do the SWSLs, since the procedures for developing them are not as established as those used in developing SWSLs. In addition, sediment type (pH, acid volatile sulfide, total organic carbon) also has a significant impact on the bioavailability and toxicity of contaminants.

There is uncertainty in comparing tissue concentrations to fish collected in Courthouse Bay Pond and Powerline Pond to fish collected in other studies. In many cases, the fish that were collected from the ponds were different species than the fish collected in the other studies. Many contaminants bioaccumulate differently in different species. Therefore, comparisons of contaminant concentrations of different fish may be misleading. Finally, there is limited data in the literature to assess potential impacts to fish from contaminants in their tissue.

Potential adverse impacts to terrestrial invertebrates and plants were evaluated by comparing the COPC concentration in the soil to SSSVs. Most of these studies do not take into account the soil type, which may have a large influence on the toxicity of the contaminants. For example, soil with high organic carbon content will tend to sorb many of the organic COPCs, thus making them less bioavailable to terrestrial receptors. In addition, most of the SSSVs are based on one or two studies, which greatly adds to their uncertainty.

There are some differences of opinion found in the literature as to the effectiveness of using models to predict concentrations of contaminants found in terrestrial species. According to one source, the food chain models currently used incorporate simplistic assumptions that may not represent actual site conditions, bioavailability of contaminants, or site-specific behavior of the receptors. Simple food chain models can provide an effective means of initial characterization of risk; however, residue analyses, toxicity tests, and the use of biomarkers provide a better approach for assessing exposure (Menzie et.al., 1993).

There are several sources of uncertainty when using these models. First, most of the terrestrial reference values are based on toxicity data from another species, which is then extrapolated to the species of concern using a body-size scaling equation. Since the toxicity of all contaminants may not be proportional to body size, the calculated TRVs may not accurately predict risk to the species of concern. Another source of uncertainty with the models is that many of the input parameters are based on default values (i.e., ingestion rate) that may or may not adequately represent the actual values of the parameters. In addition, there is uncertainty in the amount that the indicator species will represent other species potentially exposed to COPCs at the site.

There is uncertainty in use of the bioconcentration and biotransfer factors. Bioconcentration and biotransfer factors can vary widely from species to species. The species used in the calculation of the bioconcentration and biotransfer factors are different that the species that actually occur at the site. Therefore, use of the factors will tend to either overestimate or underestimate actual bioaccumulation of contaminants. Finally, terrestrial receptors also may be exposed to contaminants in the sediments. However, currently, there is no guidance in the literature that can be used to evaluate this potential exposure pathway.

The toxicity of chemical mixtures is not well understood. All the toxicity information used in the ERA for evaluating risk to the ecological receptors is for individual chemicals. Chemical mixtures can affect the organisms very differently than the individual chemicals due to synergistic or antagonistic effects. In addition, the species that were used to develop the toxicity data may not be present at the site, or have the potential to exist at the site. Depending on the sensitivity of the tested species to the species at the site use of the toxicity values may overestimate of underestimate risk. Many chemicals are not acutely toxic; however, they have the potential to bioaccumulate in ecological receptors through food chain transfer. This bioaccumulation potential typically is not taken into account when comparing contaminant concentrations to screening values.

Finally, toxicological data for several of the COPCs were limited or do not exist. Therefore, there is uncertainty in any conclusions involving the potential impacts to aquatic receptors from these contaminants

7.12 Conclusions

7.12.1 Aquatic Ecosystem

As presented earlier in the ERA, the assessment endpoints for the aquatic receptors are changes in the structure of benthic macroinvertebrate communities attributable to site-related contaminants and the potential reduction of an aquatic receptor population or subpopulation that is attributable to site-related contaminants. The remaining portion of the ERA evaluates these assessment endpoints using a series of measurement endpoints. This section of the ERA examines each of the measurement endpoints to determine if the assessment endpoints are impacted.

The first measurement endpoint is determining if there is lower benthic macroinvertebrate species diversity and richness in the Site 65 stations when compared to an ecologically similar background location. There was lower species diversity and richness in the Site 65 stations. However, it is important to note that the ecologically similar off-site reference location to which the Site 65 samples were compared, was not another pond; rather, it was a small (75 to 100 feet diameter) ponded area along a creek. The reason that this sample was chosen as the off-site reference sample was because this was the most ecologically similar off-site reference sample that was collected. The benthic macroinvertebrate samples were collected along the bank of the off-site reference station, as opposed to the middle of the ponds at Site 65. Also, the dissolved oxygen was higher in the ponded area (7.1 ppm) as opposed to the Site 65 ponds (2.0 and 3.0 ppm). Therefore, the differences in species diversity and richness between these stations may be due to these differences in the abiotic and biotic habitat.

The second measurement endpoint is determining if the Site 65 benthic macroinvertebrates are dominated by contaminant-tolerant species as opposed to contaminant-sensitive species. The 7.1 MBI in Powerline Pond is indicative of a water body with fair water quality. In addition, over 75 percent of the species that have biotic index values are indicative of fair water quality. Of these 75 percent, half of the individuals are indicative of good to fair water quality, and 12.5 percent are indicative of excellent water quality. Therefore, it appears that Powerline Pone is dominated more by contaminant-sensitive species, as opposed to contaminant-tolerant species. The benthic macroinvertebrate specie collected in Courthouse Bay Pond does not have a biotic index.

The third measurement endpoint is determining if the contaminant levels in the Site 65 biota tissue samples are elevated when compared to tissue samples collected at off-site background stations or reference levels in the literature. With the exception of 4,4'-DDD, the VOCs, and a few of the inorganics (barium, selenium, and thallium), the remaining COPCs were detected in the fish tissue within the range of, or just slightly above the concentration in their respective comparison samples. 4,4'-DDD was detected in one fish sample, at a relatively low concentration (5.7 µg/kg). The VOCs that were detected in the fish tissue are most likely associated with the laboratory preparation procedures, since the VOCs either were not detected, or detected at low concentrations in the surface water and sediment. In addition, based on the relatively low BCFs, these VOCs are not expected to significantly bioconcentrate in fish tissue. Finally, barium, selenium, and thallium all were detected in low concentrations, and are not expected to be related to site activities.

The fourth measurement endpoint is determining if the contaminant levels in the Site 65 fish tissue samples exceed toxicity values in the literature. Arsenic was the only contaminant detected in the fish tissue samples for which toxicity data was located in the literature. Arsenic was detected at a concentration in the fish tissue below the reported toxicity concentration.

The last measurement endpoint is determining if the contaminant concentrations in the surface water and sediment exceed the contaminant-specific surface water and sediment effect concentrations (i.e., SWSVs, and SSVs). Several contaminants were detected in the surface water and sediment at concentrations exceeding the SWSVs and SSVs. The majority of the exceedences in the surface water and sediment occurred in Courthouse Bay Pond. Therefore, some of these contaminants have the potential to cause a reduction in the aquatic life population. However, as presented earlier in this ERA, none of these contaminants are thought to be site-related.

Based on these endpoints, the change in the structure of the benthic macroinvertebrate communities and/or the potential reduction of an aquatic receptor population or subpopulation may be attributable to contaminants detected in the surface water and/or sediment. Also, as presented earlier in this ERA, none of these contaminants are thought to be site-related. The low number of species and benthic macroinvertebrates in Courthouse Bay Pond most likely is due to the low dissolved oxygen concentration (2.0 ppm) and suspended solids in the pond. Since one benthic macroinvertabrate species collected in Powerline Pond is indicative of excellent water quality, and another is indicative of good to fair water quality, the benthic macroinvertebrate population in this pond does not appear to be adversely impacted. The decreased fish population in Courthouse Bay Pond also is most likely due to the high suspended solids concentration in this pond.

Overall, there is a moderate potential risk to aquatic life in Courthouse Bay Pond, with most of the risk associated with the non-site-related suspended solids in the surface water. There is only a slight risk to aquatic life in Powerline Pond; however, these risks are due to non-site-related contaminants (4,4'-DDD and 4,4'-DDE). Based on the ERA, no further investigations are deemed necessary. However, it is recommended that controls be established to prevent runoff from the heavy equipment training area to Courthouse Bay Pond.

7.12.2 Terrestrial Ecosystem

As presented earlier in the ERA, the assessment endpoints for the terrestrial receptors is the potential reduction of a receptor population or subpopulation that is attributable to contaminants from the site. This section evaluates this assessment endpoint using the measurement endpoints.

The first measurement endpoint is determining if there are exceedences of contaminant-specific soil effect concentrations (i.e., SSSVs). Several contaminants were detected at concentrations in the surface soil that exceed the SSSVs.

The second measurement endpoint is determining if the terrestrial CDI exceeds the TRVs. The CDI exceeded the TRV for the bobwhite quail, cottontail rabbit, raccoon, and whitetail deer. However, as presented in the Rick Characterization section of this ERA, none of the contaminants significantly adding to the risk are expected to be site-related.

Finally, the last measurement endpoint is determining if the tissue sample concentrations exceed proposed criteria for piscivorous wildlife. Mercury was the only contaminant detected in the fish tissue at a concentration that was just slightly above limits for ingestion by birds; however, it was below the limit for the protection of small mammals. Mercury was not detected in and of the surface water, sediment, surface soil, or groundwater. The source of the mercury in the fish may have bioconcentrated from non-detected concentrations in the surface water or sediment. As presented earlier in this ERA, no contaminants in the surface water or sediment are thought to be related to Site 65. Therefore, any potential impacts to the bird population are not expected to be site-related.

Overall, some potential impacts to soil invertebrates and plants may occur as a result of site-related contaminants. It should be noted that there is much uncertainty in the SSSVs. A potential decrease in the terrestrial vertebrate population from site-related contaminants is not expected based on the terrestrial intake model.

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TABLES

TABLE 7-1

FREQUENCY AND RANGE OF CONTAMINANT DETECTIONS COMPARED TO SURFACE WATER SCREENING VALUES
SITE 65 - ENGINEER AREA DUMP
REMEDIAL INVESTIGATION, CTO-0312
MCB, CAMP LEJEUNE, NORTH CAROLINA

	Surface Water Screening Values (SWSV)				Contaminant Frequency/Range			
	North Carolina Water Quality Standards (WQS)(1)	USEPA Region IV Water Quality Screening Values (WQSV)(2)		Average Reference Station Concentration	No. of Positive Detects/No. of Samples	Range of Positive Detections	No. of Positive Detects Above Lowest SWSV	No. of Positive Detects Above the Average Reference Station Concentration
Contaminant		Acute	Chronic					
Volatiles (µg/L)								
1,2-Dichloroethane (total)	NE	218,000(4)	1,100	ND	2/2	1J	0	2
Acetone	500	9,000,000(4)	11,200(5)	ND	1/2	5J	0	1
Inorganics (µg/L)								
Aluminum	NE	750	87	333	1/2	25,800	1	1
Barium	NE	69.1(5)	3.8(5)	25.7	2/2	36.7-69.3	2	2
Calcium	NE	NE	NE	17,567	2/2	12,000-26,800	NA	1
Chromium	50	794 (3)	95 (3)	ND	1/2	27.6	0	1
Copper	7	7.2 (3)	5.22 (3)	ND	1/2	41.1	1	1
Iron	1,000	NE	1,000	576	2/2	348-7,890	1	1
Lead	25	24.18	0.94	ND	1/2	45.8	1	1
Magnesium	NE	NE	NE	1,745	2/2	2,060-2,520	NA	2

TABLE 7-1 (Continued)

FREQUENCY AND RANGE OF CONTAMINANT DETECTIONS COMPARED TO SURFACE WATER SCREENING VALUES
SITE 65 - ENGINEER AREA DUMP
REMEDIAL INVESTIGATION, CTO-0312
MCB, CAMP LEJEUNE, NORTH CAROLINA

Contaminant	Surface Water Screening Values (SWSV)			Average Reference Station Concentration	Contaminant Frequency/Range		No. of Positive Detects Above Lowest SWSV	No. of Positive Detects Above the Average Reference Station Concentration
	North Carolina Water Quality Standards (WQS)(1)	USEPA Region IV Water Quality Screening Values (WQSV)(2)			No. of Positive Detects/No. of Samples	Range of Positive Detections		
		Acute	Chronic					
Inorganics (µg/L) (continued)								
Manganese	NE	1,470(5)	80.3(5)	ND	2/2	57.3-88.4	1	2
Potassium	NE	NE	NE	ND	1/2	2,970	NA	1
Sodium	NE	NE	NE	9,830	2/2	3,330-6,320	NA	2
Vanadium	NE	284(5)	19.1(5)	ND	1/2	26.2	1	1
Zinc	50	52	47	ND	2/2	33.6-144	1	2

Notes:

NE = Not Established
NA = Not Applicable

(1) NC DEHNR, 1994 (Water Quality Standards).
(2) USEPA, 1995a (Region IV Toxic Substance Spreadsheet).
(3) Criteria are hardness dependent; values are based on a hardness of 38 mg/L as $CaCO_3$.
(4) USEPA, 1995b (Region III BTAG Screening Levels).
(5) Suter and Mabrey, 1994 (Toxicological Benchmarks for Screening Potential COCs for Effects on Aquatic Biota).

TABLE 7-2

FREQUENCY AND RANGE OF CONTAMINANT DETECTIONS
COMPARED TO SEDIMENT SCREENING VALUES
SITE 65 - ENGINEER AREA DUMP
REMEDIAL INVESTIGATION, CTO-0312
MCB, CAMP LEJEUNE, NORTH CAROLINA

Contaminant	Sediment Screening Values (SSV)			Average Reference Station Concentration	Contaminant Frequency/Range		No. of Positive Detects Above Lowest SSV	No. of Positive Detect Above the Average Reference Concentration
	ER-L	ER-M	SQC$^{(3)}$		No. of Positive Detects/No. of Samples	Range of Positive Detections		
Volatiles (µg/kg)								
Acetone	NE	NE	614	ND	4/4	190J-450J	0	4
Chloroform	NE	NE	957	ND	1/4	79J	0	1
2-Butanone	NE	NE	2,331	ND	4/4	72J-94J	0	4
Carbon Tetrachloride	NE	NE	627	ND	2/4	13J-18J	0	2
Tetrachloroethene	NE	140$^{(5)}$	1,133	ND	2/4	6J-15J	0	2
Toluene	NE	NE	82	ND	3/4	3J-7J	0	3
Semivolatiles (µg/kg)								
Di-n-butylphthalate	NE	1,400$^{(5)}$	12,699	ND	4/4	940J-1,600J	1	4
Pesticides (µg/kg)								
Beta-BHC	NE	NE	7.57	2.51	1/4	8.3NJ	1	1
4,4'-DDD	2$^{(2)}$	20$^{(2)}$	19.17	1.57	2/4	76J-84J	2	2
4,4'-DDE	2.2$^{(1)}$	27$^{(1)}$	109.56	2.42	2/4	18J-19NJ	2	2
Inorganics (mg/kg)								
Aluminum	NE	NE	NE	1,166	4/4	394-37,000J	NA	3
Antimony	2$^{(2)}$	25$^{(2)}$	NE	ND	1/4	46.6J	1	1
Barium	500$^{(6)}$	NE	NE	6.46	4/4	13.6-110	0	4
Calcium	NE	NE	NE	1,967	4/4	322-4,640	NA	3
Chromium	52.3$^{(2)}$	370$^{(1)}$	NE	1.86	2/4	9.8J-43.6J	0	2
Cobalt	NE	NE	NE	ND	1/4	36.3	NA	1
Copper	18.7$^{(2)}$	270$^{(1)}$	NE	0.75	3/4	8.2-100J	2	3
Iron	27,000$^{(5)}$	NE	NE	434	4/4	414-14,600J	0	3
Lead	30.2$^{(2)}$	218$^{(1)}$	NE	0.79	3/4	23.9-176J	2	3
Magnesium	NE	NE	NE	45.25	3/4	94.8-1,140	NA	3
Manganese	230$^{(5)}$	NE	NE	3.63	4/4	25.6-126J	0	4

TABLE 7-2 (Continued)

FREQUENCY AND RANGE OF CONTAMINANT DETECTIONS COMPARED TO SEDIMENT SCREENING VALUES SITE 65 - ENGINEER AREA DUMP REMEDIAL INVESTIGATION, CTO-0312 MCB, CAMP LEJEUNE, NORTH CAROLINA

Contaminant	Sediment Screening Values (SSV)			Average Reference Station Concentration	Contaminant Frequency/Range		No. of Positive Detects Above Lowest SSV	No. of Positive Detect Above the Average Reference Concentration
	ER-L	ER-M	SQC[3]		No. of Positive Detects/No. of Samples	Range of Positive Detections		
Inorganics (mg/kg) (continued)								
Potassium	NE	NE	NE	ND	1/4	1,410	NA	1
Sodium	NE	NE	NE	ND	3/4	139-203	NA	3
Vanadium	NE	NE	NE	1.52	1/4	40.5	NA	1
Zinc	124(2)	410(1)	NE	5.11	4/4	7.9-280J	1	4

Notes:

NE = Not Established
ER-L = Effects Range Low
SQC - Sediment Quality Criteria
NA = Not Applicable
ER-M = Effects Range Median

(1) Long et.al., 1995.
(2) USEPA, 1995c (Supplemental Guidance to RAGs., Region IV Bulletins, Ecological Risk Assessment)
(3) Values were calculated using the following equation: SQC = Foc*Koc*FCV/1000000
Where:
Foc = Fraction of organic carbon in the sediments (used 24,900 mg/kg)
Koc = Organic carbon partition coefficient (chemical specific)
FCV = Final water chronic value (chemical specific)

(4) USEPA, 1995b (Region III BTAG Screening Levels).
(5) Tetra Tech Inc., 1986 (Apparent Effects Threshold Sediment Quality Values).
(6) Sulliven et.al., 1985.

TABLE 7-3

CONTAMINANTS OF POTENTIAL CONCERN IN EACH MEDIA
SITE 65 - ENGINEER AREA DUMP
REMEDIAL INVESTIGATION, CTO-0312
MCB, CAMP LEJEUNE, NORTH CAROLINA

	Surface Water				Fish	
Contaminant	Aquatic Receptors	Terrestrial Receptors	Sediment	Surface Soil	Fillet	Whole Body
Volatiles						
Acetone					X	X
2-Butanone						X
Ethylbenzene				X		
Methylene chloride						X
Toluene						X
Trichloroethane				X		
Xylenes (Total)				X		
Semivolatiles						
Acenaphthene				X		
Anthracene				X		
Benzo(a)anthracene				X		
Benzo(a)pyrene				X		
Benzo(b)fluoranthene				X		
Benzo(g,h,i)perylene				X		
Benzo(k)fluoranthene				X		
Bis(2-ethylhexyl)phthalate				X		
Carbazole				X		
Chrysene				X		
Dibenz(a,h)anthracene				X		
Dibenzofuran				X		
Di-n-butylphthalate			X	X		
2,4-Dinitrophenol				X		
Fluoranthene				X		
Fluorene				X		
Indeno(1,2,3-cd)pryene				X		
Phenanthrene				X		
Pyrene				X		

TABLE 7-3 (Continued)

CONTAMINANTS OF POTENTIAL CONCERN IN EACH MEDIA
SITE 65 - ENGINEER AREA DUMP
REMEDIAL INVESTIGATION, CTO-0312
MCB, CAMP LEJEUNE, NORTH CAROLINA

Contaminant	Surface Water		Sediment	Surface Soil	Fish	
	Aquatic Receptors	Terrestrial Receptors			Fillet	Whole Body
Pesticides/PCBs						
Beta-BHC			X			
4,4'-DDE			X	X		X
4,4'-DDD			X	X	X	X
4,4'-DDT				X		
Endosulfan II				X		
Heptachlor epoxide				X		
Aroclor-1260				X		
Inorganics						
Aluminum	X	X	X		X	X
Antimony			X			X
Arsenic						X
Barium	X	X		X	X	X
Beryllium						X
Chromium		X		X		
Cobalt			X			
Copper	X	X	X		X	X
Iron	X	X		X		X
Lead	X	X	X	X		X
Manganese	X	X		X	X	X
Mercury					X	X
Nickel				X		
Selenium					X	X
Thallium				X	X	X
Vanadium	X	X	X	X		
Zinc	X	X	X	X	X	X

TABLE 7-4

REGION IV, PHYSICAL/CHEMICAL CHARACTERISTICS OF THE COCs
SITE 65 - ENGINEER AREA DUMP
REMEDIAL INVESTIGATION, CTO-0312
MCB, CAMP LEJEUNE, NORTH CAROLINA

Contaminant of Potential Concern	BCF	Organic Carbon Partition Coefficient (mL/g)	Log Octanol/ Water Coefficient	Biotransfer Factors		
				Bv(1)(2)	Br(1)(2)	Bb(1)(2)
Volatiles						
Acetone	0.69(4)	2.2(5)	-0.24(6)	5.30e+01	5.30e+01	1.45e-08
2-Butanone	ND	4.5(5)	0.28(6)	3.73e+01	3.73e+01	2.68e-08
Ethylbenzene	37.5(3)	1,100(5)	3.1(6)	6.25e-01	6.25e-01	3.16e-05
Methylene chloride	0.9(3)	ND	1.3(6)	6.86e+00	6.86e+00	5.01e-07
Toluene	10.70(3)	300(5)	2.8(6)	9.32e-01	9.32e-01	1.58e-05
Trichloroethene	10.6(4)	126(5)	2.7(6)	1.07e+00	1.07e+00	1.26e-05
Xylenes	2.20(4)	240(5)	3.2(6)	5.48e-01	5.48e-01	3.98e-05
Semivolatiles						
Acenaphthylene	30(3)	2,500(5)	3.6(6)	3.22e-01	3.22e-01	1.00e-04
Anthracene	30(3)	14,000(5)	4.6(6)	8.50e-02	8.50e-02	1.00e-03
Benzo(a)anthracene	30(3)	1,380,000(5)	5.7(6)	2.00e-02	2.00e-02	1.26e-02
Benzo(a)pyrene	30(3)	5,500,000(5)	6.1(6)	1.15e-02	1.15e-02	3.16e-02
Benzo(b)fluoranthene	30(3)	550,000(5)	6.2(6)	1.01e-02	1.01e-02	3.98e-02
Benzo(k)fluoranthene	30(3)	550000	6.2(6)	1.01e-02	1.01e-02	3.98e-02
Benzo(g,h,i)perylene	30(3)	1,600,000(5)	6.7(6)	5.19e-03	5.19e-03	1.26e-01
Bis(2-ethylhexyl)phthalate	130(3)	100,000(7)	7.3(6)	2.34e-03	2.34e-03	5.01e-01
Butylbenzylphthalate	414(3)	ND	4.8(6)	6.51e-02	6.51e-02	1.58e-03
Carbazole	ND	ND	3.6(6)	5.50e-01	5.50e-01	1.00e-04
Chrysene	30(3)	200,000(5)	5.7(6)	2.00e-02	2.00e-02	1.26e-02
Dibenz(a,h)anthracene	30(3)	3,300,000(5)	6.7(6)	5.14e-03	5.14e-03	1.26e-01
Dibenzofuran	ND	ND	4.2(8)	5.50e-01	5.50e-01	3.98e-04
2,4-Dinitrophenol	1.5(3)	16.6(5)	1.6(6)	4.60e+00	4.60e+00	1.00e-06
Di-n-butylphthalate	89(3)	170,000(5)	4.6(6)	8.50e-02	8.50e-02	1.00e-03
Fluoranthene	1,150(3)	100,000(9)	5.1(9)	4.40e-02	4.40e-02	3.90e-03
Fluorene	30(3)	7,300(5)	4.2(6)	1.45e-01	1.45e-01	3.98e-04
Indeno(1,2,3-cd)pyrene	30(3)	1,600,000(5)	6.7(6)	5.19e-03	5.19e-03	1.26e-01
Phenanthrene	30(3)	28,840(10)	4.6(10)	8.50e-25	8.50e-02	1.00e-03

TABLE 7-4 (Continued)

REGION IV, PHYSICAL/CHEMICAL CHARACTERISTICS OF THE COCs
SITE 65 - ENGINEER AREA DUMP
REMEDIAL INVESTIGATION, CTO-0312
MCB, CAMP LEJEUNE, NORTH CAROLINA

Contaminant of Potential Concern	BCF	Organic Carbon Partition Coefficient (mL/g)	Log Octanol/ Water Coefficient	Biotransfer Factors		
				Bv(1)(2)	Br(1)(2)	Bb(1)(2)
Semivolatiles (continued)						
Pyrene	30(3)	38,000(5)	5.1(6)	4.37e-02	4.37e-02	3.16e-03
Pesticides/PCBs						
Beta-BHC	130(3)	3,800(5)	3.8(6)	2.46e-01	2.46e-01	1.58e-04
4,4'-DDD	53,600(3)	770,000(5)	6.1(6)	1.15e-02	1.15e-02	3.16e-02
4,4'-DDE	53,600(3)	4,400,000(5)	6.8(6)	4.55e-02	4.55e-02	1.58e-01
4,4'-DDT	53,600(3)	243,000(5)	6.5(6)	6.78e-03	6.78e-03	7.94e-02
Endosulfan II	270(3)	3,162(11)	4.1(6)	1.65e-01	1.65e-01	3.16e-04
Endosulfan Sulfate	270(3)	3,162(11)	3.7(6)	2.81e-01	2.81e-01	1.26e-04
Heptachlor epoxide	11,200(3)	220(5)	5.0(6)	4.99e-02	4.99e-02	2.51e-03
Aroclor 1260	31,200(3)	530,000(5)	6.0(6)	1.32e-02	1.32e-02	2.51e-02
Inorganics						
Aluminum	231(4)	ND	ND	4.00e-03	6.50e-04	1.50e-03
Antimony	1(3)	ND	ND	2.00e-01	3.00e-02	1.00e-03
Arsenic	44(3)	ND	ND	4.00e-02	6.00e-03	2.00e-03
Barium	8(4)	ND	ND	1.50e-01	1.50e-02	1.50e-04
Beryllium	19(3)	ND	ND	1.00e-02	1.50e-03	1.00e-03
Chromium	16(3)	ND	ND	7.50e-03	4.50e-03	5.50e-03
Cobalt	40(4)	ND	ND	2.00e-02	7.00e-03	2.00e-02
Copper	36(3)	ND	ND	4.00e-01	2.50e-01	1.00e-02
Iron	ND	ND	ND	4.00e-03	1.00e-03	2.00e-02
Lead	49(3)	ND	ND	4.50e-02	9.00e-03	3.00e-04
Manganese	35(4)	ND	ND	2.50e-01	5.00e-02	4.00e-04
Mercury	5,500(3)	ND	ND	9.00e-01	2.00e-01	2.50e-01
Selenium	6(3)	ND	ND	2.50e-02	2.50e-02	1.50e-02
Silver	0.5(3)	ND	ND	4.00e-01	1.00e-01	3.00e-03
Thallium	119(3)	ND	ND	4.00e-03	4.00e-04	4.00e-02
Vanadium	ND	ND	ND	5.50e-03	3.00e-03	2.50e-03
Zinc	47(3)	ND	ND	1.50e+00	9.00e-01	1.00e-01

Notes:

TABLE 7-4 (Continued)

REGION IV, PHYSICAL/CHEMICAL CHARACTERISTICS OF THE COCs
SITE 65 - ENGINEER AREA DUMP
REMEDIAL INVESTIGATION, CTO-0312
MCB, CAMP LEJEUNE, NORTH CAROLINA

(1) Baes et. al., 1984 for the inorganics.
(2) The organics were calculated using Travis and Arms, 1988.
(3) USEPA, 1995a (Region IV).
(4) USEPA, 1995b (Region III).
(5) USEPA, 1986.
(6) SCDM, 1991.
(7) Montgomery, 1990.
(8) Used benzo(a)pyrene Kow.
(9) USEPA, 1993e (Sediment Quality Criteria for Fluoranthene).
(10) USEPA, 1993f (Sediment Quality Criteria for Phenanthrene).
(11) ASTDR, 1993 (Toxicological Profile for Endosulfan).

BCF = Bioconcentration Factor
ND = No Data
Bv = Biotransfer factor for vegetation (stems, leaves)
Br = Biotransfer factor for vegetation (berries, fruits)
Bb = Biotransfer factor for beef

TABLE 7-5

SAMPLING STATION CHARACTERIZATION SUMMARY
SITE 65 - ENGINEER AREA DUMP
REMEDIAL INVESTIGATION, CTO-0312
MCB, CAMP LEJEUNE, NORTH CAROLINA

Station	Pond Width (ft)	Pond Depth (ft)	Canopy Cover	Sediment Description	Sediment Odor
65-SW/SD/BN/FS04	NM	3	Open	Silt with some sand, organic material below 3"	Decaying organics
65-SW/SD/BN/FS05	MN	4	Open	Silt with some sand, much organic material	Anaerobic

Notes:

NM = Not measured due to irregular shape of the ponds
SW = Surface Water Sample
SD = Sediment Sample
BN = Benthic Macroinvertebrate Sample

TABLE 7-6

FIELD CHEMISTRY DATA
SITE 65 - ENGINEER AREA DUMP
REMEDIAL INVESTIGATION, CTO-0312
MCB, CAMP LEJEUNE, NORTH CAROLINA

Station	Temperature (°C)	pH (S.U.)	Dissolved Oxygen (mg/L)	Conductivity (umhos/cm)	Salinity (ppt)
65-SW/SD04	17.3-30.4	6.7-7.2	2.0-10.6	12.0-21.5	0
65-SW/SD05	24.1-27.8	6.32-7.62	3.0-9.0	196-214	0

Notes:

°C = Degrees Centigrade
mg/L = Miligrams per Liter
S.U. = Standard Units
umhos/cm = Micromhos per centimeter
ppt = Parts Per Thousand

TABLE 7-7

TOTAL NUMBER OF FISH COLLECTED PER STATION
SITE 65 - ENGINEER AREA DUMP
REMEDIAL INVESTIGATION, CTO-0312
MCB, CAMP LEJEUNE, NORTH CAROLINA

Fish Species	Number of Fish per Station	
	65-FS04	65-FS05
Largemouth Bass	0	9
Redear Sunfish	8	31
Bluegill	32	30

TABLE 7-8

FISH DISTRIBUTION AND CHARACTERIZATION SUMMARY
SITE 65 - ENGINEER AREA DUMP
REMEDIAL INVESTIGATION, CTO-0312
MCB, CAMP LEJEUNE, NORTH CAROLINA

Common Name	Scientific Name	Length N.C. (cm)	Length Atlas (cm)	Water Type	Habitat	Spawning	Tolerance	Family	Sources
Bluegill	Lepomis macrochirus	25	18-20	Freshwater	Rivers, Streams Creeks, Ponds	May through June	Intermediate	Centrarchidae	1,2,3
Largemouth bass	Micropterus salmoides	48	12-70	Freshwater	Rivers, Streams Creeks, Ponds	May through October	Intermediate	Centrarchidae	1,2,3
Redear sunfish	Lepomis microlophus	NA	36	Freshwater	Rivers, Streams Creeks, Ponds	May through June	Intermediate	Centrarchidae	1,2,3

Notes:

1 = Menhinick, 1992.
2 = Boschung, 1983.
3 = USEPA, 1989d.

TABLE 7-9

NUMBER AND PERCENTAGE OF BENTHIC MACROINVERTEBRATE SPECIES PER STATION
SITE 65 - ENGENEER AREA DUMP
REMEDIAL INVESTIGATION, CTO-0312
MCB, CAMP LEJEUNE, NORTH CAROLINA

TAXON	65-BN04	65-BN05
Arthropoda		
Insecta		
Ephemeroptera		
Caenidae		
Caenis punctata		2 (14.3)
Diptera		
Chaoboridae		
Chaborus sp.	6 (100)	
Chironomidae		
Ablabesmyia ramphe gr.		5 (35.7)
Cricotopus elagans		1 (7.1)
Psectrocladius elatus		1 (7.1)
Tanypus sp.		2 (14.3)
Tabanidae		
Chrysops sp.		3 (21.4)

Note:

The number in parentheses is the percentage of individuals of that species.

TABLE 7-10

TOLERANCE VALUES OF BENTHIC MACROINVERTEBRATE SPECIES
SITE 65 - ENGINEER AREA DUMP
REMEDIAL INVESTIGATION, CTO-0312
MCB, CAMP LEJEUNE, NORTH CAROLINA

Species	USEPA Tolerance Values(1)		NCDEHNR Biotic Index(2)
	Metals	Organic Waste	
Arthropoda			
Insecta			
Ephemeroptera			
Caenidae			
Caenis punctata	NA	NA	7.4
Diptera			
Chaoboridae			
Chaborus sp.	NA	NA	NA
Chironomidae			
Ablabesmyia ramphe gr.	NA	2	NA
Cricotopus elagans	NA	NA	NA
Psectrocladius elatus	NA	2	3.5
Tanypus sp.	NA	NA	9.2
Tabanidae			
Chrysops sp.	NA	NA	6.7

Notes:

(1) - USEPA, 1990.
(2) - Lenat, 1993.

NA = Not Available
S = Sensitive to heavy metals
T = Tolerant to heavy metals
Organics Ranking = 0 to 5 with 0 being the least tolerant to organic wastes

TABLE 7-11

SUMMARY STATISTICS OF BENTHIC MACROINVERTEBRATE SPECIES
SITE 65 - ENGINEER AREA DUMP
REMEDIAL INVESTIGATION, CTO-0312
MCB, CAMP LEJEUNE, NORTH CAROLINA

Station	Number of Species	Number of Individuals	Species Density (#/m^2)	Brillouin's Species Diversity	Shannon-Wiener Species Diversity	Macroinvertebrate Biotic Index
Site 65 Stations						
65-BN04	1	6	38	0	0	NC
65-BN05	6	14	89	0.53	0.71	7.1
Off-Site Background Station						
WC02	20	286	1,823	0.76	0.80	7.8

Notes:

#/m^2 = Total number of individuals per square meter.
NC = Not calculated since the specie did not have a Biotic Index value.

TABLE 7-12

RESULTS OF THE JACCARD COEFFICIENT (Sj) OF COMMUNITY SIMILARITY AND SΦRENSON INDEX (Ss) OF COMMUNITY SIMILARITY BETWEEN BENTHIC MACROINVERTERBRATE STATIONS

SITE 65 - ENGINEER AREA DUMP

REMEDIAL INVESTIGATION, CTO-0312

MCB, CAMP LEJEUNE, NORTH CAROLINA

Sj

	STATION	65-BN04	65-BN05	HC01
Ss	65-BN04	NA	0.00	0.00
	65-BN05	0.00	NA	0.04
	HC01	0.00	0.08	NA

TABLE 7-13

SUMMARY OF SAMPLES SENT TO LABORATORY FOR CHEMICAL ANALYSIS
SITE 65 - ENGINEER AREA DUMP
REMEDIAL INVESTIGATION, CTO-0312
MCB, CAMP LEJEUNE, NORTH CAROLINA

Sample Number	Species	Sample Analysis	Trophic Level
65-FS04-BG01W	Bluegill	Whole Body	Insectivore
65-FS04-BG01F	Bluegill	Fillet	Insectivore
65-FS04-RS01W	Redear Sunfish	Whole Body	Insectivore
65-FS05-LB01W	Largemouth Bass	Whole Body	Piscivore
65-FS05-LB01F	Largemouth Bass	Fillet	Piscivore
65-FS05-RS01W	Redear Sunfish	Whole Body	Insectivore
65-FS05-RS01F	Redear Sunfish	Fillet	Insectivore
65-FS05-BG01W	Bluegill	Whole Body	Insectivore
65-FS05-BG01F	Bluegill	Fillet	Insectivore

TABLE 7-14

COMPARISON OF CONTAMINANT LEVELS IN SITE 65 TISSUE SAMPLES TO CONTAMINANT LEVELS IN TISSUE COLLECTED IN OTHER STUDIES
SITE 65 - ENGINEER AREA DUMP
REMEDIAL INVESTIGATION, CTO-0312
MCB, CAMP LEJEUNE, NORTH CAROLINA

Contaminant of Potential Concern	Site 65 Fish Whole Body Concentrations(1)	Pamlico Sound Study Fish Whole Body Concentrations(2)	Site 65 Fish Fillet Concentration(1)	Off-Site Background Fish Fillet Concentrations
Pesticides (µg/kg)				
4,4'-DDD	6.9J-40J(BG)	20 - 160	5.7J(BG)	ND
4,4'-DDE	15J(BG)	30 - 850	ND	9.7 - 12
Volatiles (µg/kg)				
Acetone	27,000-1,400,000J(BG)	NA	5,600-7,900(LMB)	16J-130J
2-Butanone	560J(RS)	NA	ND	ND
Methylene chloride	1,000J (RS)	NA	ND	ND
Toluene	5,000J(LMB)	NA	ND	ND
Inorganics (µg/kg)				
Aluminum	9.6J-18J(BG)	NA	0.99(LMB)	36.5
Antimony	1.1-1.5(RS)	NA	ND	ND
Arsenic	0.15J(BG)	NA	ND	0.34L-3.7L
Barium	0.44J-2.9J(RS)	NA	0.21J(BG)	ND
Beryllium	0.028(BG)	NA	ND	ND
Copper	1.1-8.6(RS)	1.43 - 5.33	0.46-0.49(BG)	0.18J - 0.46J
Iron	7.8J-26.1J(LMB)	NA	ND	ND
Lead	0.17-0.49(RS)	0.04 - 1.15	ND	ND
Manganese	1J-4.9J(BG)	NA	0.092J-0.45J(BG)	0.08J - 0.38
Mercury	0.11J(LMB)	0.04 - 1.26	0.051J-0.3J(LMB)	0.05 - 0.24
Selenium	0.16-0.42(BG)	NA	0.14-0.22(BG)	ND
Thallium	0.11-0.12(BG)	NA	0.11(RS)	ND
Zinc	14.8J-31.5J(RS)	44.9 - 67.7	5.8J-8.4J(BG)	3.9 - 6.5

Notes:

LMB = Large Mouth Bass
BG = Bluegill
RS = Redear Sunfish
NA = Not Analyzed
ND = Not Detected

(1) Species in parenthesis is sample with the highest detection.
(2) Benkert, 1992.

TABLE 7-15

COMPARISON OF WHOLE BODY FISH TISSUE CONCENTRATIONS TO PROPOSED PISCIVOROUS WILDLIFE CRITERIA
SITE 65 - ENGINEER AREA DUMP
REMEDIAL INVESTIGATION, CTO-0312
MCB, CAMP LEJEUNE, NORTH CAROLINA

Contaminant	Maximum Tissue Concentration (mg/kg)	Non-Carcinogenic Risk (mg/kg)(1)	Carcinogenic Risk (10^{-2}) (mg/kg)(1)
4,4'-DDD	0.040J	0.2	0.266
4,4'-DDE	0.015J	0.2	0.266

Note:

(1) Newell et.al., 1987.

TABLE 7-16

FREQUENCY AND RANGE OF CONTAMINANT DETECTIONS COMPARED TO SOIL FLORA AND FAUNA SCREENING VALUES
SITE 65 - ENGINEER AREA DUMP
REMEDIAL INVESTIGATION, CTO-0312
MCB, CAMP LEJEUNE, NORTH CAROLINA

		Soil Flora and Fauna Screening Values(1)				Contaminant Frequency/Range			
Contaminant	Dutch Background Soil Values(4)	Plant	Earthworm	Invertebrate	Microorganisms and Microbial Processes	No. of Positive Detects/No. of Samples	Range of Positive Detections	No. of Positive Detects Above Dutch Background Value	No. of Positive Detects Above Lowest Screening Value
Volatiles (µg/kg)									
Ethylbenzene	50	NE	100(2)	100(2)	NE	1/13	1J	0	0
Trichloroethene	NE	NE	<300 (2)	<300 (2)	NE	1/13	1J	NA	0
Xylene	50	>1000(3)	NE	NE	NE	2/13	3J-5J	0	0
Semivolatiles (µg/kg)									
Acenaphthene	NE	NE	100(2)	100(2)	NE	1/13	130J	NA	1
Anthracene	100	NE	100(2)	100(2)	NE	1/13	190J	1	1
Benzo(a)anthracene	NE	NE	100(2)	100(2)	NE	3/13	76J-510	NA	2
Benzo(b)fluoranthene	NE	NE	100(2)	100(2)	NE	3/13	89J-360J	NA	1
Benzo(k)fluoranthene	NE	NE	100(2)	100(2)	NE	2/13	120J-510	NA	2
Benzo(g,h,i)perylene	NE	NE	100(2)	100(2)	NE	2/13	70J-250J	NA	1
Benzo(a)pyrene	100	NE	20,000(2)	25,000	NE	2/13	100J-400	1	0
Bis(2-ethylhexyl)phthalate	NE	NE	NE	NE	NE	9/13	48J-87J	NA	NA
Carbazole	NE	NE	NE	NE	NE	1/13	180J	NA	NA
Chrysene	NE	NE	100(2)	100(2)	NE	3/13	70J-470	NA	2
Dibenzo(a,h)anthracene	NE	NE	100(2)	100(2)	NE	2/13	45J-150J	NA	1
Dibenzofuran	NE	NE	NE	NE	NE	1/13	58J	NA	NA

TABLE 7-16 (Continued)

FREQUENCY AND RANGE OF CONTAMINANT DETECTIONS
COMPARED TO SOIL FLORA AND FAUNA SCREENING VALUES
SITE 65 - ENGINEER AREA DUMP
REMEDIAL INVESTIGATION, CTO-0312
MCB, CAMP LEJEUNE, NORTH CAROLINA

Contaminant	Dutch Background Soil Values(4)	Soil Flora and Fauna Screening Values(1)				Contaminant Frequency/Range		No. of Positive Detects Above Dutch Background Value	No. of Positive Detects Above Lowest Screening Value
		Plant	Earthworm	Invertebrate	Microorganisms and Microbial Processes	No. of Positive Detects/No. of Samples	Range of Positive Detections		
Semivolatiles (µg/kg) (continued)									
Di-n-butylphthalate	NE	200,000	NE	NE	NE	2/13	260J-390J	NA	0
2,4-Dinitrophenol	NE	200,000	NE	NE	NE	1/13	150J	NA	0
Fluoranthene	100	NE	100(2)	100(2)	NE	3/13	130J-830	3	3
Fluorene	NE	NE	30,000	100(2)	NE	1/13	100J	NA	0
Indeno(1,2,3-cd)pyrene	NE	NE	100(2)	100(2)	NE	2/13	88J-310J	NA	1
Phenanthrene	100	NE	100(2)	100(2)	NE	3/13	59J-860	1	1
Pyrene	100	NE	100(2)	100(2)	NE	3/13	150J-850	3	3
Pesticides/PCBs (µg/kg)									
4',4-DDD	100	NE	100(2)	100(2)	NE	7/13	3.8NJ-59J	0	0
4',4-DDE	100	NE	100(2)	100(2)	NE	6/13	4.3-83J	0	0
4',4-DDT	100	NE	4(2)	4(2)	NE	3/13	25-56J	0	3
Endosulfan II	100	>1000(3)	NE	NE	NE	2/13	3.8NJ-3.9NJ	0	0
Heptachlor epoxide	100	NE	<100(2)	<100(2)	NE	1/13	2.3	0	0
PCBs	50	40,000	40(2)	40(2)	NE	1/13	52J	1	1

TABLE 7-16 (Continued)

FREQUENCY AND RANGE OF CONTAMINANT DETECTIONS COMPARED TO SOIL FLORA AND FAUNA SCREENING VALUES
SITE 65 - ENGINEER AREA DUMP
REMEDIAL INVESTIGATION, CTO-0312
MCB, CAMP LEJEUNE, NORTH CAROLINA

		Soil Flora and Fauna Screening Values(1)				Contaminant Frequency/Range			
Contaminant	Dutch Background Soil Values(4)	Plant	Earthworm	Invertebrate	Microorganisms and Microbial Processes	No. of Positive Detects/No. of Samples	Range of Positive Detections	No. of Positive Detects Above Dutch Background Value	No. of Positive Detects Above Lowest Screening Value
Inorganics (mg/kg)									
Barium	200	500	400(2)	400(2)	3,000	13/13	2.7-36.3	0	0
Chromium	100	1	0.4	0.0075(2)	10	11/13	2.3-8.6	0	11
Copper	50	100	50	20	100	9/13	2.5-55.6	2	3
Iron	NE	100(2)	NE	3,515	200	13/13	509-16400	NA	13
Lead	50	50	500	300	900	13/13	2-178J	3	4
Manganese	NE	500	330(2)	330(2)	100	13/13	2.9-163J	NA	2
Nickel	50	30	200	NE	90	2/13	4.6-5.7	0	0
Thallium	NE	1	NE	NE	NE	1/13	2.3	NA	1
Vanadium	NE	2	58(2)	58(2)	20	9/13	2.8-12	NA	9
Zinc	200	50	200	500	100	11/13	3.7-377J	1	3

Notes:

(1) Will and Suter, 1994a and 1994b unless indicated otherwise. (Values presented for plants, earthworms, and microorganisms and microbial processes are benchmarks below which adverse inpacts to these species are not expected. Values for invertebrates are No Observed Effects Concentrations however, they are based on less data than the benchmarks).

(2) USEPA, 1995b (Region III BTAG Soil Screening Values for Soil Fauna).

(3) Hulzebos et.al., 1993 (EC50).

(4) Richardson, 1987 (Dutch Soil Criteria)

TABLE 7-17

EXPOSURE FACTORS FOR TERRESTRIAL CHRONIC DAILY INTAKE MODEL
SITE 65 - ENGINEER AREA DUMP
REMEDIAL INVESTIGATION, CTO-0312
MCB, CAMP LEJEUNE, NORTH CAROLINA

Exposure Parameter	Units	White-Tailed Deer	Eastern Cottontail Rabbit	Bobwhite Quail	Red Fox	Raccoon	Small Mammal
Food Source Ingestion	NA	Vegetation 100%	Vegetation 100%	Vegetation 100%	Small Mammals 80% Vegetation 20%	Vegetation 40% Fish 60%	Vegetation 100%
Feeding Rate	kg/day	1.6⁽²⁾	0.237⁽⁴⁾	0.0135⁽³⁾	0.601⁽³⁾	0.214⁽⁶⁾	0.112⁽³⁾
Incident Soil Ingestion	kg/day	0.0185⁽¹⁾	0.0057⁽⁵⁾	0.0011⁽⁵⁾	0.0168⁽⁵⁾	0.0201⁽⁵⁾	0.00269⁽⁵⁾
Rate of Drinking Water Ingestion	L/day	1.1⁽²⁾	0.119⁽³⁾	0.0191⁽³⁾	0.385⁽³⁾	0.422⁽³⁾	0.0652⁽³⁾
Rate of Vegetation Ingestion	kg/day	1.6	0.237	0.0135	0.12	0.086	0.112
Body Weight	kg	45.4⁽²⁾	1.229⁽³⁾	0.174⁽³⁾	4.54⁽³⁾	5.12⁽³⁾	0.3725⁽³⁾
Rate of Small Mammal Ingestion	kg/day	NA	NA	NA	0.48	NA	NA
Rate of Fish Ingestion	kg/day	NA	NA	NA	NA	0.128	NA
Home Range Size	acres	454⁽²⁾	9.30⁽³⁾	26.24⁽³⁾	1,245⁽³⁾	257⁽³⁾	0.032⁽³⁾

Notes:

NA = Not Applicable

(1) Arthur and Alldridge, 1979.
(2) Dee, 1991.
(3) USEPA, 1993g.
(4) Opresko, et. al., 1994.
(5) Beyer, 1993.
(6) Nagy, 1987.

TABLE 7-18

SURFACE WATER QUOTIENT INDEX
SITE 65 - ENGINEER AREA DUMP
REMEDIAL INVESTIGATION CTO-0312
MCB, CAMP LEJEUNE, NORTH CAROLINA

Contaminant	Station	Concentration (µg/L)	Quotient Index		
			North Carolina WQS	USEPA SWSV	
				Acute	Chronic
Total Inorganics					
Aluminum	65-SW04	25800	NA	34.40	296.55
Barium	65-SW04	69.3	NA	1.00	18.24
	65-SW05	36.7	NA	0.53	9.66
Copper	65-SW04	41.1	5.87	5.71	7.87
Iron	65-SW04	7890	7.89	NA	7.89
Lead	65-SW04	45.8	1.83	1.89	48.72
Manganese	65-SW04	88.4	NA	0.06	1.10
Vanadium	65-SW04	26.2	NA	0.09	1.37
Zinc	65-SW04	144	2.88	2.77	3.06

Notes:

Shaded samples are Quotient Indices that exceed "1".
NA = Not Available
WQS = Water Quality Standard
SWSV = Surface Water Screening Value

TABLE 7-19

SEDIMENT QUOTIENT INDEX
STIE 65 - ENGINEER AREA DUMP
REMEDIAL INVESTIGATION CTO-0312
MCB, CAMP LEJEUNE, NORTH CAROLINA

Contaminant	Station	Concentration	Quotient Index ER-L	 ER-M	 SQC
Semivolatiles (µg/Kg)					
Di-n-butylphthalate	65-SD04-612	1600J	NA	1.14	0.01
Pesticides (µg/Kg)					
4,4'-DDE	65-SD04-06	18J	8.18	0.67	0.16
	65-SD05-06	19NJ	8.64	0.70	0.02
4,4'-DDD	65-SD04-06	76J	38.00	3.80	3.96
	65-SD05-06	84J	42.00	4.20	0.63
Total Metals (µg/Kg)					
Antimony	65-SD04-06	47J	23.30	1.86	NA
Copper	65-SD04-06	100J	2.94	0.37	NA
	65-SD04-612	21.4J	1.14	0.08	NA
Lead	65-SD04-06	176J	3.77	0.81	NA
	65-SD04-612	38.5J	1.27	0.18	NA
Zinc	65-SD04-06	280J	2.26	0.68	NA

Notes:

Shaded samples are Quotient Indices that exceed "1".
NE = Not Established
ER-L = Effects Range Low
ER-M = Effects Range Median
SQC = Sediment Quality Criteria

TABLE 7-20

TERRESTRIAL QUOTIENT INDEX
SITE 65 - ENGINEER AREA DUMP
REMEDIAL INVESTIGATION, CTO-0312
MCB, CAMP LEJEUNE, NORTH CAROLINA

Contaminant	Red Fox	Bobwhite Quail	Cottontail Rabbit	Raccoon	Whitetail Deer
Acetone	1.46E-04	2.23E-03	1.05E-02	8.60E+00	4.26E-04
2-Butanone	NA	NA	NA	NA	NA
Ethylbenzene	1.02E-07	4.45E-06	1.96E-05	3.67E-07	6.70E-07
Methylene chloride	NA	NA	NA	NA	NA
Toluene	1.25E-07	5.55E-06	2.51E-05	1.38E-02	8.65E-07
Trichloroethene	1.57E-08	7.00E-07	3.19E-06	5.39E-08	1.10E-07
Xylenes (total)	2.50E-08	1.07E-06	4.68E-06	9.05E-08	1.60E-07
Acenaphthene	3.73E-06	1.49E-04	5.89E-04	1.48E-05	1.96E-05
Anthracene	1.26E-06	4.39E-05	1.38E-04	5.71E-06	4.25E-06
Benzo(a)anthracene	1.21E-04	3.60E-03	7.42E-03	6.11E-04	1.85E-04
Benzo(a)pyrene	1.04E-04	2.98E-03	5.45E-03	5.34E-04	1.23E-04
Benzo(b)fluoranthene	1.02E-04	2.91E-03	5.18E-03	5.26E-04	1.15E-04
Benzo(g,h,i)perylene	9.58E-05	2.62E-03	4.22E-03	4.90E-04	8.44E-05
Benzo(k)fluoranthene	1.10E-04	3.14E-03	5.59E-03	5.67E-04	1.24E-04
Bis(2-ethylhexyl)phthalate	7.23E-05	5.29E-04	2.72E-03	3.46E-04	4.99E-05
Carbazole	3.66E-04	1.57E-02	6.87E-02	1.33E-03	2.34E-03
Chrysene	1.19E-04	3.55E-03	7.31E-03	6.03E-04	1.82E-04
Dibenz(a,h)anthracene	6.61E-05	1.81E-03	2.91E-03	3.38E-04	5.82E-05
Dibenzofuran	1.18E-04	5.07E-03	2.21E-02	4.28E-04	7.55E-04
Di-n-butylphthalate	5.50E-07	2.86E-02	6.01E-05	2.49E-06	1.85E-06
2,4-Dinitrophenol	4.62E-05	3.75E-03	1.02E-02	1.50E-04	3.54E-04
Fluoranthene	1.28E-05	4.13E-04	1.07E-03	6.20E-05	3.06E-05
Fluorene	2.96E-06	1.11E-04	3.96E-04	1.26E-05	1.28E-05
Indeno(1,2,3-cd)pyrene	9.68E-05	2.65E-03	4.26E-03	4.96E-04	8.53E-05
Phenanthrene	2.35E-06	8.20E-05	2.57E-04	1.07E-05	7.94E-06
Pyrene	2.20E-05	7.05E-04	1.82E-03	1.06E-04	5.19E-05
4,4'-DDD	1.35E-05	4.46E-03	7.10E-04	3.14E-03	1.61E-05
4,4'-DDE	2.02E-05	6.29E-03	8.68E-04	1.22E-03	1.71E-05
4,4'-DDT	1.36E-05	4.35E-03	6.32E-04	7.01E-05	1.31E-05
Endosulfan II	5.79E-07	3.67E-06	2.35E-04	7.02E-06	7.65E-06
Heptachlor epoxide	7.89E-04	2.57E-02	6.92E-02	3.77E-03	2.00E-03
Aroclor-1260	9.91E-04	2.87E-02	5.39E-02	5.08E-03	1.25E-03
Aluminum	1.29E-01	2.07E+00	2.09E+00	1.21E+01	1.16E-01
Antimony	0.00E+00	0.00E+00	0.00E+00	2.63E+00	0.00E+00
Arsenic	0.00E+00	0.00E+00	0.00E+00	1.66E-01	0.00E+00
Barium	8.34E-02	2.40E-01	5.46E-01	8.45E-01	5.97E-02
Beryllium	0.00E+00	0.00E+00	0.00E+00	3.18E-03	0.00E+00
Chromium	2.80E-03	6.71E-04	7.25E-04	4.97E-03	1.41E-04

TABLE 7-20 (Continued)

TERRESTRIAL QUOTIENT INDEX
SITE 65 - ENGINEER AREA DUMP
REMEDIAL INVESTIGATION, CTO-0312
MCB, CAMP LEJEUNE, NORTH CAROLINA

Contaminant	Red Fox	Bobwhite Quail	Cottontail Rabbit	Raccoon	Whitetail Deer
Copper	2.60E-03	9.71E-02	3.92E-01	3.54E-02	7.25E-02
Iron	6.79E-02	7.18E-01	1.43E+00	2.40E-01	6.59E-02
Lead	6.49E-03	5.00E-01	1.36E+00	2.74E-02	1.10E-01
Manganese	8.42E-03	2.01E-02	2.54E-01	5.11E-02	4.69E-02
Mercury	0.00E+00	0.00E+00	0.00E+00	2.11E-02	0.00E+00
Nickel	1.12E-05	1.68E-03	1.83E-02	8.01E-04	1.46E-03
Selenium	0.00E+00	0.00E+00	0.00E+00	6.44E-01	0.00E+00
Thallium	1.13E-02	3.15E-01	4.93E-01	1.65E-01	9.54E-03
Vanadium	1.01E-02	2.53E-03	7.51E-01	1.91E-02	2.71E-03
Zinc	3.02E-01	6.47E-01	3.82E+00	1.14E-02	3.55E-01
Total Quotient Index	**6.27e-01**	**4.77e+00**	**1.14e+01**	**2.56e+01**	**8.47e+01**

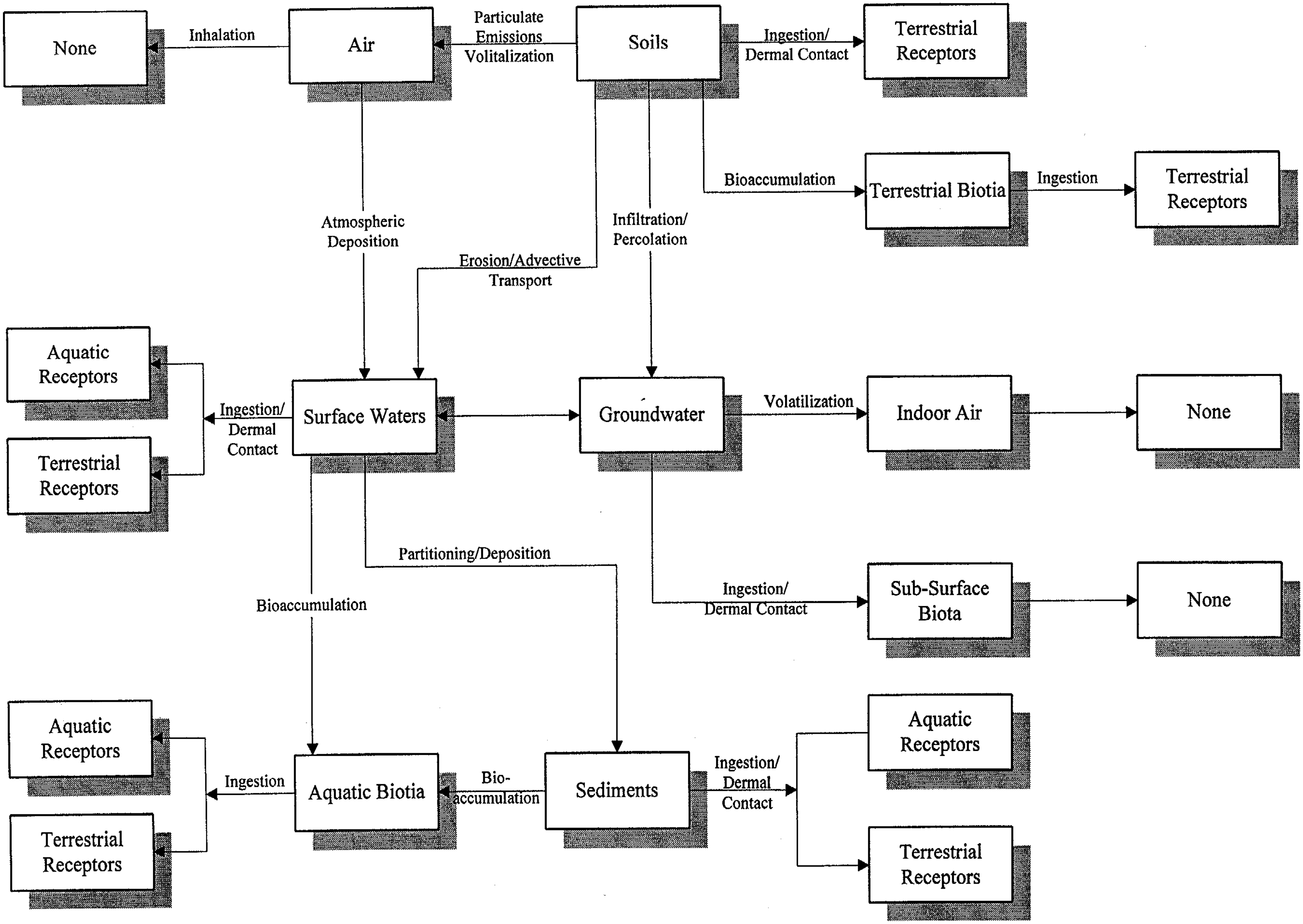
Note:

Shaded areas are Quotient Indices that exceed "1"

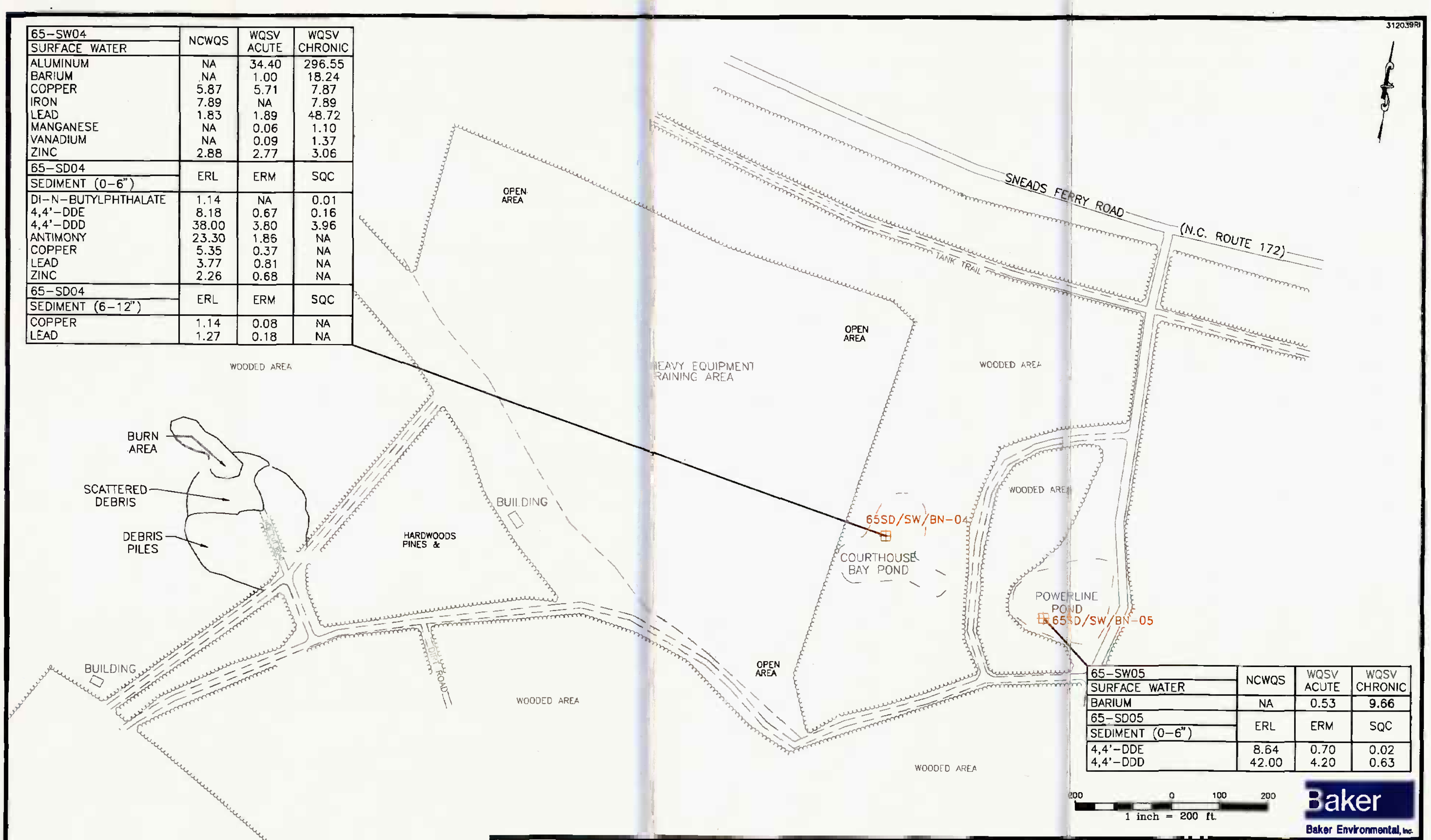
FIGURES

FIGURE 7-1

CONCEPTUAL EXPOSURE MODEL FOR ECOLOGICAL RECEPTORS
SITE 65 - ENGINEER AREA DUMP
REMEDIAL INVESTIGATION, CTO-0312
MCB, CAMP LEJEUNE, NORTH CAROLINA



312039RI



65-SW04 SURFACE WATER	NCWQS	WQSV ACUTE	WQSV CHRONIC
ALUMINUM	NA	34.40	296.55
BARIUM	NA	1.00	18.24
COPPER	5.87	5.71	7.87
IRON	7.89	NA	7.89
LEAD	1.83	1.89	48.72
MANGANESE	NA	0.06	1.10
VANADIUM	NA	0.09	1.37
ZINC	2.88	2.77	3.06
65-SD04 SEDIMENT (0-6")	ERL	ERM	SQC
DI-N-BUTYLPHTHALATE	1.14	NA	0.01
4,4'-DDE	8.18	0.67	0.16
4,4'-DDD	38.00	3.80	3.96
ANTIMONY	23.30	1.86	NA
COPPER	5.35	0.37	NA
LEAD	3.77	0.81	NA
ZINC	2.26	0.68	NA
65-SD04 SEDIMENT (6-12")	ERL	ERM	SQC
COPPER	1.14	0.08	NA
LEAD	1.27	0.18	NA

65-SW05 SURFACE WATER	NCWQS	WQSV ACUTE	WQSV CHRONIC
BARIUM	NA	0.53	9.66
65-SD05 SEDIMENT (0-6")	ERL	ERM	SQC
4,4'-DDE	8.64	0.70	0.02
4,4'-DDD	42.00	4.20	0.63

Baker
Baker Environmental, Inc.

LEGEND

65SD/SW/BN-04 ⊞	SURFACE WATER, SEDIMENT AND BENTHIC SAMPLE LOCATION

SOURCE: BRENT A. LANIER, SURVEYING AND PLANNING, MAY 1995

FIGURE 7-2
QUOTIENT INDEX RATIOS THAT EXCEEDED "1"
IN THE SURFACE WATER AND SEDIMENT
SITE 65 - ENGINEER AREA DUMP
REMEDIAL INVESTIGATION CTO-0312
MARINE CORPS BASE, CAMP LEJEUNE
NORTH CAROLINA

00145027Y

8.0 CONCLUSIONS AND RECOMMENDATIONS

Baker performed a Remedial Investigation, including baseline human health and ecological risk assessments, for the Engineer Area Dump (Site 65, Operable Unit No. 9) at MCB, Camp Lejeune, North Carolina. The remedial investigation was performed consistent with the approved Work Plan and as described in this report.

The nature and extent of contamination is discussed in detail in Section 4.0 of this report. In general, volatile organic compounds were not detected at Site 65 above comparison levels, although one detection of carbon disulfide in the groundwater was carried through the risk assessment. Also several volatile organic compounds were detected in sediments, but it is concluded that the presence of these compounds is not related to waste disposal at the site, since these compounds were not detected in the soils near the waste disposal area.

Semivolatile organic compounds were detected in the surface and subsurface soils, with the largest number of compounds and highest concentrations near the waste disposal areas. Although the PAHs may be attributable to heavy equipment or other sources, the most likely source is products of incomplete combustion at the waste disposal areas. Semivolatile organic compounds were not detected above screening values in the groundwater, surface water or sediments.

Pesticides were detected in soils and sediments throughout the study area at levels typically observed at MCB, Camp Lejeune. One soil sample near the waste disposal area contained a PCB compound at a level well below USEPA PCB Clean Up Policy requirements. Neither pesticides nor PCBs were detected in the groundwater.

Metals were detected throughout the Site 65. Some of the metals concentrations were greater than two times base background levels, but none of the environmental media presented a risk to human health. Although mercury was not detected in the surface water or sediments of the two ponds that were sampled, mercury in fish tissue produced an estimated chronic health index of 1.7 which is above the acceptable level of 1.0. However, mercury is not related to the waste at the site and apparently not even the local environment. Other factors should be considered such as whether fish are transported to these ponds or bioaccumulation is occurring through a food chain.

The human health risk assessment was based upon very conservative assumptions. All viable pathways were considered and the site model included the following receptors:

- Current military personnel (equipment operator trainees and recreational users)
- Future residents (adult and child)
- Future construction worker
- Current fisherman (adult and child)

All incremental lifetime cancer risk estimates were between 8.2E-09 and 2.8E-06, thus all cancer risks are either insignificant or within the acceptable range of 1.0E-06 to 1.0E-04. Except for the hazard index due to a young child consuming fish, the estimated hazard indices for non-carcinogens were all less than 0.47.

The ecological risk assessment concluded that the most significant ecological effects result from high turbidity and low dissolved oxygen particularly in Courthouse Bay pond. These environmental impacts are unrelated to the waste disposal areas, because of the significant distance between the waste disposal areas and the ponds, and the land does not slope toward the ponds from the waste areas.

Overall, the conclusion of the Site 65 Remedial Investigation is that there are no releases of hazardous substances from the waste disposal areas that result in a risk to human health or the environment. Based upon the conclusions of the Remedial Investigation, Baker recommends no further studies at this site, including no Feasibility Study. Although a "no action" Feasibility Study could be performed, there is no benefit to the environment or the administrative process.

The next step in the administrative process appears to be a proposed plan describing the no action alternative for review and concurrence by the Department of the Navy, United States Environmental Protection Agency, and North Carolina Department of Environment, Health and Natural Resources.

APPENDIX A
TEST BORING AND WELL CONSTRUCTION RECORDS

Baker

Baker Environmental, Inc

TEST BORING AND WELL CONSTRUCTION RECORD

PROJECT: NAVY CLEAN SITE 65
S.O. NO.: 62470-312-0000-09000 BORING NO.: 65-DW01
COORDINATES: EAST: 2494851.66 NORTH: 307336.56
ELEVATION: SURFACE 30.00 TOP OF CASING: 32.07

RIG: Truckmount CME-75

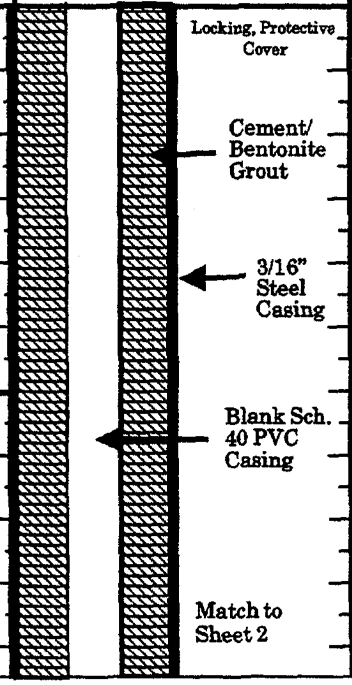
	SPLIT SPOON	CASING	AUGERS	CORE BARREL	DATE	PROGRESS (FT)	WEATHER	WATER DEPTH (FT)	TIME
SIZE (DIAM.)	2" OD	6" ID	4¼" ID		4/10/95	43.0	Clear, 60°	11.0	08:30
LENGTH	24"	10.0'	5.0'		4/18/95	23.0			
TYPE	S.S.	3/16"	H.S.		4/20/95			7.96 msl	
HAMMER WT.	140				4/23/95			9.24 msl	
FALL	STD				8/21/95			8.06 msl	
STICK UP									

REMARKS:

SAMPLE TYPE

S = Split Spoon	A = Auger		
T = Shelby Tube	W = Wash		
R = Air Rotary	C = Core		
D = Denison	P = Piston		
N = No Sample			

WELL INFORMATION	DIAM	TYPE	TOP DEPTH (FT)	BOTTOM DEPTH (FT)
Well Casing	2.0"	PVC Threaded	-1.88	56
Well Screen	2.0"	PVC Slotted	56	66

Depth (Ft.)	Sample Type and No.	Samp. Rec. Ft. & %	SPT or RQD	HNu (ppm) Bkgrd	HNu (ppm) Point Source	Visual Description	Well Installation Detail	Elevation (msl)
1 1.0						(*Sample 65-DW01-00 collected)		29.0
2 3.0 3	S-01	1.75 85%	5 6 7 7	0.2	0.2	SAND, fine to very fine, trace SILT, brown to light brown, damp, loose to medium dense.		28.0 27.0
4 5.0 5	S-02	1.75 100%	5 3 3 4	0.1	0.1			26.0 25.0
6 7.0 7	S-03	2.0 100%	7 8 10 6	0.2	0.2	Some black staining. SAND, fine to very fine, and CLAY, gray, damp, dense.		24.0 23.0
8 9.0 9	S-04	2.0 100%	16 18 12 12	0.2	0.2	(*Sample 65-DW01-04 collected)		22.0 21.0
10 10.0	S-05	2.0 100%	2 2 3 3	0.2	0.2	CLAY, little fine to very fine SAND, gray, stained orange, moist, wet at 11.0', medium stiff.		20.0

DRILLING CO.: Parrott Wolff BAKER REP.: R.M. Lewis
DRILLER: Mark Eaves BORING NO.: 65-DW01 SHEET 1 OF 4

Baker

Baker Environmental, Inc.

TEST BORING AND WELL CONSTRUCTION RECORD

PROJECT: NAVY CLEAN SITE 65
S.O. NO.: 62470-312-0000-09000 BORING NO.: 65-DW01

SAMPLE TYPE

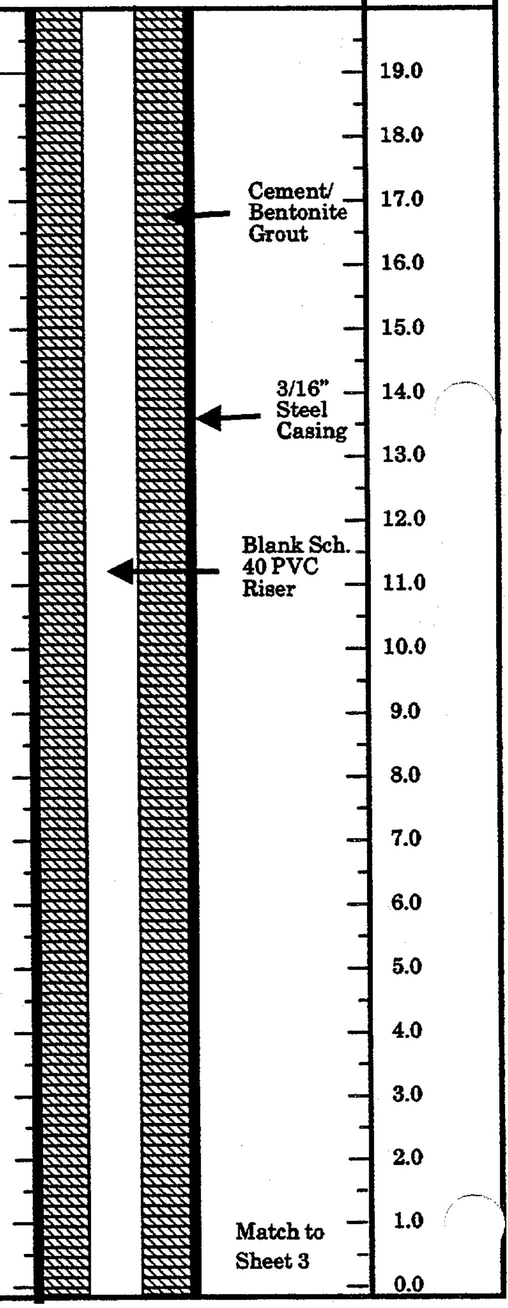
S = Split Spoon
T = Shelby Tube
R = Air Rotary
D = Denison
A = Auger
W = Wash
C = Core
P = Piston
N = No Sample

DEFINITIONS

SPT = Standard Penetration Test (ASTM D-1586) (Blows/0.5')
RQD = Rock Quality Designation (%)
Lab Class. = USCS (ASTM D-2487) or AASHTO (ASTM D-3282)
Lab Moist. = Moisture Content (ASTM D-2216) Dry Weight Basis

Depth (Ft.)	Sample Type and No.	Samp. Rec. (Ft. & %)	SPT or RQD	HNu (ppm) Bkgrd	HNU (ppm) Point Source	Continued from Sheet 1
11.0 13.0	S-06	1.5 75%	3 5 5 6	0.2	0.2	SAND, fine to very fine, trace to some CLAY, trace SILT, gray stained orange, wet, medium dense to loose.
15.0 17.0	S-07	1.0 50%	3 6 5 6	0.1	0.1	
20.0 22.0	S-08	1.0 50%	3 4 4 3	0.1	0.1	
25.0 27.0	S-09	1.5 75%	5 6 9 11	0.1	0.1	- 2" layer of dark brown SILT.
30.0						

Well Installation Detail



DRILLING CO.: Parrott Wolff BAKER REP.: R.M. Lewis
DRILLER: Mark Eaves BORING NO.: 65-DW01 SHEET 2 OF 4

Baker

Baker Environmental, Inc.

TEST BORING AND WELL CONSTRUCTION RECORD

PROJECT: NAVY CLEAN SITE 65
S.O. NO.: 62470-312-0000-09000 BORING NO.: 65-DW01

SAMPLE TYPE

S = Split Spoon
T = Shelby Tube
R = Air Rotary
D = Denison
A = Auger
W = Wash
C = Core
P = Piston
N = No Sample

DEFINITIONS

SPT = Standard Penetration Test (ASTM D-1586) (Blows/0.5')
RQD = Rock Quality Designation (%)
Lab Class. = USCS (ASTM D-2487) or AASHTO (ASTM D-3282)
Lab Moist. = Moisture Content (ASTM D-2216) Dry Weight Basis

Depth (Ft.)	Sample Type and No.	Samp. Rec. (Ft. & %)	SPT or RQD	HNu (ppm) Bkgrd	HNu (ppm) Point Source
32.0	S-10	1.5 75%	3 5 10 8	0.1	0.1
35.0					
37.0	S-11	2.0 100%	9 10 12 12	0.1	0.1
39.0	S-12	1.7 85%	12 12 10 9	0.1	0.1
41.0	S-13	1.9 95%	4 5 6 5	0.1	0.1
43.0	S-14	1.0 50%	3 2 2 3	0.1	0.1
45.0	S-15	2.0 100%	6 5 3 4	0.3	0.3
47.0	S-16	2.0 100%	3 3 2 2	0.3	0.3
49.0	S-17	2.0 100%	2 1 4 2	0.3	0.3
50.0	S-18	2.0 100%	3 6 9 16	0.3	0.3

Continued from Sheet 2

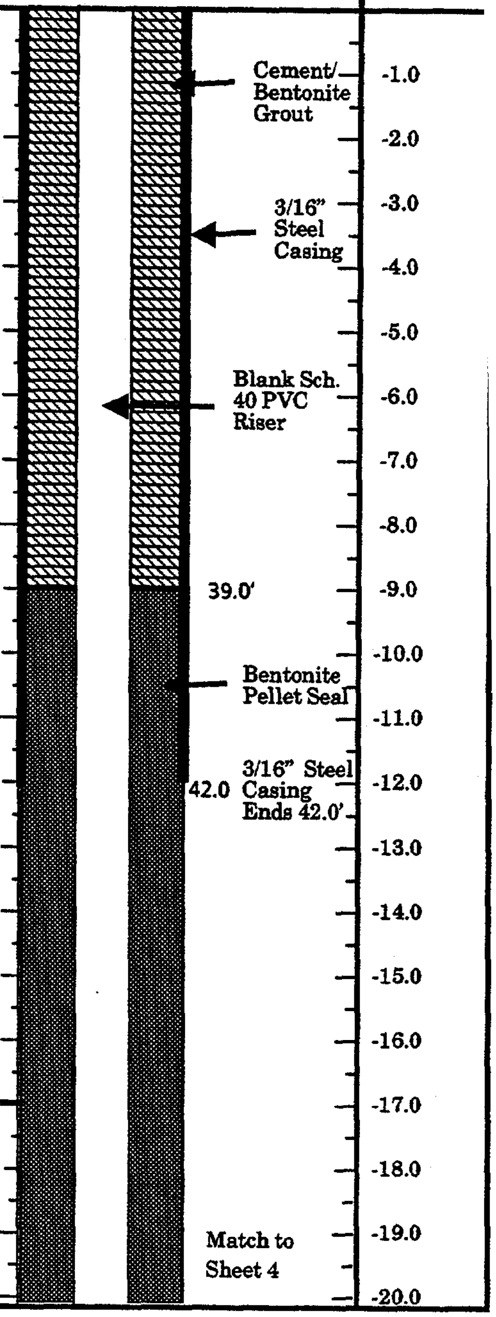
SAND, fine, trace SILT, gray stained orange, wet, medium dense.

SAND, fine to very fine, and CLAY, gray to gray green, wet.

CLAY, little to trace fine SAND, gray green wet, soft.

SAND, fine to very fine, trace CLAY, trace fine gravel, gray, wet, loose.

Well Installation Detail



DRILLING CO.: Parrott Wolffe
DRILLER: Mark Eaves
BAKER REP.: R.M. Lewis
BORING NO.: 65-DW01
SHEET 3 OF 4

Baker

Baker Environmental, Inc.

TEST BORING AND WELL CONSTRUCTION RECORD

PROJECT: NAVY CLEAN SITE 65
S.O. NO.: 62470-312-0000-09000 BORING NO.: 65-DW01

SAMPLE TYPE

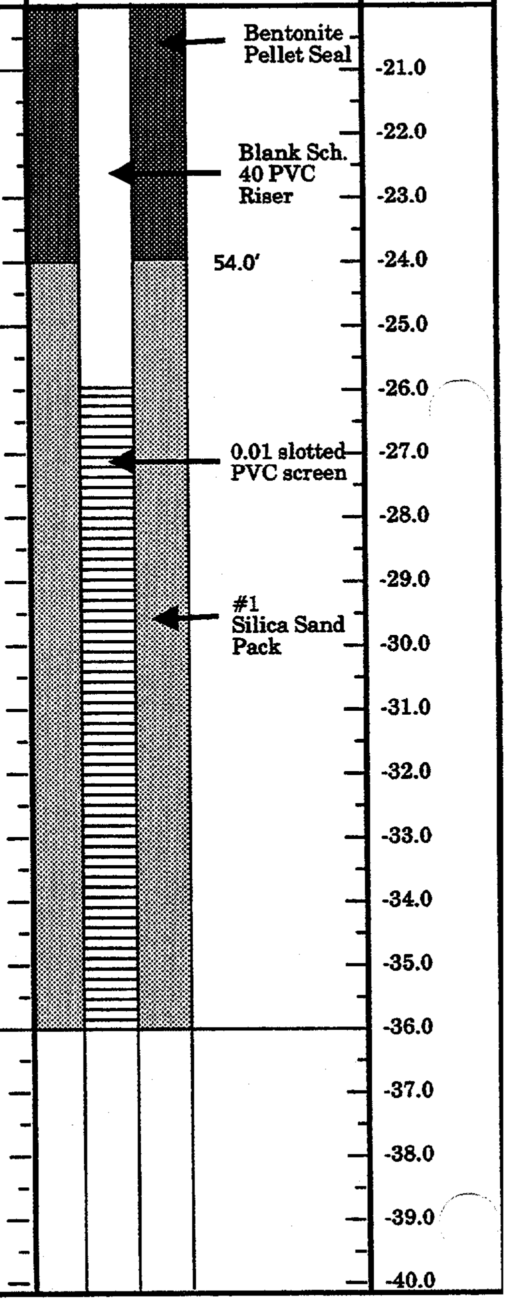
S = Split Spoon		**A** = Auger	
T = Shelby Tube		**W** = Wash	
R = Air Rotary		**C** = Core	
D = Denison		**P** = Piston	

N = No Sample

DEFINITIONS

SPT = Standard Penetration Test (ASTM D-1586) (Blows/0.5')
RQD = Rock Quality Designation (%)
Lab Class. = USCS (ASTM D-2487) or AASHTO (ASTM D-3282)
Lab Moist. = Moisture Content (ASTM D-2216) Dry Weight Basis

Depth (Ft.)	Sample Type and No.	Samp. Rec. (Ft. & %)	SPT or RQD	HNu (ppm) Bkgrd	HNu (ppm) Point Source	Continued from Sheet 3
51.0						
53.0	S-19	1.0 50%	6 3 3 10	0.3	0.3	SAND, fine to medium, calcarous cement, some shell fragments, gray, wet, loose to medium dense.
55.0	S-20	1.0 50%	12 14 12 16	0.3	0.3	
						Auger no sample, borehole cave-in.
66						End of Boring at 66.0'.



DRILLING CO.: Parrott Wolffe
DRILLER: Mark Eaves
BAKER REP.: R.M. Lewis
BORING NO.: 65-DW01 SHEET 4 OF 4

Baker

Baker Environmental, Inc

TEST BORING AND WELL CONSTRUCTION RECORI

PROJECT: NAVY CLEAN SITE 65
S.O. NO.: 62470-312-0000-09000 BORING NO.: 65-DW02
COORDINATES: EAST: 2494926.23 NORTH: 306941.21
ELEVATION: SURFACE 23.50 TOP OF CASING: 25.40

RIG: Truckmount CME-75									
	SPLIT SPOON	CASING	AUGERS	CORE BARREL	DATE	PROGRESS (FT)	WEATHER	WATER DEPTH (FT)	TIME
SIZE (DIAM.)	2" OD	6" ID	4¼" ID		4/9/95	40.0	Clear, 55°	6.0	8:30
LENGTH	24"	10.0'	5.0'		4/11/95	16.0	Cloudy, 50°		
TYPE	S.S.	3/16"	H.S.		4/20/95			7.75 msl	
HAMMER WT.	140				4/23/95			8.43 msl	
FALL	STD				8/21/95			7.07 msl	
STICK UP									

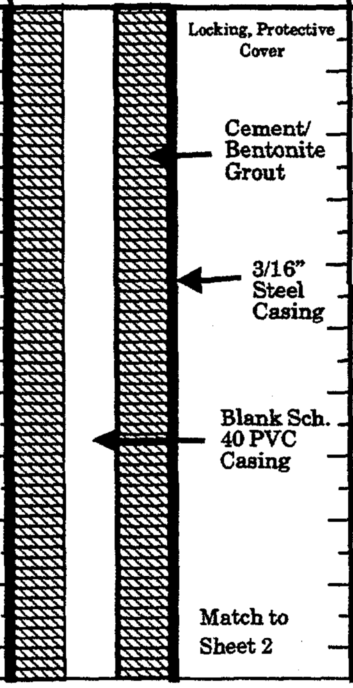
REMARKS: At 40.0', drilling methods were changed to fluid rotary methods.

SAMPLE TYPE
S = Split Spoon A = Auger
T = Shelby Tube W = Wash
R = Air Rotary C = Core
D = Denison P = Piston
N = No Sample

WELL INFORMATION	DIAM	TYPE	TOP DEPTH (FT)	BOTTOM DEPTH (FT)
Well Casing	2.0"	PVC Threaded		44.0
Well Screen	2.0"	PVC Slotted	44.0	54.0

Depth (Ft.)	Sample Type and No.	Samp. Rec. Ft. & %	SPT or RQD	HNu (ppm) Bkgrd	HNu (ppm) Point Source	Visual Description
1.0				0.2	0.3	(*Sample 65-DW02-00 collected) SAND, fine to very fine, trace SILT, light brown to tan, trace tree roots, damp, loose.
3.0	S-01	1.8 90%	3 3 5 6	0.2	0.2	SAND, fine to very fine, trace SILT, trace to little CLAY, light brown to tan, moist, medium dense to loose, some orange staining. (*Sample 65-DW02-02 collected)
5.0	S-02	2.0 100%	6 10 10 7	0.2	0.2	
7.0	S-03	2.0 100%	4 4 5 6	0.2	0.2	
9.0	S-04	2.0 100%	6 5 5 4	0.2	0.2	
11.0	S-05	2.0 100%	4 3 4 5	0.2	0.2	

Well Installation Detail



Depth (Ft.)	Elevation (msl)
1	22.5
2	21.5
3	20.5
4	19.5
5	18.5
6	17.5
7	16.5
8	15.5
9	14.5
10	13.5

DRILLING CO.: Parrott Wolff BAKER REP.: R.M. Lewis
DRILLER: Mark Eaves BORING NO.: 65-DW02 SHEET 1 OF 4

Baker

Baker Environmental, Inc.

TEST BORING AND WELL CONSTRUCTION RECORD

PROJECT: NAVY CLEAN SITE 65
S.O. NO.: 62470-312-0000-09000 BORING NO.: 65-DW02

SAMPLE TYPE

S = Split Spoon		A = Auger	
T = Shelby Tube		W = Wash	
R = Air Rotary		C = Core	
D = Denison		P = Piston	

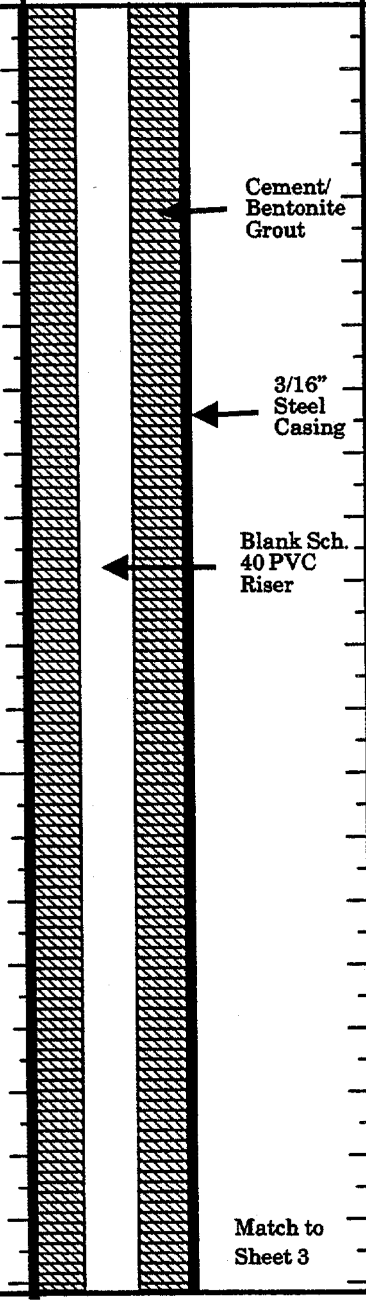
N = No Sample

DEFINITIONS

SPT = Standard Penetration Test (ASTM D-1586) (Blows/0.5')
RQD = Rock Quality Designation (%)
Lab Class. = USCS (ASTM D-2487) or AASHTO (ASTM D-3282)
Lab Moist. = Moisture Content (ASTM D-2216) Dry Weight Basis

Depth (Ft.)		Sample Type and No.	Samp. Rec. (Ft. & %)	SPT or RQD	HNu (ppm) Bkgrd	HNU (ppm) Point Source	Continued from Sheet 1	Elevation (msl)
11	11.0	S-06						12.5
12		S-07	2.0 100%	6 5 7 5	0.2	0.2	SAND, fine to very fine, trace SILT, gray stained orange, wet, medium dense to loose.	11.5
13	13.0							10.5
14								9.5
15	15.0							8.5
16		S-08	1.5 75%	3 2 3 2	0.2	0.2		7.5
17	17.0							6.5
18								5.5
19								4.5
20	20.0							3.5
21		S-09	2.0 100%	3 3 2 2	0.2	0.2		2.5
22	22.0						Trace wood fragments.	1.5
23		S-10	1.8 90%	2 4 7 7	0.2	0.2	SAND, fine to very fine, trace SILT, dark gray, wood fragments, wet, medium dense.	0.5
24	24.0							-0.5
25		S-11	1.75 85%	6 5 1 1	0.2	0.3	Some orange staining present.	-1.5
26	26.0							-2.5
27		S-12	1.75 85%	3 5 5 6	0.2	0.3		-3.5
28	28.0							-4.5
29		S-13	1.75 85%	3 3 9 9	0.2	0.2		-5.5
30	30.0							-6.5

Well Installation Detail



DRILLING CO.: Parrott Wolff
DRILLER: Mark Eaves

BAKER REP.: R.M. Lewis
BORING NO.: 65-DW02 SHEET 2 OF 4

Baker

Baker Environmental, Inc.

TEST BORING AND WELL CONSTRUCTION RECORD

PROJECT: NAVY CLEAN SITE 65

S.O. NO.: 62470-312-0000-09000 BORING NO.: 65-DW02

SAMPLE TYPE

S = Split Spoon	A = Auger
T = Shelby Tube	W = Wash
R = Air Rotary	C = Core
D = Denison	P = Piston

N = No Sample

DEFINITIONS

SPT = Standard Penetration Test (ASTM D-1586) (Blows/0.5')

RQD = Rock Quality Designation (%)

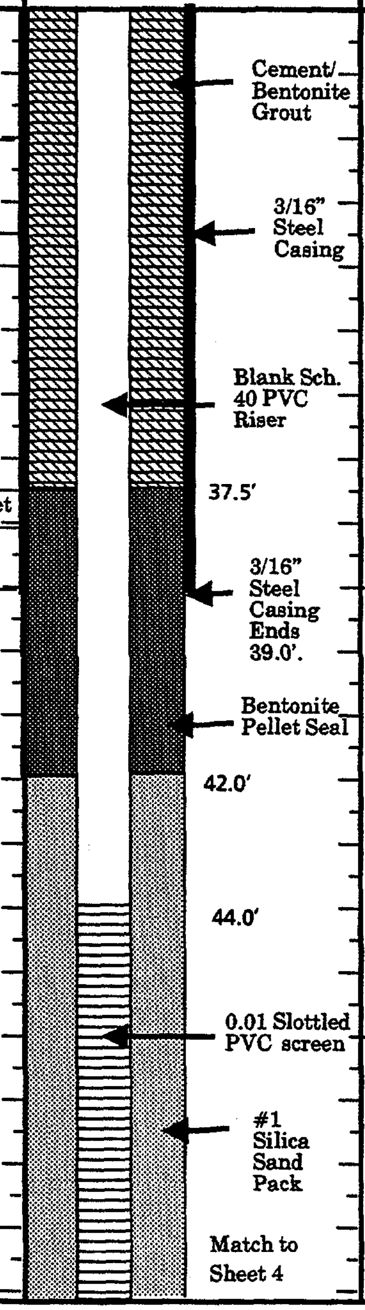
Lab Class. = USCS (ASTM D-2487) or AASHTO (ASTM D-3282)

Lab Moist. = Moisture Content (ASTM D-2216) Dry Weight Basis

Depth (Ft.)	Sample Type and No.	Samp. Rec. (Ft. & %)	SPT or RQD	HNu (ppm) Bkgrd	HNu (ppm) Point Source	Continued from Sheet 2
32.0	S-14	1.8 90%	7 5 3 3	0.2	0.2	SAND, fine to very fine, trace SILT, gray, wet, loose. CLAY in tip.
34.0	S-15	1.8 90%	3 3 5 3	0.2	0.2	SAND, fine to medium, trace SILT, gray, wet, 2" CLAY in tip, loose.
36.0	S-16	1.5 75%	3 3 4 3	0.1	0.1	SAND, fine to very fine, some CLAY, gray stained orange, moist, loose.
38.0	S-17	1.9 95%	2 2 3 3	0.1	0.1	SAND, fine to very fine, trace SILT, dark gray, wet
40.0	S-18	2.0 100%	4 5 9 10	0.2	0.2	SAND, fine to very fine, and CLAY, light brown to gray stained orange, wet. SAND, fine to medium gravel, calcarous cement, lots of shell fragments, gray green, wet.
44.0						
46.0	S-19	2.0 100%	12 8 17 17	0.0	0.0	
50.0	S-20	1.0 50%	20 19 17 19	0.1	0.1	

Depth (Ft.)	Elevation (msl)
31	-7.5
32	-8.5
33	-9.5
34	-10.5
35	-11.5
36	-12.5
37	-13.5
38	-14.5
39	-15.5
40	-16.5
41	-17.5
42	-18.5
43	-19.5
44	-20.5
45	-21.5
46	-22.5
47	-23.5
48	-24.5
49	-25.5
50	-26.5

Well Installation Detail



DRILLING CO.: Parrott Wolffe

DRILLER: Mark Eaves

BAKER REP.: R.M. Lewis

BORING NO.: 65-DW02

SHEET 3 OF 4

TEST BORING AND WELL CONSTRUCTION RECORD

Baker Environmental, Inc.

PROJECT: NAVY CLEAN SITE 65
S.O. NO.: 62470-312-0000-09000 BORING NO.: 65-DW02

SAMPLE TYPE

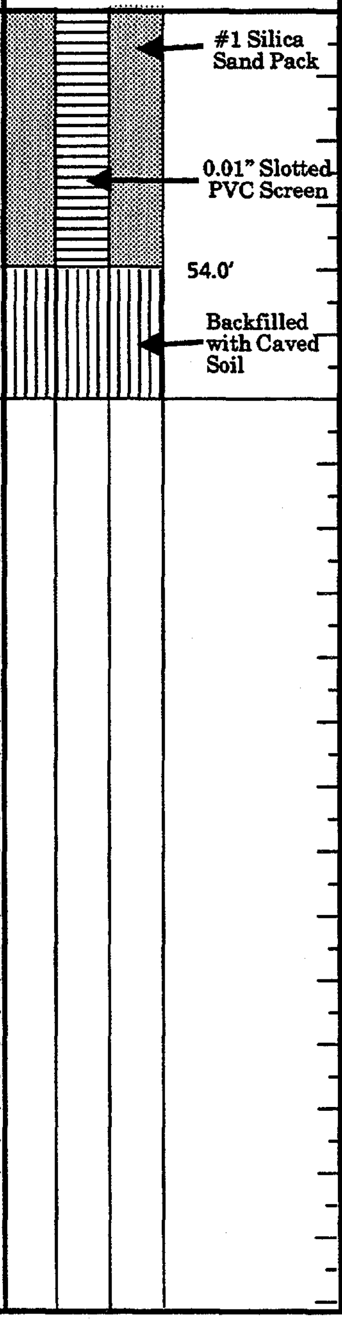
S = Split Spoon
T = Shelby Tube
R = Air Rotary
D = Denison
A = Auger
W = Wash
C = Core
P = Piston
N = No Sample

DEFINITIONS

SPT = Standard Penetration Test (ASTM D-1586) (Blows/0.5')
RQD = Rock Quality Designation (%)
Lab Class. = USCS (ASTM D-2487) or AASHTO (ASTM D-3282)
Lab Moist. = Moisture Content (ASTM D-2216) Dry Weight Basis

Depth (Ft.)		Sample Type and No.	Samp. Rec. (Ft. & %)	SPT or RQD	HNu (ppm) Bkgrd	HNu (ppm) Point Source	Continued from Sheet 3	Elevation (msl)
51	51.0							-27.5
52							SAND, fine to medium gravel, calcarous cement, lots of shell fragments, gray green, wet, very dense.	-28.5
53								-29.5
54	54.0							-30.5
55		S-21	1.5 75%	30 36 25 22	0.1	0.1		-31.5
56	56.0						End of Boring at 56.0'.	-32.5
57								-33.5
58								-34.5
59								-35.5
60								-36.5
61								-37.5
62								-38.5
63								-39.5
64								-40.5
65								-41.5
66								-42.5
67								-43.5
68								-44.5
69								-45.5
70								-46.5

Well Installation Detail



DRILLING CO.: Parrott Wolffe
DRILLER: Mark Eaves
BAKER REP.: R.M. Lewis
BORING NO.: 65-DW02
SHEET 4 OF 4

Baker

Baker Environmental, Inc.

TEST BORING AND WELL CONSTRUCTION RECORD

PROJECT: NAVY CLEAN SITE 65
S.O. NO.: 62470-312-0000-09000
BORING NO.: 65-DW04
COORDINATES: EAST: 2496564.35
NORTH: 307503.91
ELEVATION: SURFACE 42.43
TOP OF CASING: 44.49

RIG: Truckmount CME-75

	SPLIT SPOON	CASING	AUGERS	CORE BARREL	DATE	PROGRESS (FT)	WEATHER	WATER DEPTH (FT)	TIME
SIZE (DIAM.)	2" OD	6" ID	4¼" ID		4/5/95	31	Windy, 75°	10.5	15:00
LENGTH	24"	10.0'	5.0'		4/6/95	24	Overcast, 55°		
TYPE	S.S.	3/16"	H.S.		4/7/95	15	Clear, 75°		
HAMMER WT.	140				4/20/95			10.39 msl	
FALL	STD				4/23/95			11.21 msl	
STICK UP					8/21/95			9.67 msl	

REMARKS: At 31.0', drilling methods were changed to fluid rotary methods.

SAMPLE TYPE

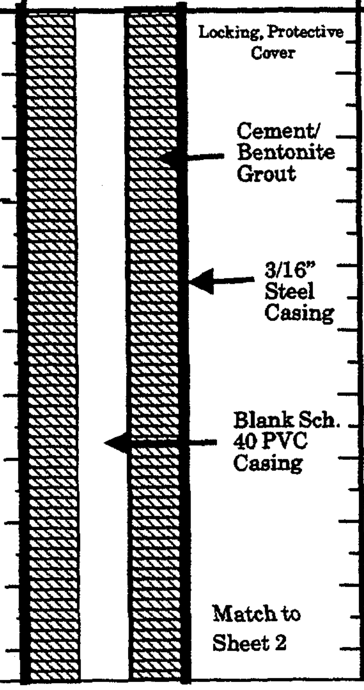
S = Split Spoon	A = Auger
T = Shelby Tube	W = Wash
R = Air Rotary	C = Core
D = Denison	P = Piston

N = No Sample

WELL INFORMATION	DIAM	TYPE	TOP DEPTH (FT)	BOTTOM DEPTH (FT)
Well Casing	2.0"	PVC Threaded	-2.06	58.0
Well Screen	2.0"	PVC Slotted	58.0	68.0

Depth (Ft.)	Sample Type and No.	Samp. Rec. Ft. & %	SPT or RQD	HNu (ppm) Bkgrd	HNu (ppm) Point Source	Visual Description
1.0	NA			1.0	1.1	(*Sample 65-DW04-00 collected) SAND, fine to very fine, trace SILT, trace ORGANICS, black to gray to brown, damp to dry, loose.
3.0	S-01	1.7 85%	2 3 3 3	1.0	1.1	
5.0	S-02	1.5 75%	3 5 3 4	1.0	1.0	SAND, fine to very fine, trace SILT, light brown to gray, damp, loose.
7.0	S-03	2.0 100%	5 3 3 3	1.1	1.1	
9.0	S-04	1.7 85%	3 3 4 5	1.1	1.1	
10.5	S-05	1.7 85%	6 5 3 3	1.1	1.1	(*Sample 65-DW04-05 collected) -Wet at 10.5 feet.

Well Installation Detail



Depth (Ft.)	Elevation (msl)
1	41.4
2	40.4
3	39.4
4	38.4
5	37.4
6	36.4
7	35.4
8	34.4
9	33.4
10	32.4

DRILLING CO.: Parrott Wolff
BAKER REP.: R.M. Lewis
DRILLER: Mark Eaves
BORING NO.: 65-DW04
SHEET 1 OF 4

Baker

Baker Environmental, Inc.

TEST BORING AND WELL CONSTRUCTION RECORD

PROJECT: NAVY CLEAN SITE 65
S.O. NO.: 62470-312-0000-09000 BORING NO.: 65-DW04

SAMPLE TYPE

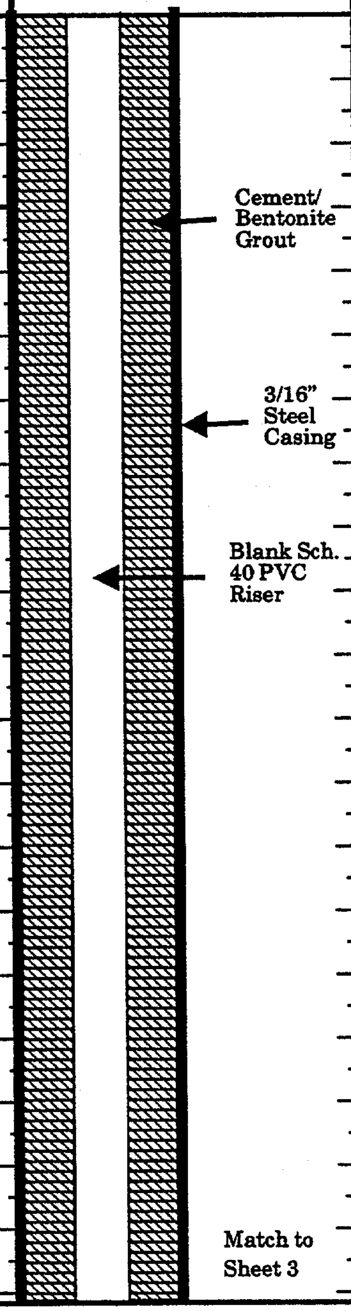
- S = Split Spoon
- T = Shelby Tube
- R = Air Rotary
- D = Denison
- A = Auger
- W = Wash
- C = Core
- P = Piston
- N = No Sample

DEFINITIONS

SPT = Standard Penetration Test (ASTM D-1586) (Blows/0.5')
RQD = Rock Quality Designation (%)
Lab Class. = USCS (ASTM D-2487) or AASHTO (ASTM D-3282)
Lab Moist. = Moisture Content (ASTM D-2216) Dry Weight Basis

Depth (Ft.)	Sample Type and No.	Samp. Rec. (Ft. & %)	SPT or RQD	HNu (ppm) Bkgrd	HNU (ppm) Point Source	Continued from Sheet 1
11.0	S-05					
13.0	S-06	1.8 90%	6 6 5 4	0.9	0.9	SAND, fine to very fine, and CLAY, trace SILT, gray, damp, medium dense.
15.0	S-07	1.5 75%	3 6 8 11	0.8	0.8	SAND, fine to very fine, trace SILT, gray, moist to wet, medium dense. SAND, fine to very fine, and CLAY, gray, damp to moist, medium dense.
17.0	S-08	2.0 100%	10 12 16 19	0.8	0.8	SAND, fine to very fine, trace SILT, gray to light brown, wet, some staining.
19.0	S-09	2.0 100%	8 12 16 22	0.8	0.8	
21.0	S-10	1.0 50%	29 33 40 46	0.8	0.8	24" color change to light gray to white.
23.0	S-11	2.0 100%	49 42 33 21	0.8	0.8	
25.0	S-12	2.0 100%	4 8 12 17	1.0	1.1	
27.0	S-13	1.7 85%	5 6 8 8	0.8	0.8	SAND, fine to very fine, trace SILT, gray to dark brown, wet, medium dense to dense.
29.0	S-14	2.0 100%	14 22 22 24	0.8	0.8	
30.0	S-15	1.0 50%	15 10 11 19	0.8	0.8	

Well Installation Detail



Match to Sheet 3

Depth (Ft.)	Elevation (msl)
11	31.4
12	30.4
13	29.4
14	28.4
15	27.4
16	26.4
17	25.4
18	24.4
19	23.4
20	22.4
21	21.4
22	20.4
23	19.4
24	18.4
25	17.4
26	16.4
27	15.4
28	14.4
29	13.4
30	12.4

DRILLING CO.: Parrott Wolff
DRILLER: Mark Eaves
BAKER REP.: R.M. Lewis
BORING NO.: 65-DW04 SHEET 2 OF 4

Baker
Baker Environmental, Inc

TEST BORING AND WELL CONSTRUCTION RECORD

PROJECT: NAVY CLEAN SITE 65
S.O. NO.: 62470-312-0000-09000 BORING NO.: 65-DW04

SAMPLE TYPE

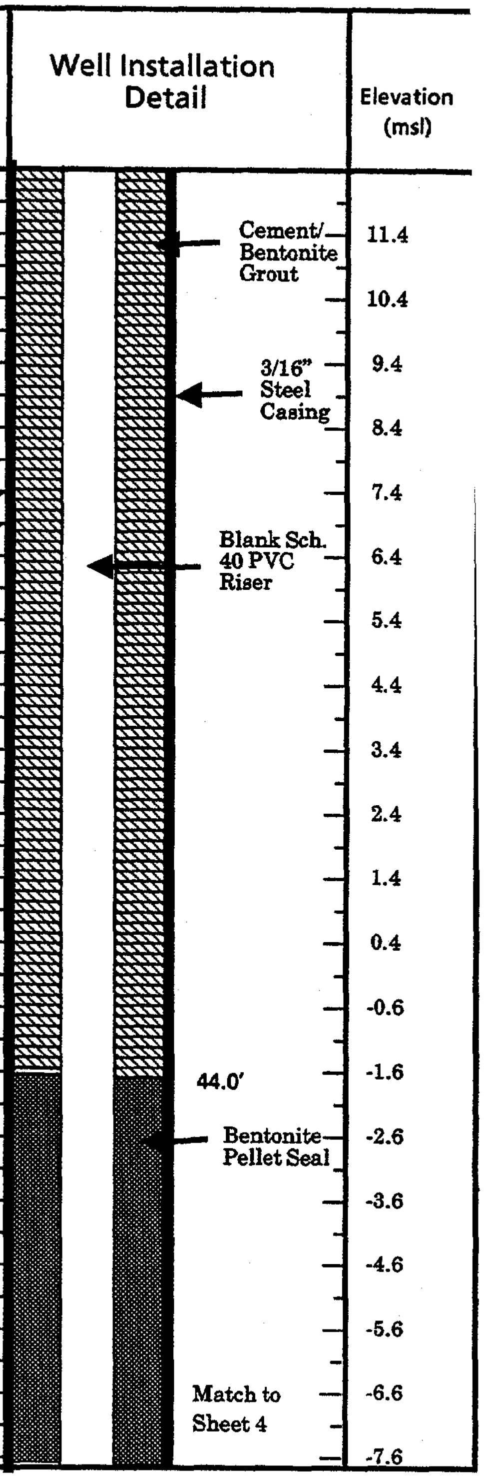
S = Split Spoon	**A** = Auger		
T = Shelby Tube	**W** = Wash		
R = Air Rotary	**C** = Core		
D = Denison	**P** = Piston		

N = No Sample

DEFINITIONS

SPT = Standard Penetration Test (ASTM D-1586) (Blows/0.5')
RQD = Rock Quality Designation (%)
Lab Class. = USCS (ASTM D-2487) or AASHTO (ASTM D-3282)
Lab Moist. = Moisture Content (ASTM D-2216) Dry Weight Basis

Depth (Ft.)	Sample Type and No.	Samp. Rec. (Ft. & %)	SPT or RQD	HNu (ppm) Bkgrd	HNu (ppm) Point Source	Continued from Sheet 2
31.0	S-15					
33.0	S-16	1.9 95%	2 3 3 4	0.6	0.6	CLAY, gray to black, moist, soft.
35.0	S-17	1.9 95%	15 7 9 10	0.6	0.6	SAND, fine to very fine, trace SILT, gray to reddish brown, wet. SAND, fine to very fine, some CLAY, some SILT, black, wet.
37.0	S-18	2.0 100%	3 1 2 2	0.5	0.5	CLAY, black, wet. SAND, fine to very fine, trace SILT, trace CLAY, gray to dark brown, wet.
39.0	S-19	2.0 100%	5 3 7 5	0.5	0.5	
41.0	S-20	2.0 100%	5 7 12 16	0.3	0.3	CLAY, black, dry.
43.0	S-21	2.0 100%	12 14 30 21	0.4	0.4	SAND, fine to very fine, trace SILT, greenish gray, wet, very dense to medium dense.
45.0	S-22	1.0 50%	9 9 12 9	0.4	0.4	
47.0	S-23	2.0 100%	2 1 2 1	0.4	0.4	SAND, fine to very fine, and CLAY, greenish gray, moist.
49.0	S-24	2.0 100%	WOH WOH 1 1	0.4	0.4	
50.0	S-25	2.0 100%	2 2 1 2	0.4	0.4	



DRILLING CO.: Parrott Wolffe
DRILLER: Mark Eaves

BAKER REP.: R.M. Lewis
BORING NO.: 65-DW04 SHEET 3 OF 4

Baker

Baker Environmental, Inc.

TEST BORING AND WELL CONSTRUCTION RECORD

PROJECT: NAVY CLEAN SITE 65
S.O. NO.: 62470-312-0000-09000 BORING NO.: 65-DW04

SAMPLE TYPE

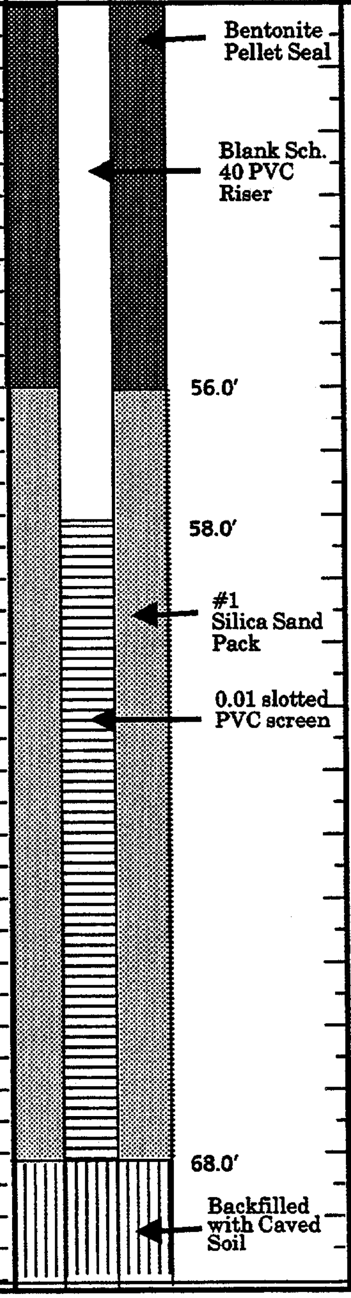
S = Split Spoon
T = Shelby Tube
R = Air Rotary
D = Denison
A = Auger
W = Wash
C = Core
P = Piston
N = No Sample

DEFINITIONS

SPT = Standard Penetration Test (ASTM D-1586) (Blows/0.5')
RQD = Rock Quality Designation (%)
Lab Class. = USCS (ASTM D-2487) or AASHTO (ASTM D-3282)
Lab Moist. = Moisture Content (ASTM D-2216) Dry Weight Basis

Depth (Ft.)	Sample Type and No.	Samp. Rec. (Ft. & %)	SPT or RQD	HNu (ppm) Bkgrd	HNu (ppm) Point Source	Continued from Sheet 3
51.0 53.0	S-26	2.0 100%	WOH 1 1 WOH	0.4	0.4	SAND, fine and very fine, and CLAY, dark green, moist to wet, very loose.
53.0 55.0	S-27	1.7 100%	12 14 15 18	0.4	0.4	SAND, fine to very fine, trace SILT, gray green, lots of shell fragments, moist, medium dense.
55.0 60.0						
60.0 62.0	S-28	1.0 50%	30 36 30 20	0.2	0.2	SAND, coarse to medium grained, some gravels, calcarous cement, lots of shell fragments, gray to grayish green, wet, very dense.
62.0 68.0						
68.0 70.0	S-29	1.0 50%	24 22 20 15	0.2	0.3	End of Boring at 70.0'.

Well Installation Detail



Depth (Ft.)	Elevation (msl)
51	-8.6
52	-9.6
53	-10.6
54	-11.6
55	-12.6
56	-13.6
57	-14.6
58	-15.6
59	-16.6
60	-17.6
61	-18.6
62	-19.6
63	-20.6
64	-21.6
65	-22.6
66	-23.6
67	-24.6
68	-25.6
69	-26.6
70	-27.6

DRILLING CO.: Parrott Wolffe
DRILLER: Mark Eaves
BAKER REP.: R.M. Lewis
BORING NO.: 65-DW04
SHEET 4 OF 4

Baker Environmental, Inc.

TEST BORING AND WELL CONSTRUCTION RECORD

PROJECT: NAVY CLEAN SITE 65
S.O. NO.: 62470-312-0000-09000 BORING NO.: 65-MW04
COORDINATES: EAST: 2496564.78 NORTH: 307498.29
ELEVATION: SURFACE 42.90 TOP OF CASING: 44.84

RIG: Truckmount CME-75

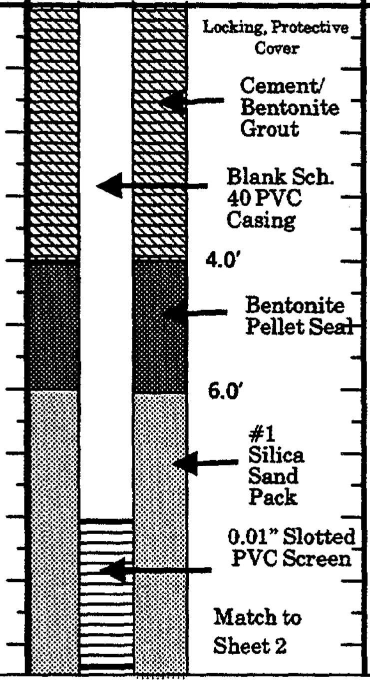
	SPLIT SPOON	CASING	AUGERS	CORE BARREL	DATE	PROGRESS (FT)	WEATHER	WATER DEPTH (FT)	TIME
SIZE (DIAM.)			6¼ ID		4/7/95	23.0	Clear, 55°	10.5	08:00
LENGTH			5.0'		4/20/95			29.40 msl	
TYPE			H.S.		4/23/95			30.30 msl	
HAMMER WT.					8/21/95			28.09 msl	
FALL									
STICK UP									

REMARKS:

SAMPLE TYPE
S = Split Spoon A = Auger
T = Shelby Tube W = Wash
R = Air Rotary C = Core
D = Denison P = Piston
N = No Sample

WELL INFORMATION	DIAM	TYPE	TOP DEPTH (FT)	BOTTOM DEPTH (FT)
Well Casing	2.0"	PVC Threaded	-1.94	8.0
Well Screen	2.0"	PVC Slotted	8.0	23.0

Depth (Ft.)	Sample Type and No.	Samp. Rec. Ft. & %	SPT or RQD	HNu (ppm) Bkgrd	HNu (ppm) Point Source	Visual Description	Well Installation Detail	Elevation (msl)
						(*See test boring record for 65-DW04.)		
1								41.9
2								40.9
3								39.9
4								38.9
5								37.9
6								36.9
7								35.9
8								34.9
9								33.9
10								32.9



DRILLING CO.: Parrott Wolff BAKER REP.: R.M. Lewis
DRILLER: Mark Eaves BORING NO.: 65-MW04 SHEET 1 OF 2

Baker

Baker Environmental, Inc.

TEST BORING AND WELL CONSTRUCTION RECORD

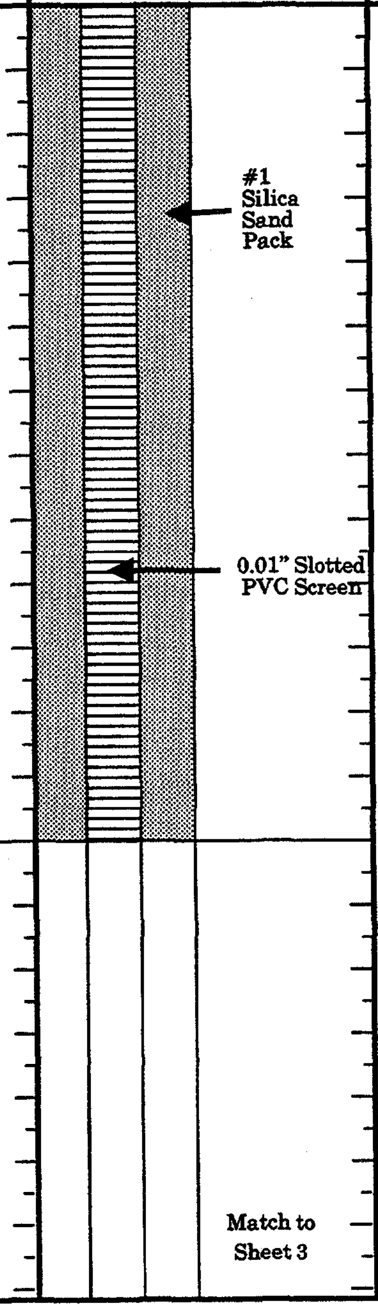
PROJECT: NAVY CLEAN SITE 65
S.O. NO.: 62470-312-0000-09000 BORING NO.: 65-MW04

SAMPLE TYPE

S = Split Spoon
T = Shelby Tube
R = Air Rotary
D = Denison
A = Auger
W = Wash
C = Core
P = Piston
N = No Sample

DEFINITIONS

SPT = Standard Penetration Test (ASTM D-1586) (Blows/0.5')
RQD = Rock Quality Designation (%)
Lab Class. = USCS (ASTM D-2487) or AASHTO (ASTM D-3282)
Lab Moist. = Moisture Content (ASTM D-2216) Dry Weight Basis

Depth (Ft.)	Sample Type and No.	Samp. Rec. (Ft. & %)	SPT or RQD	HNu (ppm) Bkgrd	HNU (ppm) Point Source	Continued from Sheet 1	Well Installation Detail	Elevation (msl)
11								31.9
12								30.9
13								29.9
14								28.9
15								27.9
16								26.9
17								25.9
18								24.9
19								23.9
20								22.9
21								21.9
22								20.9
23								19.9
24						End of Boring at 23.0'.		18.9
25								17.9
26								16.9
27								15.9
28								14.9
29								13.9
30								12.9

DRILLING CO.: Parrott Wolff
DRILLER: Mark Eaves
BAKER REP.: R.M. Lewis
BORING NO.: 65-MW04
SHEET 2 OF 2

Baker

Baker Environmental, Inc

TEST BORING AND WELL CONSTRUCTION RECOR

PROJECT: NAVY CLEAN SITE 65
S.O. NO.: 62470-312-0000-09000 BORING NO.: 65-MW05
COORDINATES: EAST: 2494774.11 NORTH: 306968.44
ELEVATION: SURFACE 28.00 TOP OF CASING: 30.28

RIG: Truckmount CME-75									
	SPLIT SPOON	CASING	AUGERS	CORE BARREL	DATE	PROGRESS (FT)	WEATHER	WATER DEPTH (FT)	TIME
SIZE (DIAM.)	2" OD		4¼" ID		4/5/95	23.0	Windy, 60°	9.0	09:20
LENGTH	24"		5.0'			4/20/94		18.58 msl	
TYPE	S.S.		H.S.			4/23/95		19.46 msl	
HAMMER WT.	140					8/21/95		17.99 msl	
FALL	STD								
STICK UP									

REMARKS: Borehole reamed with 6¼" ID augers before well completion.

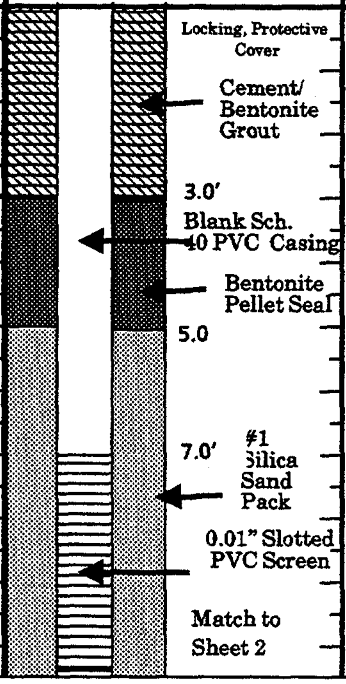
SAMPLE TYPE

S = Split Spoon A = Auger
T = Shelby Tube W = Wash
R = Air Rotary C = Core
D = Denison P = Piston
N = No Sample

WELL INFORMATION	DIAM	TYPE	TOP DEPTH (FT)	BOTTOM DEPTH (FT)
Well Casing	2.0"	PVC Threaded	-2.28	7.0
Well Screen	2.0"	PVC Slotted	7.0	22.0

Depth (Ft.)	Sample Type and No.	Samp. Rec. Ft. & %	SPT or RQD	HNu (ppm) Bkgrd	HNu (ppm) Point Source	Visual Description	Elevation (msl)
1 1.0	NA			1.0	1.0	(*Sample 65-MW05A-00 collected)	27.0
2 3 3.0	S-01	1.0 50%	2 3 3 4	1.4	1.4	SAND, fine to very fine, some SILT, some ORGANICS, light brown to brown, damp, loose.	26.0 25.0
4 5 5.0	S-02	1.7 85%	4 5 12 14	1.1	1.1	CLAY, some SILT, some fine to very fine, SAND, light brown mottled gray to red, damp, medium dense.	24.0 23.0
6 7 7.0	S-03	1.5 75%	3 5 11 10	1.1	1.1	SAND, fine to very fine, trace SILT, light brown to gray, moist, medium dense.	22.0 21.0
8 9 9.0	S-04	1.7 85%	10 12 17 17	1.1	1.1	(*Sample 65-MW05A-04 collected)	20.0 19.0
10 10.5	S-05	1.7 85%	9 12 14 14	1.0	1.0	SAND, fine to very fine, trace SILT, light brown, stained yellow to tan, wet at 9.0', medium dense.	18.0

Well Installation Detail



DRILLING CO.: Parrott Wolff BAKER REP.: R.M. Lewis
DRILLER: Mark Eaves BORING NO.: 65-MW05 SHEET 1 OF 2

Baker
Baker Environmental, Inc.

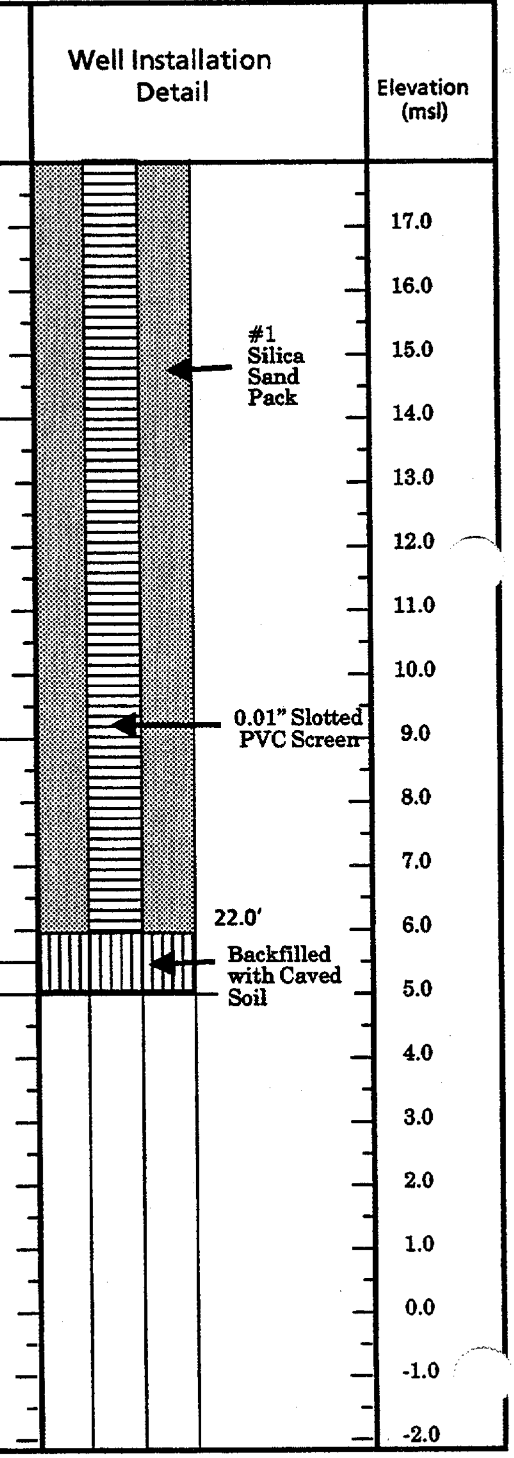
TEST BORING AND WELL CONSTRUCTION RECORD

PROJECT: NAVY CLEAN SITE 65
S.O. NO.: 62470-312-0000-09000
BORING NO.: 65-MW05

SAMPLE TYPE
S = Split Spoon
T = Shelby Tube
R = Air Rotary
D = Denison
A = Auger
W = Wash
C = Core
P = Piston
N = No Sample

DEFINITIONS
SPT = Standard Penetration Test (ASTM D-1586) (Blows/0.5')
RQD = Rock Quality Designation (%)
Lab Class. = USCS (ASTM D-2487) or AASHTO (ASTM D-3282)
Lab Moist. = Moisture Content (ASTM D-2216) Dry Weight Basis

Depth (Ft.)	Sample Type and No.	Samp. Rec. (Ft. & %)	SPT or RQD	HNu (ppm) Bkgrd	HNU (ppm) Point Source	Continued from Sheet 1
11.0	S-05					
14.0 16.0	S-06	1.2 60%	5 3 3 4	1.0	1.0	SAND, fine to very fine, some SILT, light brown stained yellow to tan, wet, loose.
19.0 21.0	S-07	1.0 50%	8 7 7 8	1.0	1.0	SAND, fine to medium, little SILT, light brown stained yellow to tan, wet, medium dense.
21.0 23.0	S-08	1.9 95%	8 6 7 6	1.0	1.0	Color change to orange.
						End of Boring at 23.0'.



DRILLING CO.: Parrott Wolff
DRILLER: Mark Eaves
BAKER REP.: R.M. Lewis
BORING NO.: 65-MW05
SHEET 2 OF 2

Baker
Baker Environmental, Inc.

TEST BORING AND WELL CONSTRUCTION RECORD

PROJECT: NAVY CLEAN SITE 65
S.O. NO.: 62470-312-0000-09000 BORING NO.: 65-MW06
COORDINATES: EAST: 2496052.20 NORTH: 307201.04
ELEVATION: SURFACE 32.55 TOP OF CASING: 34.71

RIG: Truckmount CME-75									
	SPLIT SPOON	CASING	AUGERS	CORE BARREL	DATE	PROGRESS (FT)	WEATHER	WATER DEPTH (FT)	TIME
SIZE (DIAM.)	2" OD		4¼" ID		4/8/95	21.0	Foggy, 50°	7.5	08:45
LENGTH	24"		5.0'		4/20/95			25.38 msl	
TYPE	S.S.		H.S.		4/23/95			26.29 msl	
HAMMER WT.	140				8/21/95			24.37 msl	
FALL	STD								
STICK UP									

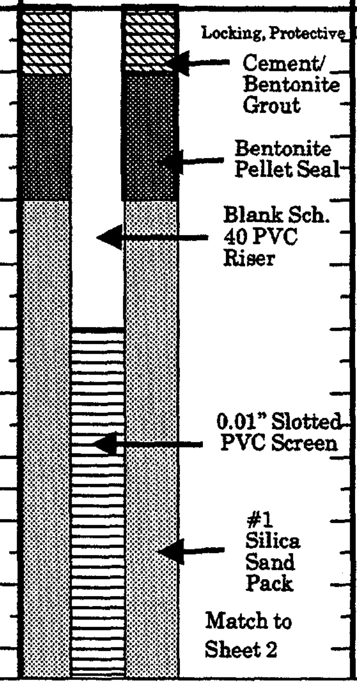
REMARKS: Borehole was reamed with 6¼" ID augers before well completion.

SAMPLE TYPE
S = Split Spoon A = Auger
T = Shelby Tube W = Wash
R = Air Rotary C = Core
D = Denison P = Piston
N = No Sample

WELL INFORMATION	DIAM	TYPE	TOP DEPTH (FT)	BOTTOM DEPTH (FT)
Well Casing	2.0"	PVC Threaded	-2.16	5.0
Well Screen	2.0"	PVC Slotted	5.0	20.0

Depth (Ft.)		Sample Type and No.	Samp. Rec. Ft. & %	SPT or RQD	HNu (ppm) Bkgrd	HNu (ppm) Point Source	Visual Description	Elevation (msl)
1	1.0				0.1	0.2	(*Sample 65-MW06A-00 collected)	31.6
2 3	3.0	S-01	2.0 100%	4 4 9 10	0.1	0.1	SAND, fine to very fine, trace SILT, light brown, moist to damp, medium dense.	30.6 29.6
4 5	5.0	S-02	2.0 100%	4 4 8 8	0.2	0.2	SAND, fine to very fine, trace SILT, dark gray to black, damp, loose to medium dense.	28.6 27.6
6 7	7.0	S-03	1.5 75%	5 4 3 5	0.2	0.2	(*Sample 65-MW06A-03 collected)	26.6 25.6
8 9	9.0	S-04	1.5 75%	4 4 4 4	0.2	0.2	SAND, fine to very fine, trace SILT, light gray, wet at 7.5', loose.	24.6 23.6
10								22.6

Well Installation Detail



DRILLING CO.: Parrott Wolff BAKER REP.: R.M. Lewis
DRILLER: Mark Eaves BORING NO.: 65-MW06 SHEET 1 OF 2

Baker

Baker Environmental, Inc.

TEST BORING AND WELL CONSTRUCTION RECORD

PROJECT: NAVY CLEAN SITE 65
S.O. NO.: 62470-312-0000-09000 BORING NO.: 65-MW06

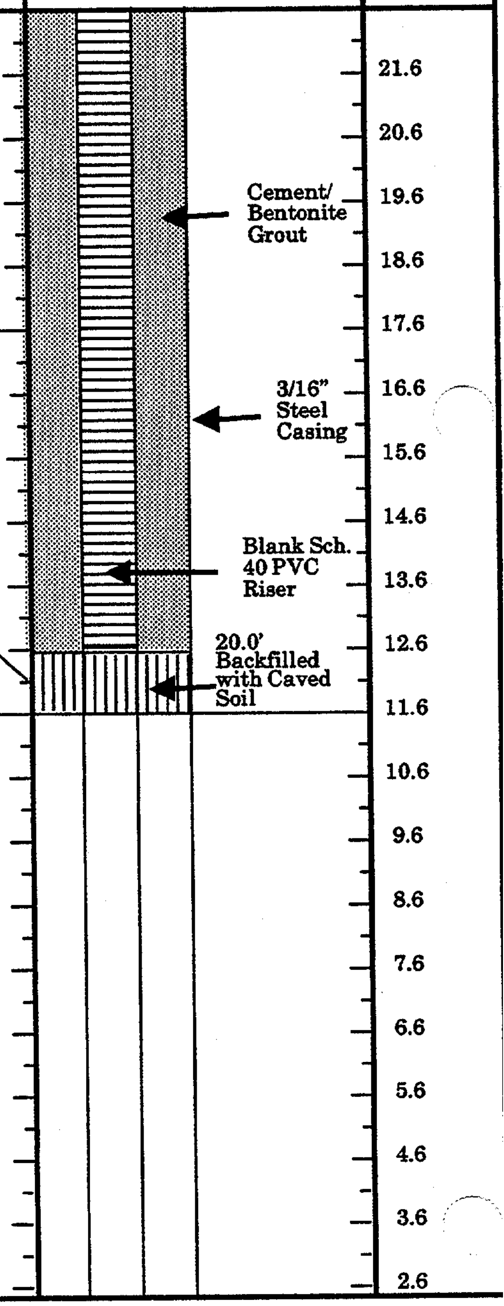
SAMPLE TYPE

S = Split Spoon
T = Shelby Tube
R = Air Rotary
D = Denison
A = Auger
W = Wash
C = Core
P = Piston
N = No Sample

DEFINITIONS

SPT = Standard Penetration Test (ASTM D-1586) (Blows/0.5')
RQD = Rock Quality Designation (%)
Lab Class. = USCS (ASTM D-2487) or AASHTO (ASTM D-3282)
Lab Moist. = Moisture Content (ASTM D-2216) Dry Weight Basis

Depth (Ft.)	Sample Type and No.	Samp. Rec. (Ft. & %)	SPT or RQD	HNu (ppm) Bkgrd	HNU (ppm) Point Source	Continued from Sheet 1
15.0 17.0	S-05	1.2 60%	3 5 14 12	0.2	0.2	SAND, fine to very fine, trace SILT, very dark brown to black, wet, medium dense.
19.0 21.0	S-06	2.0 100%	4 5 12 10	0.2	0.2	SAND, fine to very fine, and CLAY, gray green, moist, medium dense.
						End of Boring at 21.0'.



DRILLING CO.: Parrott Wolff
DRILLER: Mark Eaves
BAKER REP.: R.M. Lewis
BORING NO.: 65-MW06
SHEET 2 OF 2

Baker

Baker Environmental, Inc

TEST BORING AND WELL CONSTRUCTION RECORD

PROJECT: NAVY CLEAN SITE 65
S.O. NO.: 62470-312-0000-09000 BORING NO.: 65-MW07
COORDINATES: EAST: 2495281.52 NORTH: 307271.63
ELEVATION: SURFACE 34.47 TOP OF CASING: 36.74

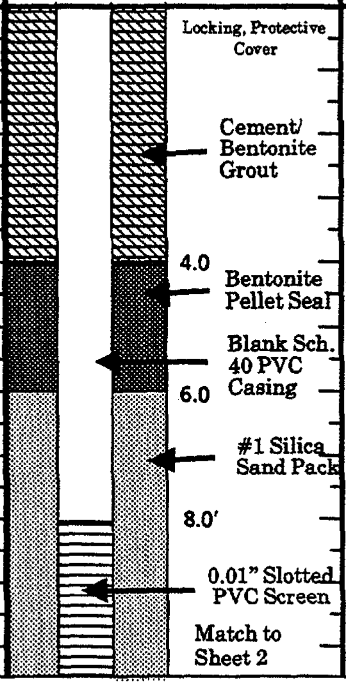
RIG: Truckmount CME-75									
	SPLIT SPOON	CASING	AUGERS	CORE BARREL	DATE	PROGRESS (FT)	WEATHER	WATER DEPTH (FT)	TIME
SIZE (DIAM.)	2" OD		4¼" ID		4/4/95	23.0	Clear, 75°	11.0	14:00
LENGTH	24"		5.0'		4/21/95			23.31 msl	
TYPE	S.S.		H.S.		4/23/95			24.36 msl	
HAMMER WT.	140				8/21/95			22.89 msl	
FALL	STD								
STICK UP									

REMARKS: Borehole reamed with 6½" ID augers before well completion.

SAMPLE TYPE

S = Split Spoon
T = Shelby Tube
R = Air Rotary
D = Denison
A = Auger
W = Wash
C = Core
P = Piston
N = No Sample

WELL INFORMATION	DIAM	TYPE	TOP DEPTH (FT)	BOTTOM DEPTH (FT)
Well Casing	2.0"	PVC Threaded	-2.27	8.0
Well Screen	2.0"	PVC Slotted	8.0	23.0

Depth (Ft.)	Sample Type and No.	Samp. Rec. Ft. & %	SPT or RQD	HNu (ppm) Bkgrd	HNu (ppm) Point Source	Visual Description	Well Installation Detail	Elevation (msl)
1 1.0	NA			3.4	1.9	(*Sample 65-MW07A-00 collected) SAND, fine to very fine, little SILT, gray to black, dry, loose.		33.5
2 3.0	S-01	1.2 60%	1 3 2 3	1.4	1.4	SAND, fine to very fine, trace SILT, light brown to brown, dry, loose.		32.5 31.5
3 4 5.0	S-02	1.5 75%	2 2 3 3	1.4	1.4	SAND, fine to very fine, trace SILT, trace CLAY, light brown, damp, loose.		30.5 29.5
5 6 7.0	S-03	1.0 50%	2 3 4 4	1.8	1.7	SAND, fine to very fine, trace SILT, 1" layer of black ORGANICS, brown to light brown, moist, loose.		28.5 27.5
7 8 9.0	S-04	2.0 100%	5 4 3 3	1.5	1.5	SAND, fine to very fine, trace SILT, trace CLAY, brown to light brown, moist, loose.		26.5 25.5
9 10 10.5	S-05	1.0 50%	3 3 3 4	1.3	1.4	SAND, fine to very fine, trace SILT, light brown to brown, moist, wet at 11.0', loose.		24.5

DRILLING CO.: Parrott Wolff BAKER REP.: R.M. Lewis
DRILLER: Mark Eaves BORING NO.: 65-MW07 SHEET 1 OF 2

Baker

Baker Environmental, Inc

TEST BORING AND WELL CONSTRUCTION RECORD

PROJECT: NAVY CLEAN SITE 65
S.O. NO.: 62470-312-0000-09000　BORING NO.: 65-MW07

SAMPLE TYPE

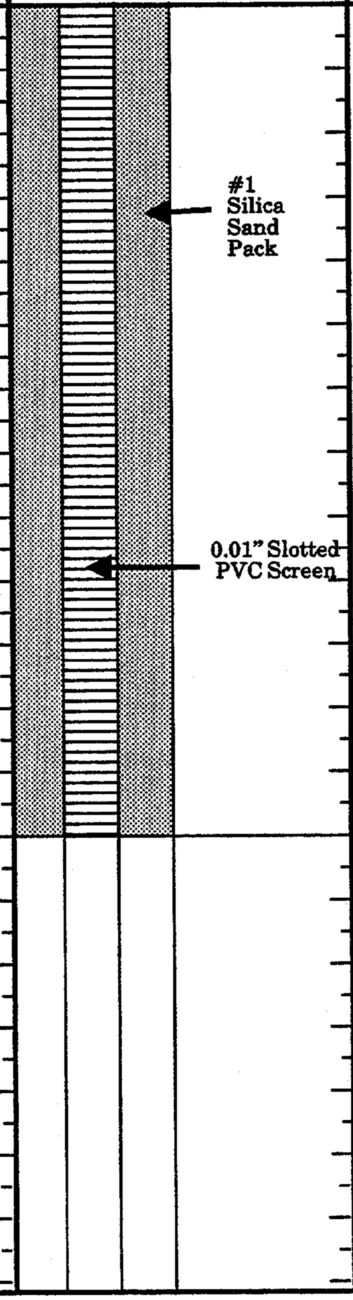
S = Split Spoon　A = Auger
T = Shelby Tube　W = Wash
R = Air Rotary　C = Core
D = Denison　P = Piston
N = No Sample

DEFINITIONS

SPT = Standard Penetration Test (ASTM D-1586) (Blows/0.5')
RQD = Rock Quality Designation (%)
Lab Class. = USCS (ASTM D-2487) or AASHTO (ASTM D-3282)
Lab Moist. = Moisture Content (ASTM D-2216) Dry Weight Basis

Depth (Ft.)	Sample Type and No.	Samp. Rec. (Ft. & %)	SPT or RQD	HNu (ppm) Bkgrd	HNU (ppm) Point Source	Continued from Sheet 1
11.0	S-05					(*Sample 65-MW07A-05 collected)
13.0	S-06	2.0 100%	6 6 5 9	1.3	1.3	SAND, fine, light brown stained yellow to tan, wet, medium dense to dense.
15.0	S-07	2.0 100%	9 11 14 17	1.2	1.2	
17.0	S-08	1.7 85%	14 17 19 17	1.3	1.5	
19.0	S-09	1.9 95%	10 7 9 7	1.3	1.3	
21.0	S-10	1.9 95%	12 14 12 15	1.1	1.1	- Trace tree roots.
23.0	S-11	2.0 100%	17 17 15 19	1.0	1.1	
						End of Boring at 23.0'.

Well Installation Detail



Depth (Ft.)	Elevation (msl)
11	23.5
12	22.5
13	21.5
14	20.5
15	19.5
16	18.5
17	17.5
18	16.5
19	15.5
20	14.5
21	13.5
22	12.5
23	11.5
24	10.5
25	9.5
26	8.5
27	7.5
28	6.5
29	5.5
30	4.5

DRILLING CO.: Parrott Wolff　BAKER REP.: R.M. Lewis
DRILLER: Mark Eaves　BORING NO.: 65-MW07　SHEET 2 OF 2

Baker

Baker Environmental, Inc

FIELD TEST BORING RECORD

PROJECT: NAVY CLEAN SITE 65
S.O. NO.: 62470-312-0000-09000 BORING NO.: 65-SB06
COORDINATES: EAST 2494852.50 NORTH: 307150.70
ELEVATION: SURFACE Not surveyed

RIG: Truckmount CME-75									
	SPLIT SPOON	CASING	AUGERS	CORE BARREL	DATE	PROGRESS (FT)	WEATHER	WATER DEPTH (FT)	TIME
SIZE (DIAM.)	2" OD		4¼" ID		4/10/95	7.0	Clear, 60°	5.0	16:40
LENGTH	24"		5.0'						
TYPE	S.S.		H.S.						
HAMMER WT.	140								
FALL	STD								
STICK UP									

REMARKS: HNu background = 0.1.

DRILL RECORD							VISUAL DESCRIPTION					
DEPTH	SOIL / *ROCK*	Sample ID —— Type - No. (N = No Samp.)	Samp. Rec. (Ft. and %)	SPT Blows Per 0.5' / *RQD (Ft. & %)*	HNu / *ppm*	Time	Gradation / *Classification*	Color / *Color*	Consist. or Density / *Hardness*	Moisture Content, Organic Content, Plasticity, and Other Observations / *Weathering, Bedding Fracturing, and Other Observations*	SOIL / *ROCK*	ELEVATION
1	1.0	NA			0.2		(*Sample 65-SB06-00 collected)	Light brown	Loose	Possible fill, damp.		
2	3.0	S-01	2.0 100%	2 2 4 4	0.1		SAND, fine to very fine, trace SILT.			Black streaks, damp.		
3												
4	5.0	S-02	1.0 50%	4 4 3 3	0.1		(*Sample 65-SB07-02 collected)			Moist.		
5										- Wet at 5.0'.		
6	7.0	S-03	0.2 10%	2 1 1 3	0.1							
7												
8							End of Boring at 7.0'.					
9												
10												

DRILLING CO. Parrott Wolff BAKER REP. R.M. Lewis
DRILLER Mark Eaves BORING NO. 65-SB06 Sheet 1 of 1

Baker

Baker Environmental, Inc.

FIELD TEST BORING RECORD

PROJECT: NAVY CLEAN SITE 65
S.O. NO.: 62470-312-0000-09000
BORING NO.: 65-SB07
COORDINATES: EAST 2494811.94
NORTH: 307091.49
ELEVATION: SURFACE Not surveyed

RIG: Truckmount CME-75

	SPLIT SPOON	CASING	AUGERS	CORE BARREL	DATE	PROGRESS (FT)	WEATHER	WATER DEPTH (FT)	TIME
SIZE (DIAM.)	2" OD		4¼" ID		4/8/95	9.0	Clear, 60°	7.5	15:40
LENGTH	24"		5.0'						
TYPE	S.S.		H.S.						
HAMMER WT.	140								
FALL	STD								
STICK UP									

REMARKS: HNu background = 0.1.

DRILL RECORD							VISUAL DESCRIPTION					
DEPTH	SOIL ROCK	Sample ID Type - No. (N = No Samp.)	Samp. Rec. (Ft. and %)	SPT Blows Per 0.5' RQD (Ft. & %)	HNu ppm	Time	Gradation Classification	Color Color	Consist. or Density Hardness	Moisture Content, Organic Content, Plasticity, and Other Observations Weathering, Bedding Fracturing, and Other Observations	SOIL ROCK	ELEVATION
1	1.0				0.1		(*Sample 65-SB07-00 collected) SAND, fine to very fine, trace SILT.	Light brown to brown	Loose	Damp.		
2 3	3.0	S-01	1.8 90%	5 4 4 5	0.1					Little tree roots.		
4 5	5.0	S-02	2.0 100%	5 7 5 6	0.1		SAND, fine to very fine, little CLAY.	Light brown to orange	Medium Dense	Damp, some mottling.		
6 7	7.0	S-03	2.0 100%	4 6 6 7	0.2		(*Sample 65-SB07-03 collected)			Moist.		
8 9	9.0	S-04	2.0 100%	5 6 7 7	0.1		SAND, fine to very fine, trace SILT.	Gray	Medium Dense	Wet at 7.5'.		
10							End of Boring at 9.0'.					

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BAKER REP. R.M. Lewis
DRILLER Mark Eaves
BORING NO. 65-SB07
Sheet 1 of 1

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Baker Environmental, Inc.

FIELD TEST BORING RECORD

PROJECT: NAVY CLEAN SITE 65
S.O. NO.: 62470-312-0000-09000 BORING NO.: 65-SB08
COORDINATES: EAST 2494765.10 NORTH: 307111.32
ELEVATION: SURFACE Not surveyed

RIG: Truckmount CME-75									
	SPLIT SPOON	CASING	AUGERS	CORE BARREL	DATE	PROGRESS (FT)	WEATHER	WATER DEPTH (FT)	TIME
SIZE (DIAM.)	2" OD		4¼" ID		4/10/95	13.0	Clear, 60°	11.0	8:00
LENGTH	24"		5.0'						
TYPE	S.S.		H.S.						
HAMMER WT.	140								
FALL	STD								
STICK UP									

REMARKS: HNu background = 0.1.

DRILL RECORD							VISUAL DESCRIPTION					
DEPTH	SOIL ROCK	Sample ID Type - No. (N = No Samp.)	Samp. Rec. (Ft. and %)	SPT Blows Per 0.5' RQD (Ft. & %)	HNu ppm	Time	Gradation Classification	Color Color	Consist. or Density Hardness	Moisture Content, Organic Content, Plasticity, and Other Observations Weathering, Bedding Fracturing, and Other Observations	SOIL ROCK	ELEVATION
1	1.0						(*Sample 65-SB08-00 collected) SAND, fine to very fine, trace SILT.	Dark gray		Damp.		
2 3	3.0	S-01	2.0 100%	2 2 3 3	0.1			Light brown	Loose			
4 5	5.0	S-02	2.0 100%	4 3 4 5	0.1		SAND, fine to very fine, some CLAY.	Brown				
6 7	7.0	S-03	2.0 100%	10 8 8 7	0.1			Gray	Medium Dense	Stained orange.		
8 9	9.0	S-04	2.0 100%	10 8 7 8	0.1		SAND, fine to very fine, and CLAY. (*Sample 65-SB08-04 collected)			Moist.		
10	11.0	S-05	1.8 90%	9 8 9 10	0.1		SAND, fine to very fine, trace CLAY.					

DRILLING CO. Parrott Wolff
DRILLER Mark Eaves
BAKER REP. R.M. Lewis
BORING NO. 65-SB08

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Baker Environmental, Inc.

FIELD TEST BORING RECORD

PROJECT: NAVY CLEAN SITE 65

S.O NO.: 62470-312-0000-09000 BORING NO: 65-SB08

DRILL RECORD							VISUAL DESCRIPTION					
DEPTH	SOIL / *ROCK*	Sample ID ----- Type - No. (N = No Samp.)	Samp. Rec. (Ft. and %)	SPT Blows Per 0.5' / *RQD (Ft. & %)*	HNu / *ppm*	*Time*	Classification (Grain Size, Principal Constituents, Etc.) / *Classification (Name, Grain Size, Principal Constituents, Etc.)*	Color / *Color*	Consist. or Density / *Hardness*	Moisture Content, Organic Content, Plasticity, and Other Observations / *Weathering, Bedding Fracturing, and Other Observations*	SOIL / *ROCK*	ELEVATION
11	11.0											
12		S-06	2.0	10 9			SAND, fine to very fine, trace SILT.	Gray	Medium Dense	Wet at 11.0'. Stained orange.		
13	13.0		100%	10 12	0.1							
14							End of Boring at 13.0'.					
15												
16												
17												
18												
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30												

DRILLING CO. Parrott Wolff

BAKER REP. R.M. Lewis

DRILLER Mark Eaves

BORING NO. 65-SB08 Sheet 2 of 2

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FIELD TEST BORING RECORD

PROJECT: NAVY CLEAN SITE 65
S.O. NO.: 62470-312-0000-09000
BORING NO.: 65-SB09
COORDINATES: EAST 2495465.18
NORTH: 307575.47
ELEVATION: SURFACE Not surveyed

RIG: Truckmount CME-75									
	SPLIT SPOON	CASING	AUGERS	CORE BARREL	DATE	PROGRESS (FT)	WEATHER	WATER DEPTH (FT)	TIME
SIZE (DIAM.)	2" OD		4¼" ID		4/8/95	7.0	Clear, 60°	6.0	14:30
LENGTH	24"		5.0'						
TYPE	S.S.		H.S.						
HAMMER WT.	140								
FALL	STD								
STICK UP									

REMARKS: HNu background = 0.1.

DRILL RECORD							VISUAL DESCRIPTION					
DEPTH	SOIL / *ROCK*	Sample ID ----- Type - No. (N = No Samp.)	Samp. Rec. (Ft. and %)	SPT Blows Per 0.5' / *RQD (Ft. & %)*	HNu / *ppm*	Time	Gradation / *Classification*	Color / *Color*	Consist. or Density / *Hardness*	Moisture Content, Organic Content, Plasticity, and Other Observations / *Weathering, Bedding Fracturing, and Other Observations*	SOIL / *ROCK*	ELEVATION
1	1.0				0.1		(*Sample 65-SB09-00 collected) SAND, fine to very fine, trace SILT.	Light brown	Medium Dense	Damp.		
2 3	3.0	S-01	2.0 100%	6 11 14 15	0.2							
4 5	5.0	S-02	2.0 100%	12 19 18 10	0.1		(*Sample 65-SB09-02 collected)	Brown	Dense			
6 7	7.0	S-03	2.0 100%	9 6 5 7	0.1			Gray	Loose	- Wet at 6.0'.		
8 9 10							End of Boring at 7.0'.					

DRILLING CO. Parrott Wolff
BAKER REP. R.M. Lewis
DRILLER Mark Eaves
BORING NO. 65-SB09
Sheet 1 of 1

Baker

Baker Environmental, Inc

FIELD TEST BORING RECORD

PROJECT: NAVY CLEAN SITE 65
S.O. NO.: 62470-312-0000-09000 BORING NO.: 65-SB10
COORDINATES: EAST 2495732.63 NORTH: 307345.10
ELEVATION: SURFACE Not surveyed

RIG: Truckmount CME-75

	SPLIT SPOON	CASING	AUGERS	CORE BARREL	DATE	PROGRESS (FT)	WEATHER	WATER DEPTH (FT)	TIME
SIZE (DIAM.)	2" OD		4¼" ID		4/8/95	5.0	Clear, 60°	5.0	10:55
LENGTH	24"		5.0'						
TYPE	S.S.		H.S.						
HAMMER WT.	140								
FALL	STD								
STICK UP									

REMARKS: HNu background = 0.1.

DRILL RECORD							VISUAL DESCRIPTION					
DEPTH	SOIL / ROCK	Sample ID ----- Type - No. (N = No Samp.)	Samp. Rec. (Ft. and %)	SPT Blows Per 0.5' / RQD (Ft. & %)	HNu / ppm	Time	Gradation / Classification	Color / Color	Consist. or Density / Hardness	Moisture Content, Organic Content, Plasticity, and Other Observations / Weathering, Bedding Fracturing, and Other Observations	SOIL / ROCK	ELEVATION
1	1.0	NA			0.1		(*Sample 65-SB10-00 collected) SAND, fine to very fine, trace SILT.	Light brown	Loose	Damp.		
2 3	3.0	S-01	1.7 85%	3 3 3 7	0.1		SAND fine to very fine and CLAY (*Sample 65-SB10-01 collected)	Gray	Medium Dense			
4 5	5.0	S-02	2.0 100%	4 7 11 9	0.1		SAND, fine to very fine, trace SILT.	Gray		- Wet at 5.0'.		
6 7 8 9 10							End of Boring at 5.0'.					

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DRILLER Mark Eaves BORING NO. 65-SB10 Sheet 1 of 1

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Baker Environmental, Inc

FIELD TEST BORING RECORD

PROJECT: NAVY CLEAN SITE 65
S.O. NO.: 62470-312-0000-09000
BORING NO.: 65-SB11
COORDINATES: EAST 2496067.37
NORTH: 307363.60
ELEVATION: SURFACE Not surveyed

RIG: Truckmount CME-75									
	SPLIT SPOON	CASING	AUGERS	CORE BARREL	DATE	PROGRESS (FT)	WEATHER	WATER DEPTH (FT)	TIME
SIZE (DIAM.)	2" OD		4¼" ID		4/8/95	11.0	Overcast, 50°	9.0	10:55
LENGTH	24"		5.0'						
TYPE	S.S.		H.S.						
HAMMER WT.	140								
FALL	STD								
STICK UP									

REMARKS: HNu background = 0.1.

DRILL RECORD							VISUAL DESCRIPTION					
DEPTH	SOIL	Sample ID ------ Type - No. (N = No Samp.)	Samp. Rec. (Ft. and %)	SPT Blows Per 0.5'	HNu		Gradation	Color	Consist. or Density	Moisture Content, Organic Content, Plasticity, and Other Observations	SOIL	ELEVATION
	ROCK			*RQD (Ft. & %)*	*ppm*	Time	*Classification*	*Color*	*Hardness*	*Weathering, Bedding Fracturing, and Other Observations*	*ROCK*	
1	1.0				0.2		(*Sample 65-SB11-00 collected) SAND, fine to very fine, trace SILT.	Light brown	Medium Dense	Damp.		
2 3	3.0	S-01	2.0 100%	4 7 11 11	0.1							
4 5	5.0	S-02	2.0 100%	10 12 18 19	0.1							
6 7	7.0	S-03	1.7 85%	4 6 7 7	0.1		SAND, fine to very fine, and CLAY. (*Sample 65-SB11-04 collected)	Light gray to gray	Medium Dense	Some mottling, moist.		
8 9	9.0	S-04	2.0 100%	10 12 15 17	0.1							
10	11.0	S-05	2.0 100%	4 5 7 11	0.1		End of Boring at 11.0'.			Wet at 9.0'.		

DRILLING CO. Parrott Wolff
BAKER REP. R.M. Lewis
DRILLER Mark Eaves
BORING NO. 65-SB11
Sheet 1 of 1

Baker

Baker Environmental, Inc.

FIELD TEST BORING RECORD

PROJECT: NAVY CLEAN SITE 65
S.O. NO.: 62470-312-0000-09000 BORING NO.: 65-SB12
COORDINATES: EAST 2495271.74 NORTH: 307800.79
ELEVATION: SURFACE Not surveyed

RIG: Truckmount CME-75

	SPLIT SPOON	CASING	AUGERS	CORE BARREL	DATE	PROGRESS (FT)	WEATHER	WATER DEPTH (FT)	TIME
SIZE (DIAM.)	2" OD		4¼" ID		4/17/95	13.0	Clear, 70°	11.0	16:00
LENGTH	24"		5.0'						
TYPE	S.S.		H.S.						
HAMMER WT.	140								
FALL	STD								
STICK UP									

REMARKS: HNu background = 0.1.

DRILL RECORD							VISUAL DESCRIPTION					
DEPTH	SOIL	Sample ID Type - No. (N = No Samp.)	Samp. Rec. (Ft. and %)	SPT Blows Per 0.5'	HNu		Gradation	Color	Consist. or Density	Moisture Content, Organic Content, Plasticity, and Other Observations	SOIL	ELEVATION
	ROCK			RQD (Ft. & %)	ppm	Time	*Classification*	*Color*	*Hardness*	*Weathering, Bedding Fracturing, and Other Observations*	ROCK	
1	1.0				0.2		(*Sample 65-SB12-00 collected) SAND, fine to very fine, trace SILT.	Gray		(Fill) Concrete and wood fragments, dry.		
2 3	3.0	S-01	2.0 100%	3 4 9 10	0.1			Dark brown	Medium Dense			
4 5	5.0	S-02	2.0 100%	16 21 14 16	0.1				Dense	(Fill) Damp.		
6 7	7.0	S-03	2.0 100%	8 3 5 3	0.1				Loose	(Fill) Tire and scrap metal.		
8 9	9.0	S-04	1.7 85%	2 7 12 12	0.1			Gray	Medium Dense	Moist.		
10	11.0	S-05	1.7 85%	6 7 7 8	0.1		(*Sample 65-SB12-05 collected)					

DRILLING CO. Parrott Wolff **BAKER REP.** R.M. Lewis

DRILLER Mark Eaves **BORING NO.** 65-SB12 **Sheet 1 of 2**

Baker

Baker Environmental, Inc.

FIELD TEST BORING RECORD

PROJECT: NAVY CLEAN SITE 65

S.O NO.: 62470-312-0000-09000 BORING NO: 65-SB12

DRILL RECORD							VISUAL DESCRIPTION					
DEPTH	SOIL *ROCK*	Sample ID ----- Type - No. (N = No Samp.)	Samp. Rec. (Ft. and %)	SPT Blows Per 0.5' *RQD (Ft. & %)*	HNu *ppm*	*Time*	Classification (Grain Size, Principal Constituents, Etc.) *Classification (Name, Grain Size, Principal Constituents, Etc.)*	Color *Color*	Consist. or Density *Hardness*	Moisture Content, Organic Content, Plasticity, and Other Observations *Weathering, Bedding Fracturing, and Other Observations*	SOIL *ROCK*	ELEVATION
11	11.0											
12		S-06	2.0	6 7 6 6	0.1		SAND, fine to very fine, trace SILT.	Gray	Medium Dense	Wet at 11.0'.		
13	13.0		100%									
14							End of Boring at 13.0'.					
15												
16												
17												
18												
19												
20												
21												
22												
23												
24												
25												
26												
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DRILLER Mark Eaves **BORING NO.** 65-SB12 **Sheet** 2 **of** 2

APPENDIX B
SAMPLING SUMMARY

APPENDIX

SAMPLING SUMMARY
SITE 65 - ENGINEER AREA DUMP
REMEDIAL INVESTIGATION, CTO-0312
MCB, CAMP LEJEUNE, NORTH CAROLINA

Media	Sample ID	Date Shipped	TCL VOA	TCL SVOA	TCL PEST/PCB	TAL Metals	Dissolved Metals	ENG PAR	TSS	TPH	TOC
Soil	65-SB06-00	4/11/95	X	X	X	X	NA	-	NA	-	-
	65-SB06-02	4/11/95	X	X	X	X	NA	-	NA	-	-
	65-SB06	4/11/95						X			
	65-SB07-00	4/10/95	X	X	X	X	NA	-	NA	-	-
	65-SB07-00D	4/10/95	X	X	X	X	NA	-	NA	-	-
	65-SB07-04	4/10/95	X	X	X	X	NA	-	NA	-	-
	65-RB-03	4/11/95	X	X	X	X	NA	-	NA	-	-
	65-SB08-00	4/11/95	X	X	X	X	NA	-	NA	-	-
	65-SB08-04	4/11/95	X	X	X	X	NA	-	NA	-	-
	65-SB09-00	4/10/95	X	X	X	X	NA	-	NA	-	-
	65-SB09-02	4/10/95	X	X	X	X	NA	-	NA	-	-
	65-SB10-00	4/10/95	X	X	X	X	NA	-	NA	-	-
	65-SB10-01	4/10/95	X	X	X	X	NA	-	NA	-	-
	65-SB11-00	4/10/95	X	X	X	X	NA	-	NA	-	-
	65-SB11-04	4/10/95	X	X	X	X	NA	-	NA	-	-
	65-SB11-04D	4/10/95	X	X	X	X	NA	-	NA	-	-
	65-SB12-00	4/18/95	X	X	X	X	NA	-	NA	-	-
	65-SB12-05	4/18/95	X	X	X	X	NA	-	NA	-	-
	65-TP01	5/9/95	X	X	X	X	NA	-	NA	X	-
	65-TP02	5/9/95	X	X	X	X	NA	-	NA	X	-
	65-TP04	5/9/95	X	X	X	X	NA	-	NA	X	-

NA = Not an Applicable Analysis for the Media
- = Not Analyzed

APPENDIX (CONTINUED)

SAMPLING SUMMARY
SITE 65 - ENGINEER AREA DUMP
REMEDIAL INVESTIGATION, CTO-0312
MCB, CAMP LEJEUNE, NORTH CAROLINA

Media	Sample ID	Date Shipped	TCL VOA	TCL SVOA	TCL PEST/PCB	TAL Metals	Dissolved Metals	ENG PAR	TSS	TPH	TOC
Soil (Continued)	65-TP05	5/9/95	X	X	X	X	NA	-	NA	X	-
	65-TP06	5/9/95	X	X	X	X	NA	-	NA	X	-
	65-TP07	5/9/95	X	X	X	X	NA	-	NA	X	-
	65-DW01-00	4/10/95	X	X	X	X	NA	-	NA	-	-
	65-DW01-04	4/10/95	X	X	X	X	NA	-	NA	-	-
	65-DW01-04D	4/10/95	X	X	X	X	NA	-	NA	-	-
	65-DW02-00	4/10/95	X	X	X	X	NA	-	NA	-	-
	65-DW02-02	4/10/95	X	X	X	X	NA	-	NA	-	-
	65-RB-01	4/10/95	X	X	X	X	NA	-	NA	-	-
	65-TB-01	4/10/95	X	-	-	-	NA	-	NA	-	-
	65-TB-02	4/11/95	X	-	-	-	NA	-	NA	-	-
	65-DW04-00	4/6/95	X	X	X	X	NA	-	NA	-	-
	65-DW04-05	4/6/95	X	X	X	X	NA	-	NA	-	-
	65-MW05-00	4/5/95	X	X	X	X	NA	-	NA	-	-
	65-MW05-04	4/5/95	X	X	X	X	NA	-	NA	-	-
	65-MW06-00	4/10/95	X	X	X	X	NA	-	NA	-	-
	65-MW06-00D	4/10/95	X	X	X	X	NA	-	NA	-	-
	65-MW06-03	4/10/95	X	X	X	X	NA	-	NA	-	-
	65-MW07-00	4/5/95	X	X	X	X	NA	-	NA	-	-
	65-MW07-05	4/5/95	X	X	X	X	NA	-	NA	-	-

NA = Not an Applicable Analysis for the Media
- = Not Analyzed

APPENDIX (CONTINUED)

SAMPLING SUMMARY
SITE 65 - ENGINEER AREA DUMP
REMEDIAL INVESTIGATION, CTO-0312
MCB, CAMP LEJEUNE, NORTH CAROLINA

Media	Sample ID	Date Shipped	TCL VOA	TCL SVOA	TCL PEST/PCB	TAL Metals	Dissolved Metals	ENG PAR	TSS	TPH	TOC
Groundwater	65-MW01-01	5/9/95	X	X	X	X	-	-	X	-	-
	65-MW01-01D	5/9/95	X	X	X	X	-	-	X	-	-
	65-MW01F-01	5/9/95	-	-	-	-	X	-	-	-	-
	65-MW01F-01D	5/9/95	-	-	-	-	X	-	-	-	-
	65-DW01-01	5/9/95	X	X	X	X	-	-	X	-	-
	65-MW02-01	5/10/95	X	X	X	X	-	-	X	-	-
	65-DW02-01	5/10/95	X	X	X	X	-	-	X	-	-
	65-DW02-02	5/20/95	X	X	X	X	-	-	X	-	-
	65-MW03-01	5/10/95	X	X	X	X	-	-	X	-	-
	65-MW04-01	5/17/95	X	X	X	X	-	-	X	-	-
	65-DW04-01	5/17/95	X	X	X	X	-	-	X	-	-
	65-MW05-01	5/10/95	X	X	X	X	-	-	X	-	-
	65-MW06-01	5/10/95	X	X	X	X	-	-	X	-	-
	65-MW07-01	5/10/95	X	X	X	X	-	X	X	-	-
Surface Water	65-SW04-01	5/16/95	X	X	X	X	-	-	-	-	-
	65-SW04-01D	5/16/95	X	X	X	X	-	-	-	-	-
	65-TB-03	5/16/95	X				-	-	-	-	-
	65-SW05-01	5/17/95	X	X	X	X	-	-	-	-	-
	65-RB-23	5/17/95	X	X	X	X	-	-	-	-	-

NA = Not an Applicable Analysis for the Media
- = Not Analyzed

SAMPLING SUMMARY
SITE 65 - ENGINEER AREA DUMP
REMEDIAL INVESTIGATION, CTO-0312
MCB, CAMP LEJEUNE, NORTH CAROLINA

Media	Sample ID	Date Shipped	TCL VOA	TCL SVOA	TCL PEST/PCB	TAL Metals	Dissolved Metals	ENG PAR	TSS	TPH	TOC
Sediment	65-SD04-06	5/17/95	X	X	X	X	NA	X	NA	X	X
	65-SD04-06D	5/17/95	X	X	X	X	NA	-	NA	X	-
	65-SD04-612	5/17/95	X	X	X	X	NA	-	NA	X	X
	65-SD05-06	5/18/95	X	X	X	X	NA	X	NA	X	X
	65-SD05-612	5/18/95	X	X	X	X	NA	-	NA	X	X
Fish	65-FS04-BG01W	6/6/95	X	X	X	X	NA	NA	NA	-	-
	65-FS04-BG01WMS	6/6/95	X	X	X	X	NA	NA	NA	-	-
	65-FS04-BG01WMD	6/6/95	X	X	X	X	NA	NA	NA	-	-
	65-FS04-BG01WD	6/6/95	X	X	X	X	NA	NA	NA	-	-
	65-FS04-BG01F	6/6/95	X	X	X	X	NA	NA	NA	-	-
	65-FS04-RS01W	6/6/95	X	X	X	X	NA	NA	NA	-	-
	65-FS05-LB01W	6/6/95	X	X	X	X	NA	NA	NA	-	-
	65-FS05-LB01F	6/6/95	X	X	X	X	NA	NA	NA	-	-
	65-FS05-RS01W	6/6/95	X	X	X	X	NA	NA	NA	-	-
	65-FS05-RS01F	6/6/95	X	X	X	X	NA	NA	NA	-	-
	65-FS05-BG01W	6/6/95	X	X	X	X	NA	NA	NA	-	-
	65-FS05-BG01F	6/6/95	X	X	X	X	NA	NA	NA	-	-

NA = Not an Applicable Analysis for the Media
- = Not Analyzed

APPENDIX C
TEST PIT RECORDS

Baker
Baker Environmental

TEST PIT RECORD

PROJECT: MCB Camp Lejeune, O. U. #9, Sites 65 and 73 Remedial Investigations
CTO NO.: 0312
TEST PIT NO.: 65TP-06
COORDINATES: EAST: 2,494,756.91
NORTH: 307,127.47
SURFACE ELEVATION: 32.0 feet
WATER LEVEL: NA
WEATHER: Sunshine, @ 85° F, Humid
DATE: 5/8/95
REMARKS: Test Pit Dimensions : length 10 feet width 3.5 feet Depth 10 feet

DEFINITIONS

HNU = Photoionization Detector Reading
LEL/O$_2$ (Results) = Readings Recorded by LEL/O$_2$ Meter
OVA = Organic Vapor Analyzer Reading

Background
HNU = 0.2
LEL/O$_2$ = 0.0/21%

Depth (ft.)	Samp. Type and No.	HNU or OVA (ppm)		LEL/O$_2$ (Results)	Visual Description (Principal Constituents, Gradation, Color, Moisture Content, Organic Content, Plasticity, and Other Observations)	Elevation 32.0 feet
		Field	Head-space			
1	Grab Sample	0.2	No Readings above background		SAND v.f. light brown, loose, dry to 3 feet, damp from 3 to 10 feet No foreign objects observed in this test pit.	
2		0.2				30.0 feet
3	65-TP06 was collected at bottom of test Pit ≈10'.	0.2				
4		0.3				28.0 feet
5		0.2			Probable all Native soils	
6		0.2				26.0 feet
7		0.2				
8		0.3				24.0 feet
9		0.2				
10		0.2				22.0 feet
11					End of Test Pit	
12						
13						
14						
15						
16						
17						
18						
19						
20						

CONTRACTOR: Parratt Wolff
BAKER REP.: Thomas Valli / James Culp
EQUIPMENT: Ford 555 D
TEST PIT NO.: 65TP-06
SHEET 1 OF 1

Baker
Baker Environmental

TEST PIT RECORD

PROJECT: MCB Camp Lejeune, O. U. #9, Sites 65 and 73 Remedial Investigations
CTO NO.: 0312
TEST PIT NO.: 65 TP-01
COORDINATES: EAST: 2,494,813.74
NORTH: 307,153.71
SURFACE ELEVATION: 32.5 feet
WATER LEVEL: 9.2 feet
WEATHER: Sunshine, @ 85°F, Humid
DATE: 5/7/95
REMARKS: Test Pit Dimensions: length 10feet, width 3.5 feet, Depth 9.5 feet

DEFINITIONS

HNU = Photoionization Detector Reading
OVA = Organic Vapor Analyzer Reading
LEL/O_2 (Results) = Readings Recorded by LEL/O_2 Meter

Background
HNu = 0.3
LEL/O_2 = 0.0/21%

Depth (ft.)	Samp. Type and No.	HNU or OVA (ppm) Field	HNU or OVA (ppm) Head-space	LEL/O_2 (Results)	Visual Description (Principal Constituents, Gradation, Color, Moisture Content, Organic Content, Plasticity, and Other Observations)	Elevation 32.5 feet
1	GRAB SAMPLE 65-TP01 was collected near bottom of test Pit ≈9.2'	0.4	No Readings Above Background		← Scrap Pieces of metal debris SAND v.f., light brown to brown loose dry Probable Fill Material	
2		0.5				30.5 feet
3		0.6			SAND. v.f. brown, loose, moist, frequent Roots from trees. Probable Native Soils	
4		0.4				28.5 feet
5		0.3				
6		0.4			SAND, v.f. brown, loose, damp. Probable Native soils.	26.5 feet
7		0.4				
8		0.3				24.5 feet
9		0.4				
10					End of Test Pit WATER at 9.2 feet SAME AS ABOVE, WET	22.0 feet
11						
12						
13						
14						
15						
16						
17						
18						
19						
20						

CONTRACTOR: Parratt Wolff
BAKER REP.: Thomas Volli / James Culp
EQUIPMENT: Ford 555 D
TEST PIT NO.: 65TP-01
SHEET 1 OF 1

Baker
Baker Environmental

TEST PIT RECORD

PROJECT: MCB Camp Lejeune, O. U. #9, Sites 65 and 73 Remedial Investigations
CTO NO.: 0312 **TEST PIT NO.:** 65TP-02
COORDINATES: EAST: 2,494,826.46 **NORTH:** 307,130.95
SURFACE ELEVATION: 27.5 feet **WATER LEVEL:** 8 feet
WEATHER: Sunshine @ 85°F Humid **DATE:** 5/8/95
REMARKS: Test Pit Dimensions: Length 9.5 ft Width 3.5 ft Depth 8.5 feet

DEFINITIONS

HNU = Photoionization Detector Reading
OVA = Organic Vapor Analyzer Reading
LEL/O_2 (Results) = Readings Recorded by LEL/O_2 Meter

Background
HNu = 0.3
LEL/O_2 00/21%

Depth (ft.)	Samp. Type and No.	HNU or OVA (ppm) Field	HNU or OVA (ppm) Head-space	LEL/O_2 (Results)	Visual Description (Principal Constituents, Gradation, Color, Moisture Content, Organic Content, Plasticity, and Other Observations)	Elevation 27.5 feet
1	Grab Sample 65TP-02 was collected near bottom of Test Pit ≈ 8.0'.	0.3	No Readings above background		SAND, v.f. light brown to brown, loose, damp.	
2		0.3			Probable Fill Material scrap Pieces of Metal	25.5 feet
3		0.4			SAND, v.f. brown, loose, damp	
4		0.5			Probable Native soils	23.5 feet
5		0.4			No foreign objects observed.	
6		0.5			SAME AS Above, moist	21.5 feet
7		0.4				
8		0.4		wet at 8 feet	SAME AS Above, trace silt, trace clay, moist to wet	
9					End of Test Pit	19.5 feet
10					Clay, gray, soft, damp	
11						
12						
13						
14						
15						
16						
17						
18						
19						
20						

CONTRACTOR: Parratt Wolff **BAKER REP.:** Thomas Valli / James Culp
EQUIPMENT: Ford 555 D **TEST PIT NO.:** 65TP02 **SHEET 1 OF 1**

Baker
Baker Environmental

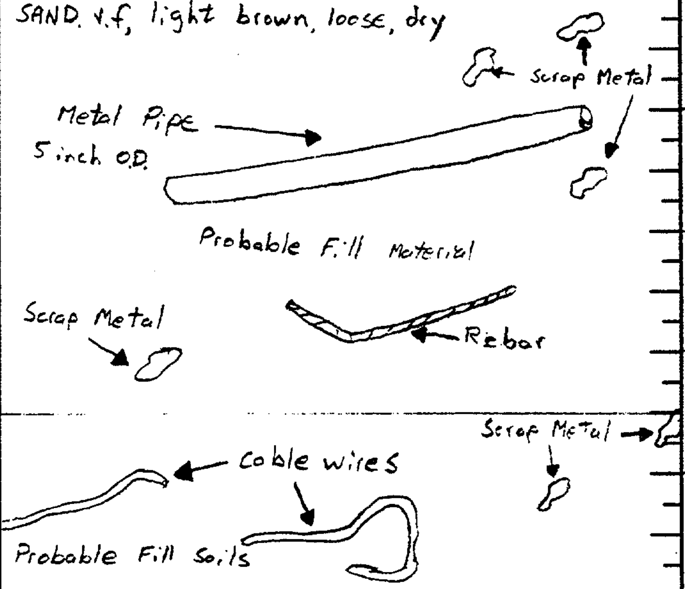
TEST PIT RECORD

PROJECT: MCB Camp Lejeune, O. U. #9, Sites 65 and 73 Remedial Investigations
CTO NO.: 0312
TEST PIT NO.: 65TP-07
COORDINATES: EAST: 2,494,754.54
NORTH: 307,327.86
SURFACE ELEVATION: 32.8 feet
WATER LEVEL: NA
WEATHER: Sunshine, @85°F, Humid
DATE: 5/7/95
REMARKS: Test Pit Dimensions: Length 10 feet, width 3.5 feet, Depth 10 feet

Background
HNu = 0.2
LEL/O2 = 00/21%

DEFINITIONS

HNU = Photoionization Detector Reading
OVA = Organic Vapor Analyzer Reading
LEL/O$_2$ (Results) = Readings Recorded by LEL/O$_2$ Meter

Depth (ft.)	Samp. Type and No.	HNU or OVA (ppm) Field	HNU or OVA (ppm) Head-space	LEL/O$_2$ (Results)	Visual Description (Principal Constituents, Gradation, Color, Moisture Content, Organic Content, Plasticity, and Other Observations)	Elevation 32.8 ~~feet~~
1	Grab Sample 65TP-07 was collected at bottom of test Pit ≈10'.	0.4	No Above	Readings Background	SAND. v.f, light brown, loose, dry	
2		0.8				30.8 feet
3		0.4				
4		0.4			Probable Fill Material	28.8 feet
5		0.6				
6		0.5				26.8 feet
7		0.5				
8		0.4	SAND, V.f. light brown, damp	loose		24.8 feet
9		0.4			Probable Fill Soils	
10		0.4			End of Test Pit	22.8 feet
11						
12						
13						
14						
15						
16						
17						
18						
19						
20						

CONTRACTOR: Parratt Wolff
BAKER REP.: Thomas Vall / James Culp
EQUIPMENT: Ford 555 D
TEST PIT NO.: 65TP-07
SHEET 1 OF 1

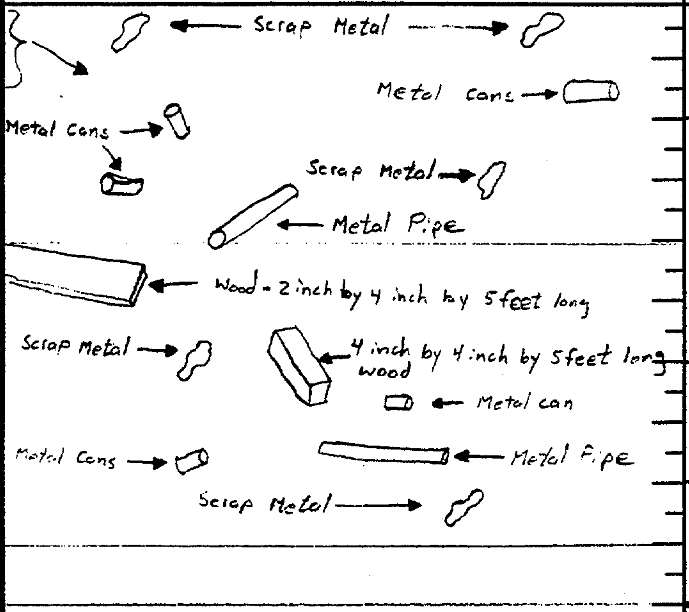
Baker
Baker Environmental

TEST PIT RECORD

PROJECT: MCB Camp Lejeune, O. U. #9, Sites 65 and 73 Remedial Investigations
CTO NO.: 0312
TEST PIT NO.: 65TP-05
COORDINATES: EAST: 2,494,791.92
NORTH: 307,197.75
SURFACE ELEVATION: 28.1 feet
WATER LEVEL: 9.5 feet
WEATHER: Sunshine @ 95°F, Humid
DATE: 5/7/95
REMARKS: Test Pit Dimensions: length 7.5 feet long, width 3.5 feet, Depth 10 feet

DEFINITIONS
HNU = Photoionization Detector Reading
OVA = Organic Vapor Analyzer Reading
LEL/O_2 (Results) = Readings Recorded by LEL/O_2 Meter

Background
HNu = 0.3
LEL/O_2 = 0.0/21%

Depth (ft.)	Samp. Type and No.	HNU or OVA (ppm) Field	HNU or OVA (ppm) Head-space	LEL/O_2 (Results)	Visual Description (Principal Constituents, Gradation, Color, Moisture Content, Organic Content, Plasticity, and Other Observations)	Elevation 28.1 feet
1	Grab Sample 65TP-05	0.4		SAND v.f. light brown loose, dry		
2	was Collected near the	0.4				26.1 feet
3	bottom of Test Pit ≈ 9.5'	0.3				
4		0.4				Probable Fill Material
5		0.4				
6		0.4	SAND V.f. grayish loose, dry	dark black to damp		22.1 feet
7		0.3				
8		0.5				20.1 feet
9		0.4	SAND v.f.	brown		Probable Native Soils
10		0.4	loose,	wet		18.1 feet
11					End of Test Pit	
12			No	Readings		
13			Above	Background		
14						
15						
16						
17						
18						
19						
20						

CONTRACTOR: Parratt Wolff
BAKER REP.: Thomas Volli / James Culp
EQUIPMENT: Ford 555 D
TEST PIT NO.: 65TP-05
SHEET 1 OF 1

Baker
Baker Environmental, Inc.

TEST PIT RECORD

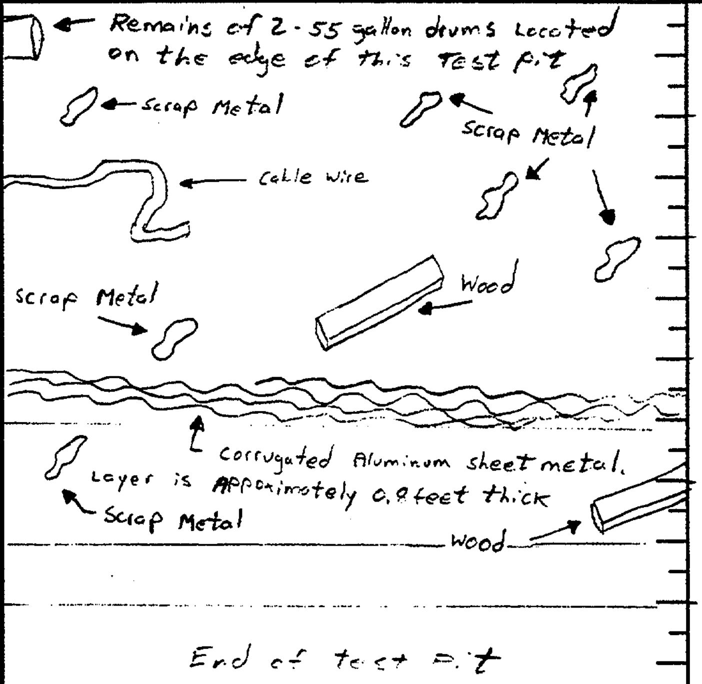
PROJECT: MCB Camp Lejeune, O. U. #9, Sites 65 and 73 Remedial Investigations
CTO NO.: 0312
TEST PIT NO.: 65TP04
COORDINATES: EAST: 2494821.00
NORTH: 307222.91
SURFACE ELEVATION: 29.2 feet
WATER LEVEL: 9 feet
WEATHER: Sunny, @ 85°F, Humid
DATE: 5/7/95
REMARKS: Test Pit Dimensions: Length 7 feet, width 3.5 feet, Depth 10 feet

Background
HNu = 0.3
LEL/O₂ = 0.0/21%

DEFINITIONS

HNU = Photoionization Detector Reading
OVA = Organic Vapor Analyzer Reading
LEL/O₂ (Results) = Readings Recorded by LEL/O₂ Meter

Depth (ft.)	Samp. Type and No.	HNU or OVA (ppm) Field	HNU or OVA (ppm) Head-space	LEL/O₂ (Results)	Visual Description (Principal Constituents, Gradation, Color, Moisture Content, Organic Content, Plasticity, and Other Observations)	Elevation
						29.2 feet
1	Grab Sample 65TP-04 was collected at bottom of test Pit ≈10'	0.3				
2		0.3				27.2 feet
3		0.4	SAND, v.f. light brown, loose, dry			
4		0.3				25.2 feet
5		0.2				
6		0.3				23.2 feet
7		0.3				
8		0.3	SAND, v.f. grayish black, loose, moist to damp			21.2 feet
9		0.3				
10		0.3	SAND, v.f. grayish black, loose, wet			19.2 feet
11						
12			No Readings			
13			Above	Background		
14						
15						
16						
17						
18						
19						
20						



CONTRACTOR: Parratt Wolff
BAKER REP.: Thomas Valli / James Culp
EQUIPMENT: Ford 555 D
TEST PIT NO.: 65TP-04
SHEET 1 OF 1

APPENDIX D
CHAIN OF CUSTODY RECORDS

Baker COC #65001

IT ERNATIONAL TECHNOLOGY CORPORATION

ANALYSIS REQUEST AND CHAIN OF CUSTODY RECORD*

Reference Document I. 325263
Page 1 of 1

Project Name/No.[1] CTO-0312
Sample Team Members[2]
Profit Center No.[3]
Project Manager[4] Mal Petroccia
Purchase Order No.[6]
Required Report Date[11] 14-28 days

Samples Shipment Date[7] 4-5-95
Lab Destination[8]
Lab Contact[9]
Project Contact/Phone[12]
Carrier/Waybill No.[13]

Bill to:[5] Baker Environmental
420 Rouser Rd
Bldg 3
Coraopolis, Pa 15108

Report to:[10] Mal Petroccia

ONE CONTAINER PER LINE

Sample Number[14]	Sample Description/Type[15]	Date/Time Collected[16]	Container Type[17]	Sample Volume[18]	Preservative[19]	Requested Testing Program[20]	Condition on Receipt[21]	Disposal Record No.[22]
65-MW07A-05	Soil	4/4/95 1458	Glass			TCL organics TAL Metals		
65-MW07A-00	Soil	4/4/95 1410	Glass			TCL Organics TAL Metals	FOR LAB USE ONLY	
65-MW05A-04	Soil	4/5/95 1025	Glass			TCL Organics TAL Metals		
65-MW05A-00	Soil	4/5/95 0922	Glass			TCL Organics TAL Metals		
							FOR LAB USE ONLY	

COPY

Special Instructions:[23]

Possible Hazard Identification:[24]
Non-hazard ☐ Flammable ☐ Skin Irritant ☐ Poison B ☐ Unknown ☐

Sample Disposal:[25]
Return to Client ☐ Disposal by Lab ☒ Archive ______ (mos.)

Turnaround Time Required:[26]
Normal ☒ Rush ☐

QC Level:[27]
I. ☐ II. ☐ III. ☐ Project Specific (specify): LEVEL D

1. Relinquished by[28] (Signature/Affiliation) James G. Culp Date: 4-5-95 Time: 1420
1. Received by[28] (Signature/Affiliation) Date: Time:

2. Relinquished by (Signature/Affiliation) Date: Time:
2. Received by (Signature/Affiliation) Date: Time:

3. Relinquished by (Signature/Affiliation) Date: Time:
3. Received by (Signature/Affiliation) Date: Time:

Comments:[29]

White: To accompany samples
Yellow: Field copy
*See back of form for special instructions.

INTERNATIONAL TECHNOLOGY CORPORATION

Baker COC # 65002

ANALYSIS REQUEST AND CHAIN OF CUSTODY RECORD*

Reference Document No. 325249
Page 1 of 1

Project Name/No. 1 CTO-312
Sample Team Members 2
Profit Center No. 3
Project Manager 4 MAL Petroccia
Purchase Order No. 6
Required Report Date 11 14-28 DAYS

Samples Shipment Date 7 4-6-95
Lab Destination 8
Lab Contact 9
Project Contact/Phone 12
Carrier/Waybill No. 13

Bill to: 5 Baker Environmental
420 Rouser Road
Bldg 3
Coraopolis, Pa 15108

Report to: 10 Mal Petroccia

ONE CONTAINER PER LINE

Sample 14 Number	Sample 15 Description/Type	Date/Time 16 Collected	Container 17 Type	Sample 18 Volume	Pre- 19 servative	Requested Testing 20 Program	Condition on 21 Receipt	Disposal 22 Record No.
65-DW04-05	SOIL	4-5-95 1538	Glass			TCL ORGANICS TAL METALS		
65-DW04-00	SOIL	4-5-95 1505	Glass			TCL Organics TAL METALS		

FOR LAB USE ONLY

FOR LAB USE ONLY

COPY

Special Instructions: 23

Possible Hazard Identification: 24
Non-hazard ☐ Flammable ☐ Skin Irritant ☐ Poison B ☐ Unknown ☐

Sample Disposal: 25
Return to Client ☐ Disposal by Lab ☑ Archive ______ (mos.)

Turnaround Time Required: 26
Normal ☑ Rush ☐

QC Level: 27
I. ☐ II. ☐ III. ☐ Project Specific (specify): LEVEL D

1. Relinquished by 28 (Signature/Affiliation)	Date: Time:	1. Received by 28 (Signature/Affiliation)	Date: Time:
2. Relinquished by (Signature/Affiliation)	Date: Time:	2. Received by (Signature/Affiliation)	Date: Time:
3. Relinquished by (Signature/Affiliation)	Date: Time:	3. Received by (Signature/Affiliation)	Date: Time:

Comments: 29

White: To accompany samples

Yellow: Field copy

*See back of form for special instructions.

Baker COC # 65003

INTERNATIONAL TECHNOLOGY CORPORATION

ANALYSIS REQUEST AND CHAIN OF CUSTODY RECORD*

Reference Document No. 325253
Page 1 of ___

Project Name/No.¹ CTO-312
Sample Team Members²
Profit Center No.³
Project Manager⁴ Mal Petroccia
Purchase Order No.⁶
Required Report Date¹¹

Samples Shipment Date⁷ 4-10-95
Lab Destination⁸
Lab Contact⁹ Bn
Project Contact/Phone¹²
Carrier/Waybill No.¹³

Bill to:⁵ Baker Environmental
420 Rouser Rd.
Bldg 3
Coraopolis, Pa 15108

Report to:¹⁰ Mal Petroccia

ONE CONTAINER PER LINE

Sample Number 14	Sample Description/Type 15	Date/Time Collected 16	Container Type 17	Sample Volume 18	Preservative 19	Requested Testing Program 20	Condition on Receipt 21	Disposal Record No. 22
65-RB-01	WATER	4-8-95 1725	Glass PLASTIC		HCL HNO3	TCL ORGANICS, TAL METALS		
65-RB-02	Water	4-80-95 0720	Glass Plastic		HCL HNO3	TCL ORGANICS TAL METALS	HOLD FOR ANALYSIS FOR LAB USE ONLY	
65-MW06A-00MS/MSD	SOIL	4-8-95 0845	Glass			TCL Organics TAL METALS		
65-MW06A-00D	SOIL	4-8-95 0855	Glass			TCL Organics TAL METALS		
65-DW02-00	SOIL	4-9-95 0850	Glass			TCL Organics TAL METALS	FOR LAB USE ONLY	
65-DW02-02	SOIL	4-9-95 0848	Glass			TCL Organics TAL METALS		
65-DW01-04	SOIL	4-10-95 0852	Glass			TCL Organics TAL METALS		
65-DW01-04D	SOIL	4-10-95 0852	Glass			TCL Organics TAL METALS		

COPY

Special Instructions:²³ ~~TPH (8015) / Oil & Grease (9071) NEED 14 DAY TURN~~ SSL

Possible Hazard Identification:²⁴
Non-hazard ☐ Flammable ☐ Skin Irritant ☐ Poison B ☐ Unknown ☐

Sample Disposal:²⁵
Return to Client ☐ Disposal by Lab ☒ Archive ______ (mos.)

Turnaround Time Required:²⁶
Normal ☒ Rush ☐

QC Level:²⁷
I. ☐ II. ☐ III. ☐ Project Specific (specify): LEVEL D

1. Relinquished by²⁸ (Signature/Affiliation) James S Culp	Date: 4-10-95 Time: 1600	1. Received by²⁸ (Signature/Affiliation)	Date: Time:
2. Relinquished by (Signature/Affiliation)	Date: Time:	2. Received by (Signature/Affiliation)	Date: Time:
3. Relinquished by (Signature/Affiliation)	Date: Time:	3. Received by (Signature/Affiliation)	Date: Time:

Comments:²⁹

White: To accompany samples - Yellow: Field copy

*See back of form for special instructions.

BAKER COC # 65003

INTERNATIONAL TECHNOLOGY CORPORATION

ANALYSIS REQUEST AND CHAIN OF CUSTODY RECORD (cont.)*

Reference Document No.30 325253

Page 2 of ____

Project Name CTO-312

Project No. 62470-312

Samples Shipment Date 4-10-95

ONE CONTAINER PER LINE

Sample 14 Number	Sample 15 Description/Type	Date/Time 16 Collected	Container 17 Type	Sample 18 Volume	Pre-19 servative	Requested Testing 20 Program	Condition on 21 Receipt	Disposal 22 Record No.
65-SB11-04	SOIL	4-8-95 1210	GLASS			TCL VOLS, TCL organics, TAL METALS		
65-SB11-04D	SOIL	4-8-95 1210	Glass			TCL organics TAL METALS		
65-SB11-00	SOIL	4-8-95 1345	Glass			TCL Organics TAL METALS		
65-SB11-04	SOIL	4-8-95 1210	Glass			TCL ORGANICS TAL METALS		
65-SB10-00	SOIL	4-8-95 1355	Glass			TCL ORGANICS TAL METALS		
65-SB10-01	SOIL	4-8-95 1400	Glass			TCL organics TAL METALS		
65-SB09-00	Soil	4-8-95 1433	Glass			TCL Organics TAL METALS		
65-SB09-02	Soil	4-8-95 1430	Glass			TCL Organics TAL METALS		
65-SB07-00	SOIL	4-8-95 1540	Glass			TCL Organics TAL METALS		
65-SB07-00D	SOIL	4-8-95 1540	Glass			TCL Organics TAL METALS		
65-SB07-04	SOIL	4-8-95 1557	Glass			TCL organics TAL METALS		
65-TB-01	Water	4-10-95	Glass			TCL VOLS.		
65-MW06A-03	SOIL	4-8-95 0923	Glass			TCL ORGANICS TAL METALS		
65-MW06A-00	SOIL	4-8-95 0845	Glass			TCL ORGANICS TAL METALS		

FOR LAB USE ONLY

FOR LAB USE ONLY

FOR LAB USE ONLY

FOR LAB USE ONLY

FOR LAB USE ONLY

FOR LAB USE ONLY

FOR LAB USE ONLY

COPY

White: To accompany samples Yellow: Field copy

*See back of form for special instructions.

INTERNATIONAL TECHNOLOGY CORPORATION

BAKER COC # 65004

ANALYSIS REQUEST AND CHAIN OF CUSTODY RECORD*

Reference Document No. 325255
Page 1 of 1

Project Name/No.1 CTO-312
Sample Team Members 2
Profit Center No. 3
Project Manager 4 Mal Petroccia
Purchase Order No. 6
Required Report Date 11

Samples Shipment Date 7 4-11-95
Lab Destination 8
Lab Contact 9
Project Contact/Phone 12
Carrier/Waybill No. 13

Bill to: 5 Baker Environmental
420 Rouser Rd.
Bldg. 3
Coraopolis, Pa. 15108

Report to: 10 Mal Petroccia

ONE CONTAINER PER LINE

COPY

Sample 14 Number	Sample 15 Description/Type	Date/Time 16 Collected	Container 17 Type	Sample 18 Volume	Pre- 19 servative	Requested Testing 20 Program	Condition on 21 Receipt	Disposal 22 Record No.
65-SB06-00	SOIL	(1635) 4-10-95	GLASS			TCL Organics TAL METALS	FOR LAB USE ONLY	
65-SB06-02	SOIL	(1649) 4-10-95	GLASS			TCL Organics TAL Metals		
65-SB06	SOIL	(1650) 4-10-95	GLASS PLASTIC			TOC, ALKALINITY, COD, MICROBIAL COUNT, TKN, TOTAL PHOSPHOROUS, Atterberg Limits, Particle Size w/hydrometer		
65-RB-03	Water	(18[illegible]0) 4-10-95	Glass Plastic		HCL HNO3	TCL Organics, TAL METALS	FOR LAB USE ONLY	
65-SB08-04	SOIL	4-11-95 (0836)	GLASS			TCL Organics, TAL METALS		
65-SB08-00	SOIL	4-11-95 (0755)	GLASS			TCL Organics TAL Metals		
65-RB-04	Water	4-11-95 (1520)	Glass Plastic		HCL HNO3	TCL Organics TAL Metals	← HOLD FOR ANALSES	

Special Instructions: 23

Possible Hazard Identification: 24
Non-hazard ☐ Flammable ☐ Skin Irritant ☐ Poison B ☐ Unknown ☐

Sample Disposal: 25
Return to Client ☐ Disposal by Lab ☒ Archive ______ (mos.)

Turnaround Time Required: 26
Normal ☒ Rush ☐

QC Level: 27
I. ☐ II. ☐ III. ☐ Project Specific (specify): LEVEL D

1. Relinquished by 28 (Signature/Affiliation) James S. Culp Date: 4-11-95 Time: 1630
1. Received by 28 (Signature/Affiliation) Date: Time:

2. Relinquished by (Signature/Affiliation) Date: Time:
2. Received by (Signature/Affiliation) Date: Time:

3. Relinquished by (Signature/Affiliation) Date: Time:
3. Received by (Signature/Affiliation) Date: Time:

Comments: 29

White: To accompany samples
Yellow: Field copy
*See back of form for special instructions.

INTERNATIONAL TECHNOLOGY CORPORATION

Baker COC # 65005

ANALYSIS REQUEST AND CHAIN OF CUSTODY RECORD*

Reference Document No. 325261
Page 1 of 1

COPY

Project Name/No. 1 CTO-312
Sample Team Members 2
Profit Center No. 3
Project Manager 4 Mal Petroccia
Purchase Order No. 6
Required Report Date 11

Samples Shipment Date 7 4-18-95
Lab Destination 8
Lab Contact 9
Project Contact/Phone 12
Carrier/Waybill No. 13

Bill to: 5 Baker Environmental
420 Rouser Rd
Bldg 3
Coraopolis, Pa 15108

Report to: 10 Mal Petroccia

ONE CONTAINER PER LINE

Sample Number 14	Sample Description/Type 15	Date/Time Collected 16	Container Type 17	Sample Volume 18	Pre-servative 19	Requested Testing Program 20	Condition on Receipt 21	Disposal Record No. 22
65-SB12-05	SOIL	4/17/95 (1622)	Glass			TCL Organics, TAL METALS		
65-SB12-00	Soil	4/17/95 (1600)	Glass			"	FOR LAB USE ONLY	
							FOR LAB USE ONLY	

Special Instructions: 23 —

Possible Hazard Identification: 24
Non-hazard ☐ Flammable ☐ Skin Irritant ☐ Poison B ☐ Unknown ☐

Sample Disposal: 25
Return to Client ☐ Disposal by Lab ☒ Archive ______ (mos.)

Turnaround Time Required: 26
Normal ☒ Rush ☐

QC Level: 27
I. ☐ II. ☐ III. ☐ Project Specific (specify): LEVEL D

1. Relinquished by 28 (Signature/Affiliation) James S. Culp Date: 4-18-95 Time: 1500
1. Received by 28 (Signature/Affiliation) Date: Time:
2. Relinquished by (Signature/Affiliation) Date: Time:
2. Received by (Signature/Affiliation) Date: Time:
3. Relinquished by (Signature/Affiliation) Date: Time:
3. Received by (Signature/Affiliation) Date: Time:

Comments: 29

White: To accompany samples
Yellow: Field copy
*See back of form for special instructions.

BAKER COC # 65006

INTERNATIONAL TECHNOLOGY CORPORATION

ANALYSIS REQUEST AND CHAIN OF CUSTODY RECORD*

Reference Document No. 325336
Page 1 of 2

Project Name/No. 1 CTO-312
Sample Team Members 2
Profit Center No. 3
Project Manager 4 Mal Petroccia
Purchase Order No. 6 62470-312
Required Report Date 11

Samples Shipment Date 7 5-9-95
Lab Destination 8
Lab Contact 9
Project Contact/Phone 12
Carrier/Waybill No. 13

Bill to: 5 Baker Environmental
420 Rouser Rd. Bldg 3
Coraopolis, Pa
15108

Report to: 10 Mal Petroccia

ONE CONTAINER PER LINE

Sample Number 14	Sample Description/Type 15	Date/Time Collected 16	Container Type 17	Sample Volume 18	Preservative 19	Requested Testing Program 20	Condition on Receipt 21	Disposal Record No. 22
65-MW01A-01MSD	Water	1500 5-8-95	Glass		HNO3 HCL	TCL Organics, TAL METALS, TSS		
65-MW01AF01MSD		5-8-95 1500			HNO3	Dissolved Metals	FOR LAB USE ONLY	
65-MW01A-01MS					HNO3 HCL	TCL Organics, TAL Metals, TSS		
65-MW01AF-01MS					HNO3	DISSOLVED METALS		
65-MW01A-01D					HNO3 HCL	TAL METALS, TCL ORGANICS, TSS		
65-MW01AF-01D					HNO3	DISSOLVED METALS	FOR LAB USE ONLY	
65-MW01A-01					HNO3 HCL	TAL METALS, TSS TCL Organics		
65-MW01AF-01					HNO3	DISSOLVED METALS		

COPY

Special Instructions: 23

Possible Hazard Identification: 24
Non-hazard ☐ Flammable ☐ Skin Irritant ☐ Poison B ☐ Unknown ☐

Sample Disposal: 25
Return to Client ☐ Disposal by Lab ☒ Archive ______ (mos.)

Turnaround Time Required: 26
Normal ☒ Rush ☐

QC Level: 27
I. ☐ II. ☐ III. ☐ Project Specific (specify): LEVEL D

1. Relinquished by 28 (Signature/Affiliation) James S. Culp Date: 5-9-95 Time: 1100
1. Received by 28 (Signature/Affiliation) Date: Time:

2. Relinquished by (Signature/Affiliation) Date: Time:
2. Received by (Signature/Affiliation) Date: Time:

3. Relinquished by (Signature/Affiliation) Date: Time:
3. Received by (Signature/Affiliation) Date: Time:

Comments: 29

White: To accompany samples

Yellow: Field copy

*See back of form for special instructions.

MCA 3/15/91

BAKER COC# 65006

INTERNATIONAL TECHNOLOGY CORPORATION

ANALYSIS REQUEST AND CHAIN OF CUSTODY RECORD (cont.)*

Reference Document No.30 325336

Page 2 of 2

Project Name CTO-312

Project No. 62470-312

Samples Shipment Date 5-9-95

ONE CONTAINER PER LINE

Sample 14 Number	Sample 15 Description/Type	Date/Time 16 Collected	Container 17 Type	Sample 18 Volume	Pre-19 servative	Requested Testing 20 Program	Condition on 21 Receipt	Disposal 22 Record No.
65-TP01	SOIL	5-7-95 1809	Glass		—	TCL Organics, TAL METALS, TPH (8015)		
65-TP02	SOIL	5-8-95 0945	656		—	TCL Organics, TAL METALS, TPH (8015)		
65-TP04	SOIL	5-7-95 1636			—		FOR LAB USE ONLY	
65-TP05		5-7-95 1445			—			
65-TP06		5-8-95 1100			—		FOR LAB USE ONLY	
65-TP07		5-7-95 1202			—			
65-~~MW01B~~ DW01 -01	Water	5-8-95 1725	Glass PLASTIC		HNO3 HCL	TCL Organics, TAL METALS		
~~65-DW01-01~~ JG ~~Water~~							FOR LAB USE ONLY	
							FOR LAB USE ONLY	
							FOR LAB USE ONLY	
							FOR LAB USE ONLY	
							FOR LAB USE ONLY	

COPY

White: To accompany samples

Yellow: Field copy

*See back of form for special instructions.

Baker ww 65507

Quanterra
Environmental Services
5815 Middlebrook Pike
Knoxville, Tennessee 37921
(615) 588-6401

ANALYSIS REQUEST AND CHAIN OF CUSTODY RECORD*

Reference Document No. 2469
Page 1 of 1

Project Name/No.¹ CTO-312
Sample Team Members²
Profit Center No.³
Project Manager⁴ Mal Petroccia
Purchase Order No.⁶
Required Report Date¹¹

Samples Shipment Date⁷ 5-10-95
Lab Destination⁸
Lab Contact⁹
Project Contact/Phone¹²
Carrier/Waybill No.¹³

Bill to:⁵ Baker Environmental
420 Rouser Rd
Bldg 3
Coraopolis, Pa 15108

Report to:¹⁰ Mal Petroccia

ONE CONTAINER PER LINE

Sample Number 14	Sample Description/Type 15	Date/Time Collected 16	Container Type 17	Sample Volume 18	Preservative 19	Requested Testing Program 20	Condition on Receipt 21	Disposal Record No. 22
65-MW07A-01	water	5-9-95 0945	Glass & Plastic		HCl HNO_3 H_2SO_4	TCL SVOA, TCL PEST/PCB, TCL VOA, Total Phosphorus, TAL METALS, Alkalinity, TSS, TOC, TDS, Microbial Count, ~~BOD~~ COD, TKN.	FOR LAB USE ONLY	
65-[illegible]W02B-01	Water	5-9-95 1505	Glass & Plastic		HCl HNO_3	TCL VOA, TCL SVOA, TCL PEST/PCB, TAL METALS, TSS		
65-MW05A-01	Water	5-9-95 1545	Glass & Plastic		HCl HNO_3	TCL VOA, TCL SVOA, TCL PEST/PCB, TAL METALS, TSS		
65-MW02A-01	Water	5-9-95 1400	Glass & Plastic		HCl HNO_3	TCL VOA, TCL SVOA, TCL PEST/PCB, TAL METALS, TSS		
65-MW03-01	water	5-9-95 0935	Glass & Plastic		HCl HNO_3	TCL SVOA, TCL VOA, TCL PEST/PCB, TAL METALS, TSS	FOR LAB USE ONLY	
65-MW06A-01	water	5-9-95 1155	Glass & Plastic		HCl HNO_3	TCL SVOA, TCL VOA TCL PEST/PCB, TAL METALS, TSS		

Special Instructions:²³

Possible Hazard Identification:²⁴
Non-hazard ☐ Flammable ☐ Skin Irritant ☐ Poison B ☐ Unknown ☐

Sample Disposal:²⁵
Return to Client ☐ Disposal by Lab ☒ Archive (mos.)

Turnaround Time Required:²⁶
Normal ☒ Rush ☐

QC Level:²⁷
I. ☐ II. ☐ III. ☐ Project Specific (specify): LEVEL D

1. Relinquished by²⁸ (Signature/Affiliation) James S. Culp Date: 5-10-95 Time: 1500
1. Received by²⁸ (Signature/Affiliation) Date: Time:

2. Relinquished by (Signature/Affiliation) Date: Time:
2. Received by (Signature/Affiliation) Date: Time:

3. Relinquished by (Signature/Affiliation) Date: Time:
3. Received by (Signature/Affiliation) Date: Time:

Comments:²⁹

White: To accompany samples
Yellow: Field copy
*See back of form for special instructions.

Quanterra
Environmental Services
5815 Middlebrook Pike
Knoxville, Tennessee 37921
(615) 588-6401

BAKER COC # ~~73020~~ 65008

ANALYSIS REQUEST AND CHAIN OF CUSTODY RECORD*

Reference Document No. 2470
Page 1 of 1

Project Name/No. 1 CTO-312
Sample Team Members 2
Profit Center No. 3
Project Manager 4 Mal Petroccia
Purchase Order No. 6 62470-312
Required Report Date 11

Samples Shipment Date 7 5-16-95
Lab Destination 8
Lab Contact 9
Project Contact/Phone 12
Carrier/Waybill No. 13

Bill to: 5 Baker Environmental
420 Rouser Rd Bld 3
Coraopolis, PA
15108

Report to: 10 Mal Petroccia

ONE CONTAINER PER LINE

Sample 14 Number	Sample 15 Description/Type	Date/Time 16 Collected	Container 17 Type	Sample 18 Volume	Pre- 19 servative	Requested Testing 20 Program	Condition on 21 Receipt	Disposal 22 Record No.
65-SW#04-01	Water	5-15-95 1650	Glass Plastic		HNO3 HCL	TCL Organics TAL METALS		
65-SW#04-01D	Water	5-15-95 1650	GLASS PLASTIC		HNO3 HCL	TCL Organics TAL Metals	FOR LAB USE ONLY	
65-SW04-01MS	Water	5-15-95 1650	GLASS PLASTIC		HNO3 HCL	TCL Organics TAL Metals		
65-SW04-01MSD	Water	5-15-95 1650	GLASS PLASTIC		HNO3 HCL	TCL Organics TAL Metals		
65-TB-03	Water	5-16-95	Glass		HCL	TCL VOLS.		
							FOR LAB USE ONLY	

Special Instructions: 23 TCL VOLS REQUIRE 14-DAY TURN

Possible Hazard Identification: 24
Non-hazard ☐ Flammable ☐ Skin Irritant ☐ Poison B ☐ Unknown ☐

Sample Disposal: 25
Return to Client ☐ Disposal by Lab ☒ Archive (mos.)

Turnaround Time Required: 26
Normal ☒ Rush ☐

QC Level: 27
I. ☐ II. ☐ III. ☐ Project Specific (specify): LEVEL D

1. Relinquished by 28 (Signature/Affiliation) James S Culp Date: 5-16-95 Time: 1300
1. Received by 28 (Signature/Affiliation) Date: Time:

2. Relinquished by (Signature/Affiliation) Date: Time:
2. Received by (Signature/Affiliation) Date: Time:

3. Relinquished by (Signature/Affiliation) Date: Time:
3. Received by (Signature/Affiliation) Date: Time:

Comments: 29

White: To accompany samples
Yellow: Field copy
*See back of form for special instructions.

Quanterra
Environmental Services
5815 Middlebrook Pike
Knoxville, Tennessee 37921
(615) 588-6401

BAKER C[illegible] #65009

ANALYSIS REQUEST AND CHAIN OF CUSTODY RECORD*

Reference Document No. 1229
Page 1 of 1

Project Name/No.[1] CTO-312
Sample Team Members[2]
Profit Center No.[3]
Project Manager[4] Mal Petroccia
Purchase Order No.[6] 62470-312
Required Report Date[11]

Samples Shipment Date[7] 5-17-95
Lab Destination[8]
Lab Contact[9]
Project Contact/Phone[12]
Carrier/Waybill No.[13]

Bill to:[5] Baker Environmental
420 Rouser Rd - BLD 3
Coraopolis, Pa
15108

Report to:[10] Mal Petroccia

ONE CONTAINER PER LINE

Sample Number[14]	Sample Description/Type[15]	Date/Time Collected[16]	Container Type[17]	Sample Volume[18]	Preservative[19]	Requested Testing Program[20]	Condition on Receipt[21]	Disposal Record No.[22]
65-SD04-612	SOIL	(0910) 5-16-95	GLASS		—	TAL METALS, TPH(8015) TCL ORGANICS	FOR LAB USE ONLY	
65-SD04-06	SOIL	(0915) 5-16-95	↓		—	TAL METALS, TPH (8015), TCL Organics, Particle Size, ~~TOC~~		
65-SD04-06D	SOIL	↓			—	TAL METALS, TPH(8015), TCL organics		
65-SD04-06MS/MSD	SOIL				→	TAL METALS, TPH(8015) TCL Organics		
65-MW04A-01	WATER	5-16-95 (1030)	GLASS PLASTIC		HCL HNO3	TCL organics, TAL METALS, TSS	FOR LAB USE ONLY	
65-DW04-01	"	5-16-95 (1705)	"		"	TCL organics, TAL METALS, TSS		
65-SW05-01	"	5-16-95 (1335)	"		"	TCL Organics, TAL Metals		
65-RB-23	"	5-16-95 (1945)	"		"	TCL organics TAL Metals		

Special Instructions:[23] TPH (8015) is NOT 7-DAY TURN

Possible Hazard Identification:[24]
Non-hazard ☐ Flammable ☐ Skin Irritant ☐ Poison B ☐ Unknown ☐

Sample Disposal:[25]
Return to Client ☐ Disposal by Lab ☒ Archive (mos.)

Turnaround Time Required:[26]
Normal ☒ Rush ☐

QC Level:[27]
I. ☐ II. ☐ III. ☐ Project Specific (specify): LEVEL D

1. Relinquished by[28] (Signature/Affiliation) James S. Cul
Date: 5-17-95
Time: 1620

1. Received by[28] (Signature/Affiliation)
Date:
Time:

2. Relinquished by (Signature/Affiliation)
Date:
Time:

2. Received by (Signature/Affiliation)
Date:
Time:

3. Relinquished by (Signature/Affiliation)
Date:
Time:

3. Received by (Signature/Affiliation)
Date:
Time:

Comments:[29]

White: To accompany samples
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INTERNATIONAL TECHNOLOGY CORPORATION

Baker CA65010

ANALYSIS REQUEST AND CHAIN OF CUSTODY RECORD*

Reference Document No. 325467
Page 1 of 1

Project Name/No. 1 CTO-312
Sample Team Members 2
Profit Center No. 3
Project Manager 4 Mal Petroccia
Purchase Order No. 6 62470-312
Required Report Date 11

Samples Shipment Date 7 5-18-95
Lab Destination 8
Lab Contact 9
Project Contact/Phone 12
Carrier/Waybill No. 13

Bill to: 5 Baker Environmental
420 Rouser Rd. Bldg 3
Coraopolis, Pa.
15108

Report to: 10 Mal Petroccia

ONE CONTAINER PER LINE

Sample Number 14	Sample Description/Type 15	Date/Time Collected 16	Container Type 17	Sample Volume 18	Preservative 19	Requested Testing Program 20	Condition on Receipt 21	Disposal Record No. 22
65-SD05-612	Soil	(1140) 5-17-95	Glass		—	TCL Vols, Semivols, Pest/PCB, TAL Metals, TPH (8015), TOC		
65-SD05-06	Soil	(1145) 5-17-95	Glass		—	TCL Vols, Semivols, Pest/PCB, TAL Metals, TPH (8015), TOC, Grain Size		

FOR LAB USE ONLY

FOR LAB USE ONLY

Special Instructions: 23 TPH (8015) is not run as 14-DAY TURN

Possible Hazard Identification: 24
Non-hazard ☐ Flammable ☐ Skin Irritant ☐ Poison B ☐ Unknown ☐

Sample Disposal: 25
Return to Client ☐ Disposal by Lab ☒ Archive ______ (mos.)

Turnaround Time Required: 26
Normal ☒ Rush ☐

QC Level: 27
I. ☐ II. ☐ III. ☐ Project Specific (specify): LEVEL D

1. Relinquished by 28 (Signature/Affiliation) James S. Culp — Date: 5-18-95 Time: 1700
1. Received by 28 (Signature/Affiliation) — Date: Time:

2. Relinquished by (Signature/Affiliation) — Date: Time:
2. Received by (Signature/Affiliation) — Date: Time:

3. Relinquished by (Signature/Affiliation) — Date: Time:
3. Received by (Signature/Affiliation) — Date: Time:

Comments: 29

White: To accompany samples
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INTERNATIONAL TECHNOLOGY CORPORATION

Baker COC# 65011

ANALYSIS REQUEST AND CHAIN OF CUSTODY RECORD*

Reference Document I 325468
Page 1 of 1

Project Name/No.1 CTO-312
Sample Team Members 2
Profit Center No. 3
Project Manager 4 Mal Petroccia
Purchase Order No. 6 62470-312
Required Report Date 11

Samples Shipment Date 7 5-20-95
Lab Destination 8
Lab Contact 9
Project Contact/Phone 12
Carrier/Waybill No. 13

Bill to:5 Baker Environmental
420 Rouser Rd Bldg 3
Coraopolis, Pa.
15108

Report to:10 Mal Petroccia

ONE CONTAINER PER LINE

Sample 14 Number	Sample 15 Description/Type	Date/Time 16 Collected	Container 17 Type	Sample 18 Volume	Pre- 19 servative	Requested Testing 20 Program	Condition on 21 Receipt	Disposal 22 Record No.
65-DW02-01	Water	(1600) 5-18-95	Glass PLASTIC		HCL HNO3	TCL Organics TAL Metals		

COPY

FOR LAB USE ONLY

FOR LAB USE ONLY

Special Instructions: 23

Possible Hazard Identification: 24
Non-hazard ☐ Flammable ☐ Skin Irritant ☐ Poison B ☐ Unknown ☐

Sample Disposal: 25
Return to Client ☐ Disposal by Lab ☒ Archive ______ (mos.)

Turnaround Time Required: 26
Normal ☒ Rush ☐

QC Level: 27
I. ☐ II. ☐ III. ☐ Project Specific (specify): LEVEL D

1. Relinquished by 28 (Signature/Affiliation) James S Culp Date: 5-20-95 Time: 0900
1. Received by 28 (Signature/Affiliation) Date: Time:

2. Relinquished by (Signature/Affiliation) Date: Time:
2. Received by (Signature/Affiliation) Date: Time:

3. Relinquished by (Signature/Affiliation) Date: Time:
3. Received by (Signature/Affiliation) Date: Time:

Comments: 29

White: To accompany samples
Yellow: Field copy
*See back of form for special instructions.

MCA 3/15/91

APPENDIX E
WELL DEVELOPMENT RECORDS

LEGEND FOR FIELD WELL DEVELOPMENT RECORDS

PVC - Measurement taken from the top of the well stick-up, top of the PVC casing.
NA - Not Applicable
BG - Background
BZ - Breathing Zone
PS - Point Source
NTU - Nephelometric Turbidity Units
V - Visual Turbidity Estimate

Baker
Baker Environmental, Inc.

FIELD WELL DEVELOPMENT RECORD

PROJECT: MCB Camp Lejeune, O.U. #9, Sites 65 and 73 Remedial Investigations

CTO NO.: 0312 WELL NO.: 65-MW01 (existin

DATE: 5/6/95

GEOLOGIST/ENGINEER: Karl A. Thomas

TIME START: 1203

TIME FINISH: 1249

INITIAL WATER LEVEL (FT): 11.98' (PVC)

TOTAL WELL DEPTH (TD): 21.4' (PVC)

WELL DIAMETER (INCHES): 2"

CALCULATED WELL VOLUME: ~1.5 gal

BOREHOLE DIAMETER (INCHES): ~10"

BOREHOLE VOLUME: ~38.4 gal

AMOUNT OF WATER ADDED DURING DRILLING: NA

DEVELOPMENT METHOD: Pump! Surge

PUMP TYPE: Centrifugal

TOTAL TIME (A): 46 min

AVERAGE FLOW (GPM)(B): 1.83 gpm

TOTAL ESTIMATED WITHDRAWAL AxB= 84 gal

HNU/OVA READING
BG=0.0 PS=5.0
BZ=0.0 (well opening)

DEVELOPMENT DATA

TIME	CUMULATIVE VOLUME (gallons)	pH	TEMP (°C)	SPEC. COND. (µmhos/cm)	TEMP (°C)	Eh	TURBIDITY [NTU]
1132	SURGED	WELL	W/	PVC SLUG	— 10	MINUTES	
1206	4.5	6.74	21.5	876	20.2		>200
1209	10.5	6.73	20.4	868	19.4		>200
1213	16.5	6.74	19.8	849	18.8		>200
1217	24.0	6.74	19.5	838	18.4		>200 ✓
1221	31.5	6.75	20.7	863	20.0		>200
1225	39.0	6.76	20.6	860	19.9		127
1229	46.5	6.76	19.5	831	18.9		~100 ✓
1233	54.0	6.76	19.8	815	18.3		13.9
1238	61.5	7.00	20.3	827	18.4		15.4
1242	69.0	6.80	19.3	813	18.7		15.2
1246	76.5	6.82	19.4	818	18.3		8.6
1249	84.0	← STABLE →					8.0

Baker
Baker Environmental, Inc.

FIELD WELL DEVELOPMENT RECORD

PROJECT: MCB Camp Lejeune, O.U. #9, Sites 65 and 73 Remedial Investigations
CTO NO.: 0312
WELL NO.: 65-MW02 (e
DATE: 4/26/95
GEOLOGIST/ENGINEER: Karl A. Thomas

TIME START: 0920
TIME FINISH: 1010
INITIAL WATER LEVEL (FT): 6.64' (PVC)
TOTAL WELL DEPTH (TD): 15.10' (PVC)
WELL DIAMETER (INCHES): 2"
CALCULATED WELL VOLUME: ~1.5 gal
BOREHOLE DIAMETER (INCHES): ~10"
BOREHOLE VOLUME: ~34.5 gal
AMOUNT OF WATER ADDED DURING DRILLING: NA
DEVELOPMENT METHOD: Pump & Surge
PUMP TYPE: Centrifugal
TOTAL TIME (A): 50 min
AVERAGE FLOW (GPM)(B): 0.9 gpm
TOTAL ESTIMATED WITHDRAWAL AxB= 45 gal
HNU/OVA READING: PS= 0.0

DEVELOPMENT DATA

TIME	CUMULATIVE VOLUME (gallons)	pH	TEMP (°C)	SPEC. COND. (µmhos/cm)	TEMP (°C)	Eh	TURBIDITY [NTU]
0923	3	6.61	19.4	339	20.2		>200
0928	9	6.37	16.0	292	16.5		>200
0934	15	6.29	16.1	263	17.0		>200
0941	21	6.29	16.4	259	16.9		79
0949	27	6.29	16.9	251	17.0		18.9
0956	33	6.39	16.9	263	17.2		9.6
1002	39	6.37	16.6	260	17.0		7.4
1010	45	6.27	16.9	246	17.0		5.3

- 0827 Began development by surging well with PVC slug for 10 minutes.
- heavy sediments, worked down the well bottom. TDFinal = 15.92'
- sands initially filled the pump hoses – LP changed hoses.

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FIELD WELL DEVELOPMENT RECORD

PROJECT: MCB Camp Lejeune, O.U. #9, Sites 65 and 73 Remedial Investigations

CTO NO.: 0312 WELL NO.: 65-MW03

DATE: 5/5/95

GEOLOGIST/ENGINEER: Karl A. Thomas

TIME START: 1840

TIME FINISH: 1915

INITIAL WATER LEVEL (FT): 12.62' (PVC)

TOTAL WELL DEPTH (TD): 22.30' (PVC)

WELL DIAMETER (INCHES): 2"

CALCULATED WELL VOLUME: 1.6 gal (Pump 1.5)

BOREHOLE DIAMETER (INCHES): ~10"

BOREHOLE VOLUME: ~39.5 gal

AMOUNT OF WATER ADDED DURING DRILLING: 0 gal

DEVELOPMENT METHOD: Pump & Surge

PUMP TYPE: Centrifugal

TOTAL TIME (A): 35 min

AVERAGE FLOW (GPM)(B): 2.70 gpm

TOTAL ESTIMATED WITHDRAWAL AxB= 94.5 gal

HNU/OVA READING
BG=0.0 PS=0.3 top of
BZ=0.0 (at well opening: PVC)

DEVELOPMENT DATA

TIME	CUMULATIVE VOLUME (gallons)	pH	TEMP (°C)	SPEC. COND. (µmhos/cm)	TEMP (°C)	Eh	TURBIDITY [NTU]
1841	3.0	6.25	19.5	265	19.2		>>200
1842	6.0	6.27	19.6	230	19.6		>> 200
1843	9.0	6.26	19.0	269	18.7		>200
1845	12.0	6.26	18.7	278	18.6		>200
1848	16.5	6.28	18.9	284	18.5		149
1850	21.0	6.28	18.6	282	18.7		>200
1851	25.5	6.27	18.4	278	18.3		>200
1852	30.0	6.28	18.1	282	18.1		>200
1854	34.5	6.28	18.0	277	18.0		>200
1857	40.5	6.30	18.2	280	18.2		154
1858	46.5	6.29	18.3	277	18.3		142
1903	58.5	6.31	18.3	262	18.1		86
1907	70.5	6.35	18.6	272	17.9		19.2
1911	82.5	6.41	18.2	270	17.9		22.0
1915	94.5	6.34	18.0	265	18.0		2.8

1820-30 Surged well with PVC slug

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FIELD WELL DEVELOPMENT RECORD

PROJECT: MCB Camp Lejeune, O.U. #9, Sites 65 and 73 Remedial Investigation

CTO NO.: 0312

WELL NO.: 65-MW04

DATE: 4/25/95

GEOLOGIST/ENGINEER: Tom P. Valli

TIME START: 0904

TIME FINISH: 1154

INITIAL WATER LEVEL (FT): 14.61'(PVC)

TOTAL WELL DEPTH (TD): 24.60'(PVC)

WELL DIAMETER (INCHES): 2"

CALCULATED WELL VOLUME: 1.70 gal

BOREHOLE DIAMETER (INCHES): ~10"

BOREHOLE VOLUME: ~40.8 gal

AMOUNT OF WATER ADDED DURING DRILLING: 0 gal

DEVELOPMENT METHOD: Pump & Surge

PUMP TYPE: Waterra

TOTAL TIME (A): 170 min

AVERAGE FLOW (GPM)(B): 0.48 gpm

TOTAL ESTIMATED WITHDRAWAL AxB= 81 gal

HNU/OVA READING: PS=0.0 -assumed, no record

DEVELOPMENT DATA

ALL DATA POINTS NOT PRESENTED, FOR COMPLETE RECORD SEE TPV's FIELD LOG BOOK: CTO 312, VOL.I. p. 81-82

TIME	CUMULATIVE VOLUME (gallons)	pH	TEMP (°C)	SPEC. COND. (µmhos/cm)	TEMP (°C)	Eh	TURBIDITY [NTU]
0904	3	4.82	15.5	71.5	15.7		>200
0916	9	3.97	15.4	68.4	16.6		>200
0927	15	4.19	14.6	64.9	16.0		>200
0939	21	4.41	15.5	64.7	15.9		>200
0952	27	4.63	16.2	65.9	16.4		>200
1002	30	4.31	15.5	66.7	16.5		152
1026	39	4.64	16.6	67.4	16.6		172
1039	45	4.27	17.0	66.3	16.7		118
1102	54	3.97	16.5	66.2	16.8		91
1106	57	4.23	15.9	65.7	16.1		88
1114	63	4.79	15.8	66.1	16.2		63
1130	69	4.96	16.2	66.2	16.4		52.5
1144	75	4.97	16.1	66.3	16.5		48.8
1149	78	4.98	16.4	66.4	16.6		45.9
1154	81	4.99	17.5	66.6	17.1		44.5

Waterra's action while pumping serves to surge the well, therefore the PVC slug used to surge wells developed with the Centrifugal pump is not used.

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FIELD WELL DEVELOPMENT RECORD

PROJECT: MCB Camp Lejeune, O.U. #9, Sites 65 and 73 Remedial Investigations
CTO NO.: 0312
WELL NO.: 65-MW05
DATE: 5/5/95
GEOLOGIST/ENGINEER: Karl A. Thomas

TIME START: 1608
TIME FINISH: 1721
INITIAL WATER LEVEL (FT): 11.10' (PVC)
TOTAL WELL DEPTH (TD): 24.91' (PVC)
WELL DIAMETER (INCHES): 2"
CALCULATED WELL VOLUME: 2.3 gal (Pump 2.5)
BOREHOLE DIAMETER (INCHES): ~10"
BOREHOLE VOLUME: ~56.3 gal
AMOUNT OF WATER ADDED DURING DRILLING: 20 gal
DEVELOPMENT METHOD: Pump & Surge
PUMP TYPE: Centrifugal
TOTAL TIME (A): 73 min
AVERAGE FLOW (GPM)(B): 1.44 gpm
TOTAL ESTIMATED WITHDRAWAL AxB= 105 gal
HNU/OVA READING
BG=0.1 PS= 2.5
BZ= 0.1 (well opening: PVC top)

DEVELOPMENT DATA

ALL DATA POINTS NOT PRESENTED, FOR COMPLETE RECORD, SEE KAT'S FIELD LOGBOOK: CTO 312, VOL. II. p. 78-81.

TIME	CUMULATIVE VOLUME (gallons)	pH	TEMP (°C)	SPEC. COND. (µmhos/cm)	TEMP (°C)	Eh	TURBIDITY [NTU]
1610	5	5.85	19.3	221	18.2		>>200
1616	15	5.98	18.0	240	17.8		>200
1622	25	5.99	18.0	245	17.9		>200
1631	35	6.03	18.0	243	17.9		195
1638	45	6.01	17.9	244	18.3		81
1645	55	6.11	18.2	245	17.9		97
1653	65	6.06	18.1	245	18.0		61
1656	70	6.06	18.1	240	18.2		27
1700	75	← S	T	A B L	E →		24
1703	80						26
1706	85						21
1710	90						20
1714	95						18.4
1718	100						12.9
1721	105	↓	↓	↓	↓		7.6

During development, moved intake from the water level (or 8' off bottom) down to the well bottom — moving across most of the well screen.

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FIELD WELL DEVELOPMENT RECORD

PROJECT: MCB Camp Lejeune, O.U. #9, Sites 65 and 73 Remedial Investigations
CTO NO.: 0312
WELL NO.: 65-MW06
DATE: 4/25/95
GEOLOGIST/ENGINEER: Tom P. Valli

TIME START: 1330 (1st reading)
TIME FINISH: 1603
INITIAL WATER LEVEL (FT): 7.50' (PVC)
TOTAL WELL DEPTH (TD): 21.38' (PVC)
WELL DIAMETER (INCHES): 2"
CALCULATED WELL VOLUME: 2.36 gal
BOREHOLE DIAMETER (INCHES): ~10"
BOREHOLE VOLUME: ~56.6 gal
AMOUNT OF WATER ADDED DURING DRILLING: 0 gal
DEVELOPMENT METHOD: Pump
PUMP TYPE: Waterra
TOTAL TIME (A): 153 min
AVERAGE FLOW (GPM)(B): 0.91 gpm
TOTAL ESTIMATED WITHDRAWAL AxB= 140 gal
HNU/OVA READING: PS=0.0

DEVELOPMENT DATA

ALL DATA POINTS NOT PRESENTED, FOR COMPLETE WELL RECORD SEE TPV's FIELD LOGBOOK: CTO 312, VOL. I. p. 83-85

TIME	CUMULATIVE VOLUME (gallons)	pH	TEMP (°C)	SPEC. COND. (µmhos/cm)	TEMP (°C)	Eh	TURBIDITY [NTU]
1330	5	5.44	16.4	183.2	16.4		>200
1345	15	5.44	16.2	171.0	15.9		>200
1400	25	5.44	16.1	166.8	16.0		>200
1415	35	5.48	16.3	161.7	16.1		>200
1429	45	5.47	16.2	157.1	16.2		>200
1440	55	5.50	16.3	156.6	16.4		>200
1452	65	5.48	16.4	156.0	16.6		>200
1505	75	5.47	16.6	156.1	16.4		>200
1520	85	5.44	16.9	155.5	16.6		192
1529	95	5.44	16.9	155.7	16.6		>200
1536	105	5.49	16.6	157.7	16.7		>200
1544	115	5.50	16.4	156.1	16.6		>200
1553	125	5.50	16.6	154.1	16.5		>200
1559	135	5.51	16.8	155.7	16.8		200
1603	140	5.52	17.0	156.7	16.8		200

The waterra pump serves the purpose of a surge devise throughout the duration of the development due to its designed motion. This may be the reason why the TURB never got much below 200 NTU.

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FIELD WELL DEVELOPMENT RECORD

PROJECT: MCB Camp Lejeune, O.U. #9, Sites 65 and 73 Remedial Investigations
CTO NO.: 0312
WELL NO.: 65-MW07
DATE: 5/6/95
GEOLOGIST/ENGINEER: Karl A. Thomas

TIME START: 0952
TIME FINISH: 1035
INITIAL WATER LEVEL (FT): 12.75' (PVC)
TOTAL WELL DEPTH (TD): 24.91' (PVC)
WELL DIAMETER (INCHES): 2"
CALCULATED WELL VOLUME: 2.1 gal (Pump 2)
BOREHOLE DIAMETER (INCHES): ~10"
BOREHOLE VOLUME: ~49.6 gal
AMOUNT OF WATER ADDED DURING DRILLING: ~25 gal
DEVELOPMENT METHOD: Pump : Surge
PUMP TYPE: Centrifugal
TOTAL TIME (A): 43 min
AVERAGE FLOW (GPM)(B): 1.91 gpm
TOTAL ESTIMATED WITHDRAWAL AxB= 82 gal
HNU/OVA READING: BG=0.2 PS=0.2 BZ=0.2 (at top of PVC)

DEVELOPMENT DATA

TIME	CUMULATIVE VOLUME (gallons)	pH	TEMP (°C)	SPEC. COND. (µmhos/cm)	TEMP (°C)	Eh	TURBIDITY [NTU]
0956	8	5.78	17.9	227	17.8		>>200
0959	12	5.84	17.8	243	17.9		>>200
1002	18	5.88	17.8	242	17.9		>200
1006	26	5.89	17.2	240	17.6		>200
1010	34	5.88	17.8	243	17.9		173 M >200 V
1014	42	5.92	17.1	240	17.4		145
1018	50	5.89	17.5	236	17.7		>200
1022	58	← ERROR -		DUMPED SAMPLE	→		81
1027	66	5.91	17.7	231	17.7		17.1
1031	74	5.91	17.9	241	17.7		6.5
1035	82	← S	T	A B L	E →		8.9

0925-33 Pumped 25 gallons of installation water
0937-47 Surged well with PVC slug

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FIELD WELL DEVELOPMENT RECORD

PROJECT: MCB Camp Lejeune, O.U. #9, Sites 65 and 73 Remedial Investigations
CTO NO.: 0312 WELL NO.: 65-DW01
DATE: 5/6/95
GEOLOGIST/ENGINEER: Karl A. Thomas

*1400 started pumping out 100 gal

TIME START (after pumping 100 gal): 1513
TIME FINISH: 1725
INITIAL WATER LEVEL (FT): 19.19' (PVC)
TOTAL WELL DEPTH (TD): initial: 56.40' final: 66.90'
WELL DIAMETER (INCHES): 2"
CALCULATED WELL VOLUME (based on initial TD): 6.3 gal
BOREHOLE DIAMETER (INCHES): ~6"
BOREHOLE VOLUME: ~70.0 gal
AMOUNT OF WATER ADDED DURING DRILLING: 1,200 gal +
DEVELOPMENT METHOD: Pump: Surge
PUMP TYPE: Centrifugal
TOTAL TIME (A): 132 min
AVERAGE FLOW (GPM)(B): 1.15 gpm
TOTAL ESTIMATED WITHDRAWAL AxB= → 166.2 gal (NOT including 100 gal initially w/drawn)
HNU/OVA READING: PS=0.0

DEVELOPMENT DATA

TIME	CUMULATIVE VOLUME (gallons)	pH	TEMP (°C)	SPEC. COND. (µmhos/cm)	TEMP (°C)	Eh	TURBIDITY [NTU]
1513	100 gal	7.99	24.0	316	21.0		34
1524	112.6	8.17	21.3	309	20.7		34
WORKED INTAKE UP AND DOWN WELL SCREEN – 2 MIN							
1534	125.2	8.75	21.1	310	20.7		>200
1544	137.8	7.98	21.3	313	21.0		76
1554	150.4	8.02	20.7	312	20.6		62
1604	163.0	8.06	20.4	309	20.3		76
WORKED SCREEN AGAIN – WATERRA MOTION • STOPPED PUMPING TO RECHARGE → MAY HAVE FORCED OUT TOO MUCH WATER WHILE WORKING SCREEN							
1655	203.2	7.87	21.2	313	20.8		13.3
1705	222.1	7.80	20.7	309	20.6		9.9
1715	241.0	7.92	20.5	310	20.6		8.3
1725	266.2	7.92	20.7	310	20.6		8.3

*1400 Started pumping 100 gal out of well before taking any readings.

Initial Bottom was very soft. During 100 gallons, pumped out obvious installation fluids – grey and thick. Worked down bottom to TD final = 66.90'.

* [Due to the unusually large volume of water lost to formation during well installation, decided to pump for at least 3 hours and in this case we pumped 100 gal. then began taking stability measurements. Did not removed the entire ~1,200 gal.]

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FIELD WELL DEVELOPMENT RECORD

PROJECT: MCB Camp Lejeune, O.U. #9, Sites 65 and 73 Remedial Investigations
CTO NO.: 0312 WELL NO.: 65-DW02
DATE: 4/26/95
GEOLOGIST/ENGINEER: Karl A. Thomas

TIME START: 0905
TIME FINISH: 1052
INITIAL WATER LEVEL (FT): 17.0' (PVC)
TOTAL WELL DEPTH (TD): 55.4' (PVC)
WELL DIAMETER (INCHES): 2"
CALCULATED WELL VOLUME: 6.5 gal
BOREHOLE DIAMETER (INCHES): ~6"
BOREHOLE VOLUME: ~56.4 gal
AMOUNT OF WATER ADDED DURING DRILLING: ~120 gal
DEVELOPMENT METHOD: Pump & Surge
PUMP TYPE: Waterra
TOTAL TIME (A): 107 min
AVERAGE FLOW (GPM)(B): 1.09 gpm
TOTAL ESTIMATED WITHDRAWAL AxB= 117 gal
HNU/OVA READING: BZ=0.0 BG=0.0 PS=0.5 (at top of PVC)

DEVELOPMENT DATA

ALL DATA POINTS NOT PRESENTED, FOR COMPLETE RECORD SEE KAT'S FIELD LOGBOOK: CTO 312, VOL. II. p. 31, 34-3

TIME	CUMULATIVE VOLUME (gallons)	pH	TEMP (°C)	SPEC. COND. (µmhos/cm)	TEMP (°C)	Eh	TURBIDITY [NTU]
0914	6.5	7.32	16.6	469	17.3		>200
0919	13.0	6.99	16.7	482	16.9		>200
0924	19.5	6.92	17.5	491	17.3		140
0931	32.5	6.86	16.7	498	17.4		105
0943	45.5	6.86	17.2	495	17.3		79
0950	52.0	6.83	16.7	500	17.3		43
1003	65.0	6.82	17.0	510	17.6		28
1009	71.5	6.80	16.9	511	17.6		25
1015	78.0	← STABLE →					20.6
1027	84.5						35
1032	91.0						17.9
1037	97.5						13.5
1042	104.0						11.8
1046	110.5						9.9
1052	117.0						9.0

Although well met criteria of stability and TURB <10 NTU, not all the estimated volume of installation water (120 gal) was removed during development. GRA returned to the well on 5/7/95 and pumped out ~40 gallons of water, then measured for water stability and turbidity <10 NTU. Achieved both quickly.

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FIELD WELL DEVELOPMENT RECORD

PROJECT: MCB Camp Lejeune, O.U. #9, Sites 65 and 73 Remedial Investigations
CTO NO.: 0312
WELL NO.: 65-DW04
DATE: 5/8/95
GEOLOGIST/ENGINEER: Graydon & Allen

TIME START: 1825
TIME FINISH: 2143
INITIAL WATER LEVEL (FT): 34.2'
TOTAL WELL DEPTH (TD): 70.0' (est.)
WELL DIAMETER (INCHES): 2"
CALCULATED WELL VOLUME: 6 gal
BOREHOLE DIAMETER (INCHES): ~6"
BOREHOLE VOLUME: ~53 gal
AMOUNT OF WATER ADDED DURING DRILLING: 200+ gal
DEVELOPMENT METHOD: Pump & Surge
PUMP TYPE: Waterra
TOTAL TIME (A): 198 min
AVERAGE FLOW (GPM)(B): 1.05 gpm
TOTAL ESTIMATED WITHDRAWAL AxB= 200 gal
HNU/OVA READING: NOT RECORDED BEING TAKEN

DEVELOPMENT DATA

* For further information regarding 65-DW04 and possil
introduction of particles please see KAT's Logbook: CTO 312 VOL. II p.
See also JSC's Logbook dated 5/16/9

TIME	CUMULATIVE VOLUME (gallons)	pH	TEMP (°C)	SPEC. COND. (µmhos/cm)	TEMP (°C)	Eh	TURBIDITY [NTU]
1836	11	9.28	17.4	215	18.1		93.6
1846	23	8.71	17.3	213	18.1		77.5
1856	35	8.72	17.3	212	18.0		85
1906	45	8.69	17.3	213	18.1		80
1916	55	8.63	17.2	214	18.1		65
1926	65	8.67	17.4	214	18.1		60
1937	75	8.61	17.4	214	18.0		60
1947	85	8.59	17.2	214	18.0		53
2127	185	8.76	16.7	212	17.8		58
2135	192	8.59	16.6	214	17.6		58
2143	200	8.55	17.0	214	17.8		61

- Although not clearly noted in GRA's notes, he had to pump out 200+ gallons of installation water from well.
- with new 1/2" PVC piping; GRA & driller set up waterra and allowed it to pump for a timed interval, starting at ~1200 going until about 1445.

During development w/ KAT, KAT noticed a powder-like substance on the PVC piping which was the intake for the pump. As the crew withdrew the piping, the powder was visible on the piping which entered the well water.

* NOTE: JSC returned to this well later to pump out any introduced particles

APPENDIX F
IDW MANAGEMENT AND DISPOSAL INFORMATION

Baker

Baker Environmental, Inc.
Airport Office Park, Building 3
420 Rouser Road
Coraopolis, Pennsylvania 15108

(412) 269-6000
FAX (412) 269-2002

August 2, 1995

Commander
Atlantic Division
Naval Facilities Engineering Command
1510 Gilbert Street (Building N-26)
Norfolk, Virginia 23511-2699

Attn: Mr. Lance Laughmiller, EIT
Code 18236

Re: Contract N62470-89-D-4814
Navy CLEAN, District III
Contract Task Order (CTO) 0312
IDW Handling and Disposal
Operable Unit No. 9 (Site 73)
MCB, Camp Lejeune, North Carolina

Dear Mr. Laughmiller:

This letter report describes the sample collection activities, results, and recommendations for the disposition of investigative-derived waste (IDW) at Site 73, Marine Corps Base, Camp Lejeune, North Carolina.

The IDW from Sites 65 and 73 field activities, presently being stored at Site 73, is contained in one 6,500-gallon storage tanker, one 1,000-gallon polyethylene tank, and one 20-cubic yard roll-off box. A second 6,500-gallon storage tanker was judged to contain "clean" water and was discharged at Site 73. An inventory of the IDW along with quantities are provided in Table 1. Analytical results are provided in Attachment A.

Sample Collection and Analysis Site 73

One grab sample was collected from the 6,500-gallon tanker and given the sample identification 73-TK-615. A grab sample was also collected from the second 6,500-gallon tanker and given the sample identification 73-TK-3617. These samples were analyzed for full Target Compound List (TCL) Organics, Target Analyte List (TAL) Inorganics, and Total Suspended Solids (TSS). Another grab sample was collected from the 1,000 gallon polyethylene tank and given the sample identification 73-POLY-01. This sample was analyzed for full TCL Organics and TAL Inorganics. Five solid grab samples were collected from varying locations within the roll-off box. These grab samples were placed within a stainless steel mixing bowl, homogenized into one composite sample and given the sample identification 73-RX-01. A representative sample was collected for volatile organics analysis prior to homogenizing the samples. This composite sample was analyzed for full Toxicity Characteristic Leachate Procedure (TCLP), TCL PCBs and Resource Conservation Recovery Act (RCRA) characteristics (corrosivity, ignitability, and reactivity).

Results Site 73

Sample 73-TK-615 had five positive volatile detections, one positive semivolatile detection, and no positive detections for ether pesticides or PCBs. Inorganic analysis did not indicate concentrations above regulatory standards. Sample 73-POLY-01 had six volatile detections, two positive semivolatile detections, and no positive detections for ether pesticides or PCBs. Inorganic analysis did not indicate concentrations above regulatory standards. Sample 73-RX-01 did not have any positive detections for organics, and inorganic analysis did not indicate concentrations above regulatory standards. In addition, sample 73-RX-01 was not found to be reactive to sulfide and cyanide, ignitable at less than 140°F, or corrosive at less than or equal to 2 or greater than or equal to 12.5.

Conclusions and Recommendations Site 73

Analytical results indicate that samples 73-TK-615 and 73-POLY-01 have levels of organic contamination that do not exceed regulatory values, however due to the organic contamination levels present in both tanks site disposal is not recommended. Through working with base EMD personnel, disposal of tanker 73-TK-615 can be accomplished by utilizing the Hadnot Point Shallow Aquifer Remedial Action System located on base. This tanker will be returned to Site 73 and the contents of the polyethylene tank will be pumped into it. The tanker will remain on-site for the additional work that will begin at Site 73 during September 1995. Upon completion of the additional work at Site 73, this tanker will be sampled for TCL Organics, TAL Inorganics, and TSS. Appropriate disposal methods will be deployed upon review of the analytical results. Sample 73-RX-01 did not indicate contamination and it is recommended that the contents of the roll-off box be returned to the site and graded.

Upon LANTDIV's approval of these disposal recommendations, the IDW will be managed as identified within this letter.

If you have any questions, please do not hesitate to contact me at (412) 269-4695 or Mr. Matthew D. Bartman (Activity Coordinator) at (412) 269-2053.

Sincerely,

BAKER ENVIRONMENTAL, INC.

Matthew D Bartman
for

Malcolm W. Petroccia
Project Manager

MWP/PAM/lq

Attachments

cc: Mr. Neal Paul - w/attachments
Mr. John Riggs - w/attachments

TABLE 1

TABLE 1

SUMMARY OF INVESTIGATIVE DERIVED WASTE
OPERABLE UNIT NO. 9 (SITES 65 and 73)
REMEDIAL INVESTIGATION, CTO-0312
MCB, CAMP LEJEUNE, NORTH CAROLINA

MATERIAL (LOCATION)	QUANTITY PRODUCED	CONTAINER TYPE	VOLUME OF WASTE	UNIT	LABORATORY ANALYSIS
Development/Purge Water (Site 73)	2	6,500 Gallon Tanker	6,500	gallons	TCL Organics TAL Inorganics TSS
Development/Purge Water (Site 73)	1	1,000 Gallon Polyethylene Tank	1,000	gallons	TCL Organics TAL Inorganics
Drill Mud/Cuttings (Site 73)	1	20 cubic yard roll-off box	20	cubic yards	TCLP Organics TCLP Inorganics TCL PCBs RCRA Hazardous Characteristics

ATTACHMENT A

EPA SAMPLE NO.

73TK615

1A
VOLATILE ORGANICS ANALYSIS DATA SHEET

Lab Name: ITAS-KNOXVILLE Contract: BAKER

Lab Code: ITSTU Case No.: 3572 SAS No.: ______ SDG No.: 73TK3

Matrix: (soil/water) WATER Lab Sample ID: AF3167

Sample wt/vol: 5.0 (g/mL) ML Lab File ID: AF3167

Level: (low/med) LOW Date Received: 05/11/95

% Moisture: not dec. ____ Date Analyzed: 05/17/95

GC Column: RTX624 ID: 0.530 (mm) Dilution Factor: 1.0

Soil Extract Volume: ______ (uL) Soil Aliquot Volume: ______ (uL)

CAS NO.	COMPOUND	CONCENTRATION UNITS: (ug/L or ug/Kg) UG/L	Q
74-87-3	Chloromethane	10	U
74-83-9	Bromomethane	10	U
75-01-4	Vinyl Chloride	10	U
75-00-3	Chloroethane	10	U
75-09-2	Methylene Chloride	10	U
67-64-1	Acetone	7	BJ
75-15-0	Carbon Disulfide	10	U
75-35-4	1,1-Dichloroethene	10	U
75-34-3	1,1-Dichloroethane	10	U
540-59-0	1,2-Dichloroethene (total)	12	
67-66-3	Chloroform	1	J
107-06-2	1,2-Dichloroethane	2	BJ
78-93-3	2-Butanone	10	U
71-55-6	1,1,1-Trichloroethane	10	U
56-23-5	Carbon Tetrachloride	10	U
75-27-4	Bromodichloromethane	10	U
78-87-5	1,2-Dichloropropane	10	U
10061-01-5	cis-1,3-Dichloropropene	10	U
79-01-6	Trichloroethene	12	
124-48-1	Dibromochloromethane	10	U
79-00-5	1,1,2-Trichloroethane	10	U
71-43-2	Benzene	10	U
10061-02-6	trans-1,3-Dichloropropene	10	U
75-25-2	Bromoform	10	U
108-10-1	4-Methyl-2-Pentanone	10	U
591-78-6	2-Hexanone	10	U
127-18-4	Tetrachloroethene	10	U
79-34-5	1,1,2,2-Tetrachloroethane	10	U
108-88-3	Toluene	10	U
108-90-7	Chlorobenzene	10	U
100-41-4	Ethylbenzene	10	U
100-42-5	Styrene	10	U
1330-20-7	Xylene (total)	10	U

1E
VOLATILE ORGANICS ANALYSIS DATA SHEET
TENTATIVELY IDENTIFIED COMPOUNDS

EPA SAMPLE NO.
73TK615

Lab Name: ITAS-KNOXVILLE Contract: BAKER

Lab Code: ITSTU Case No.: 3572 SAS No.: ______ SDG No.: 73TK3

Matrix: (soil/water) WATER Lab Sample ID: AF3167

Sample wt/vol: 5.0 (g/mL) ML Lab File ID: AF3167

Level: (low/med) LOW Date Received: 05/11/95

% Moisture: not dec. ____ Date Analyzed: 05/17/95

GC Column: RTX624 ID: 0.530 (mm) Dilution Factor: 1.0

Soil Extract Volume: ______ (uL) Soil Aliquot Volume: ____(uL)

CONCENTRATION UNITS:
(ug/L or ug/Kg) UG/L

Number TICs found: 0

CAS NUMBER	COMPOUND NAME	RT	EST. CONC.	Q

FORM I VOA-TIC 3/90

1B

SEMIVOLATILE ORGANICS ANALYSIS DATA SHEET

EPA SAMPLE NO.

73TK615

Lab Name: ITAS-KNOXVILLE Contract: BAKER

Lab Code: ITSTU Case No.: 3572 SAS No.: ______ SDG No.: 73TK6

Matrix: (soil/water) WATER

Lab Sample ID: AF3168

Sample wt/vol: 1000 (g/mL) ML

Lab File ID: AF3168

Level: (low/med) LOW

Date Received: 05/11/95

% Moisture: _____ decanted: (Y/N) ___

Date Extracted: 05/12/95

Concentrated Extract Volume: 1000 (uL)

Date Analyzed: 05/17/95

Injection Volume: 2.0(uL)

Dilution Factor: 1.0

GPC Cleanup: (Y/N) N pH: ____

CAS NO.	COMPOUND	CONCENTRATION UNITS: (ug/L or ug/Kg) UG/L	Q
108-95-2	Phenol	10	U
111-44-4	bis(2-Chloroethyl)Ether	10	U
95-57-8	2-Chlorophenol	10	U
541-73-1	1,3-Dichlorobenzene	10	U
106-46-7	1,4-Dichlorobenzene	10	U
95-50-1	1,2-Dichlorobenzene	10	U
95-48-7	2-Methylphenol	10	U
108-60-1	2,2'-oxybis(1-Chloropropane)	10	U
106-44-5	4-Methylphenol	10	U
621-64-7	N-Nitroso-Di-n-Propylamine	10	U
67-72-1	Hexachloroethane	10	U
98-95-3	Nitrobenzene	10	U
78-59-1	Isophorone	10	U
88-75-5	2-Nitrophenol	10	U
105-67-9	2,4-Dimethylphenol	10	U
111-91-1	bis(2-Chloroethoxy)Methane	10	U
120-83-2	2,4-Dichlorophenol	10	U
120-82-1	1,2,4-Trichlorobenzene	10	U
91-20-3	Naphthalene	10	U
106-47-8	4-Chloroaniline	10	U
87-68-3	Hexachlorobutadiene	10	U
59-50-7	4-Chloro-3-Methylphenol	10	U
91-57-6	2-Methylnaphthalene	10	U
77-47-4	Hexachlorocyclopentadiene	10	U
88-06-2	2,4,6-Trichlorophenol	10	U
95-95-4	2,4,5-Trichlorophenol	25	U
91-58-7	2-Chloronaphthalene	10	U
88-74-4	2-Nitroaniline	25	U
131-11-3	Dimethylphthalate	10	U
208-96-8	Acenaphthylene	10	U
606-20-2	2,6-Dinitrotoluene	10	U
99-09-2	3-Nitroaniline	25	U
83-32-9	Acenaphthene	10	U

1C

SEMIVOLATILE ORGANICS ANALYSIS DATA SHEET

EPA SAMPLE NO.

73TK615

Lab Name: ITAS-KNOXVILLE Contract: BAKER

Lab Code: ITSTU Case No.: 3572 SAS No.: ______ SDG No.: 73TK6

Matrix: (soil/water) WATER Lab Sample ID: AF3168

Sample wt/vol: 1000 (g/mL) ML Lab File ID: AF3168

Level: (low/med) LOW Date Received: 05/11/95

% Moisture: ______ decanted: (Y/N) ___ Date Extracted: 05/12/95

Concentrated Extract Volume: 1000 (uL) Date Analyzed: 05/17/95

Injection Volume: 2.0(uL) Dilution Factor: 1.0

GPC Cleanup: (Y/N) N pH: ____

CAS NO.	COMPOUND	CONCENTRATION UNITS: (ug/L or ug/Kg) UG/L	Q
51-28-5	2,4-Dinitrophenol	25	U
100-02-7	4-Nitrophenol	25	U
132-64-9	Dibenzofuran	10	U
121-14-2	2,4-Dinitrotoluene	10	U
84-66-2	Diethylphthalate	10	U
7005-72-3	4-Chlorophenyl-phenylether	10	U
86-73-7	Fluorene	10	U
100-01-6	4-Nitroaniline	25	U
534-52-1	4,6-Dinitro-2-Methylphenol	25	U
86-30-6	N-Nitrosodiphenylamine (1)	10	U
101-55-3	4-Bromophenyl-phenylether	10	U
118-74-1	Hexachlorobenzene	10	U
87-86-5	Pentachlorophenol	25	U
85-01-8	Phenanthrene	10	U
120-12-7	Anthracene	10	U
86-74-8	Carbazole	10	U
84-74-2	Di-n-Butylphthalate	1	BJ
206-44-0	Fluoranthene	10	U
129-00-0	Pyrene	10	U
85-68-7	Butylbenzylphthalate	10	U
91-94-1	3,3'-Dichlorobenzidine	10	U
56-55-3	Benzo(a)Anthracene	10	U
218-01-9	Chrysene	10	U
117-81-7	bis(2-Ethylhexyl)Phthalate	10	U
117-84-0	Di-n-Octyl Phthalate	10	U
205-99-2	Benzo(b)Fluoranthene	10	U
207-08-9	Benzo(k)Fluoranthene	10	U
50-32-8	Benzo(a)Pyrene	10	U
193-39-5	Indeno(1,2,3-cd)Pyrene	10	U
53-70-3	Dibenz(a,h)Anthracene	10	U
191-24-2	Benzo(g,h,i)Perylene	10	U

(1) - Cannot be separated from Diphenylamine

1F

SEMIVOLATILE ORGANICS ANALYSIS DATA SHEET
TENTATIVELY IDENTIFIED COMPOUNDS

EPA SAMPLE NO.

73TK615

Lab Name: ITAS-KNOXVILLE Contract: BAKER

Lab Code: ITSTU Case No.: 3572 SAS No.: ______ SDG No.: 73TK6

Matrix: (soil/water) WATER Lab Sample ID: AF3168

Sample wt/vol: 1000 (g/mL) ML Lab File ID: AF3168

Level: (low/med) LOW Date Received: 05/11/95

% Moisture: _____ decanted: (Y/N) ___ Date Extracted: 05/12/95

Concentrated Extract Volume: 1000 (uL) Date Analyzed: 05/17/95

Injection Volume: 2.0 (uL) Dilution Factor: 1.0

GPC Cleanup: (Y/N) N pH: ____

CONCENTRATION UNITS:

Number TICs found: 0 (ug/L or ug/Kg) UG/L

CAS NUMBER	COMPOUND NAME	RT	EST. CONC.	Q

1D
PESTICIDE ORGANICS ANALYSIS DATA SHEET

EPA SAMPLE NO.

73TK615

Lab Name: ITAS-KNOXVILLE Contract:

Lab Code: Case No.: WO3573 SAS No.: SDG No.: 73RB19

Matrix: (soil/water) WATER Lab Sample ID: AF3176

Sample wt/vol: 1000 (g/mL) ML Lab File ID:

% Moisture: decanted: (Y/N) Date Received: 05/11/95

Extraction: (SepF/Cont/Sonc) CONT Date Extracted: 05/15/95

Concentrated Extract Volume: 10000 (uL) Date Analyzed: 05/25/95

Injection Volume: 1.00 (uL) Dilution Factor: 1.00

GPC Cleanup: (Y/N) N pH: 7.0 Sulfur Cleanup: (Y/N) N

CAS NO.	COMPOUND	CONCENTRATION UNITS: (ug/L or ug/Kg) UG/L	Q
319-84-6	alpha-BHC	0.050	U
319-85-7	beta-BHC	0.050	U
319-86-8	delta-BHC	0.050	U
58-89-9	gamma-BHC (Lindane)	0.050	U
76-44-8	Heptachlor	0.050	U
309-00-2	Aldrin	0.050	U
1024-57-3	Heptachlor epoxide	0.050	U
959-98-8	Endosulfan I	0.050	U
60-57-1	Dieldrin	0.10	U
72-55-9	4,4'-DDE	0.10	U
72-20-8	Endrin	0.10	U
33213-65-9	Endosulfan II	0.10	U
72-54-8	4,4'-DDD	0.10	U
1031-07-8	Endosulfan sulfate	0.10	U
50-29-3	4,4'-DDT	0.10	U
72-43-5	Methoxychlor	0.50	U
53494-70-5	Endrin ketone	0.10	U
7421-93-4	Endrin aldehyde	0.10	U
5103-71-9	alpha-Chlordane	0.050	U
5103-74-2	gamma-Chlordane	0.050	U
8001-35-2	Toxaphene	5.0	U
12674-11-2	Aroclor-1016	1.0	U
11104-28-2	Aroclor-1221	2.0	U
11141-16-5	Aroclor-1232	1.0	U
53469-21-9	Aroclor-1242	1.0	U
12672-29-6	Aroclor-1248	1.0	U
11097-69-1	Aroclor-1254	1.0	U
11096-82-5	Aroclor-1260	1.0	U

U.S. EPA - CLP

1

INORGANIC ANALYSES DATA SHEET

EPA SAMPLE NO.

73TK615

Lab Name: QUANTERRA_KNOXVILLE______ Contract: BAKER/CL__
Lab Code: ITSTU_ Case No.: 3572_ SAS No.: ______ SDG No.: N/A___
Matrix (soil/water): WATER Lab Sample ID: AF3169
Level (low/med): LOW__ Date Received: 05/11/95
% Solids: __0.0

Concentration Units (ug/L or mg/kg dry weight): UG/L_

CAS No.	Analyte	Concentration	C	Q	M
7429-90-5	Aluminum	21700			P
7440-36-0	Antimony	50.0	U		P
7440-38-2	Arsenic	10.0	U		P
7440-39-3	Barium	79.6	B		P
7440-41-7	Beryllium	1.0	U		P
7440-43-9	Cadmium	5.0	U		P
7440-70-2	Calcium	84600			P
7440-47-3	Chromium	43.5			P
7440-48-4	Cobalt	20.0	U		P
7440-50-8	Copper	24.4	B		P
7439-89-6	Iron	17300			P
7439-92-1	Lead	23.0			P
7439-95-4	Magnesium	4850	B		P
7439-96-5	Manganese	159			P
7439-97-6	Mercury	0.20	U		CV
7440-02-0	Nickel	20.0	U		P
7440-09-7	Potassium	4500	B		P
7782-49-2	Selenium	5.0	U		P
7440-22-4	Silver	5.0	U		P
7440-23-5	Sodium	23200			P
7440-28-0	Thallium	10.0	U		P
7440-62-2	Vanadium	37.5	B		P
7440-66-6	Zinc	154			P

Color Before: COLORLESS Clarity Before: CLEAR_ Texture: N/A___
Color After: COLORLESS Clarity After: CLEAR_ Artifacts: ______

Comments:
CLIENT_SAMPLE_ID_NO._IS_73-TK-615.

QUANTERRA INCORPORATED
PRELIMINARY DATA SUMMARY

Data have NOT been through final levels of review and are subject to change upon this review. Actions taken on these Data are the responsibility of the Data user.

C5E120060
QUANTERRA
CAMP LEJEUNE

PARAMETER	RESULT	REPORTING LIMIT	UNIT	METHOD
73-TK-3617 05/09/95 00:00				
Inorganic Analysis				Reviewed
Reactive Cyanide	ND	50.0	mg/kg	SW846 7.3.3.
Flash Point Closed Cup	>200		deg F	SW846 1010
pH Aqueous	6.9	1.0	su	SW846 9040
Sulfide Reactive	ND	50.0	mg/kg	SW846 7.3.4.
73-TK-615 05/09/95 00:00				
Inorganic Analysis				Reviewed
Reactive Cyanide	ND	50.0	mg/kg	SW846 7.3.3.
Flash Point Closed Cup	>200		deg F	SW846 1010
pH Aqueous	8.0	1.0	su	SW846 9040
Sulfide Reactive	ND	50.0	mg/kg	SW846 7.3.4.

TOTAL SUSPENDED SOLIDS ANALYSIS

Laboratory Name:	Quanterra-Knoxville	Job Number:	3682
Contract Name:	Baker Camp Lejeune	Analysis Date:	05/25/95
Sample Matrix:	Water	Concentration Units:	mg/L

Client Sample ID	Lab Sample ID	Result	Qualifier
Method Blank	AF5017	1	U
73-TK-3617	AF4536	3300	+
73-TK-615	AF4537	700	+

+ - Positive result.
U - Compound was analyzed for but not detected. The number is the detection limit for the sample.

1A
VOLATILE ORGANICS ANALYSIS DATA SHEET

EPA SAMPLE NO.

73TK3617

Lab Name: ITAS-KNOXVILLE Contract: BAKER

Lab Code: ITSTU Case No.: 3572 SAS No.: ______ SDG No.: 73TK3

Matrix: (soil/water) WATER Lab Sample ID: AF3163

Sample wt/vol: 5.0 (g/mL) ML Lab File ID: AF3163

Level: (low/med) LOW Date Received: 05/11/95

% Moisture: not dec. ____ Date Analyzed: 05/17/95

GC Column: RTX624 ID: 0.530 (mm) Dilution Factor: 1.0

Soil Extract Volume: ______ (uL) Soil Aliquot Volume: ______(uL)

CAS NO.	COMPOUND	CONCENTRATION UNITS: (ug/L or ug/Kg) UG/L	Q
74-87-3	Chloromethane	10	U
74-83-9	Bromomethane	10	U
75-01-4	Vinyl Chloride	10	U
75-00-3	Chloroethane	10	U
75-09-2	Methylene Chloride	10	U
67-64-1	Acetone	5	BJ
75-15-0	Carbon Disulfide	10	U
75-35-4	1,1-Dichloroethene	10	U
75-34-3	1,1-Dichloroethane	10	U
540-59-0	1,2-Dichloroethene (total)	5	J
67-66-3	Chloroform	10	U
107-06-2	1,2-Dichloroethane	2	BJ
78-93-3	2-Butanone	10	U
71-55-6	1,1,1-Trichloroethane	10	U
56-23-5	Carbon Tetrachloride	10	U
75-27-4	Bromodichloromethane	10	U
78-87-5	1,2-Dichloropropane	10	U
10061-01-5	cis-1,3-Dichloropropene	10	U
79-01-6	Trichloroethene	6	J
124-48-1	Dibromochloromethane	10	U
79-00-5	1,1,2-Trichloroethane	10	U
71-43-2	Benzene	10	U
10061-02-6	trans-1,3-Dichloropropene	10	U
75-25-2	Bromoform	10	U
108-10-1	4-Methyl-2-Pentanone	10	U
591-78-6	2-Hexanone	10	U
127-18-4	Tetrachloroethene	10	U
79-34-5	1,1,2,2-Tetrachloroethane	10	U
108-88-3	Toluene	10	U
108-90-7	Chlorobenzene	10	U
100-41-4	Ethylbenzene	10	U
100-42-5	Styrene	10	U
1330-20-7	Xylene (total)	10	U

EPA SAMPLE NO.

73TK3617

1E
VOLATILE ORGANICS ANALYSIS DATA SHEET
TENTATIVELY IDENTIFIED COMPOUNDS

Lab Name: ITAS-KNOXVILLE Contract: BAKER

Lab Code: ITSTU Case No.: 3572 SAS No.: ______ SDG No.: 73TK3

Matrix: (soil/water) WATER Lab Sample ID: AF3163

Sample wt/vol: 5.0 (g/mL) ML Lab File ID: AF3163

Level: (low/med) LOW Date Received: 05/11/95

% Moisture: not dec. ____ Date Analyzed: 05/17/95

GC Column: RTX624 ID: 0.530 (mm) Dilution Factor: 1.0

Soil Extract Volume: ______ (uL) Soil Aliquot Volume: ______(uL)

CONCENTRATION UNITS:
(ug/L or ug/Kg) UG/L

Number TICs found: 0

CAS NUMBER	COMPOUND NAME	RT	EST. CONC.	Q

1B

SEMIVOLATILE ORGANICS ANALYSIS DATA SHEET

EPA SAMPLE NO.

73TK3617

Lab Name: ITAS-KNOXVILLE Contraet: BAKER

Lab Code: ITSTU Case No.: 3572 SAS No.: ______ SDG No.: 73TK6

Matrix: (soil/water) WATER Lab Sample ID: AF3164

Sample wt/vol: 1000 (g/mL) ML Lab File ID: AF3164

Level: (low/med) LOW Date Received: 05/11/95

% Moisture: _____ decanted: (Y/N) ___ Date Extracted: 05/12/95

Concentrated Extract Volume: 1000 (uL) Date Analyzed: 05/17/95

Injection Volume: 2.0(uL) Dilution Factor: 1.0

GPC Cleanup: (Y/N) N pH: _____

CAS NO.	COMPOUND	CONCENTRATION UNITS: (ug/L or ug/Kg) UG/L	Q
108-95-2	Phenol	10	U
111-44-4	bis(2-Chloroethyl)Ether	10	U
95-57-8	2-Chlorophenol	10	U
541-73-1	1,3-Dichlorobenzene	10	U
106-46-7	1,4-Dichlorobenzene	10	U
95-50-1	1,2-Dichlorobenzene	10	U
95-48-7	2-Methylphenol	10	U
108-60-1	2,2'-oxybis(1-Chloropropane)	10	U
106-44-5	4-Methylphenol	10	U
621-64-7	N-Nitroso-Di-n-Propylamine	10	U
67-72-1	Hexachloroethane	10	U
98-95-3	Nitrobenzene	10	U
78-59-1	Isophorone	10	U
88-75-5	2-Nitrophenol	10	U
105-67-9	2,4-Dimethylphenol	10	U
111-91-1	bis(2-Chloroethoxy)Methane	10	U
120-83-2	2,4-Dichlorophenol	10	U
120-82-1	1,2,4-Trichlorobenzene	10	U
91-20-3	Naphthalene	10	U
106-47-8	4-Chloroaniline	10	U
87-68-3	Hexachlorobutadiene	10	U
59-50-7	4-Chloro-3-Methylphenol	10	U
91-57-6	2-Methylnaphthalene	10	U
77-47-4	Hexachlorocyclopentadiene	10	U
88-06-2	2,4,6-Trichlorophenol	10	U
95-95-4	2,4,5-Trichlorophenol	25	U
91-58-7	2-Chloronaphthalene	10	U
88-74-4	2-Nitroaniline	25	U
131-11-3	Dimethylphthalate	10	U
208-96-8	Acenaphthylene	10	U
606-20-2	2,6-Dinitrotoluene	10	U
99-09-2	3-Nitroaniline	25	U
83-32-9	Acenaphthene	10	U

1C
SEMIVOLATILE ORGANICS ANALYSIS DATA SHEET

EPA SAMPLE NO.
73TK3617

Lab Name: ITAS-KNOXVILLE Contract: BAKER

Lab Code: ITSTU Case No.: 3572 SAS No.: _____ SDG No.: 73TK6

Matrix: (soil/water) WATER

Lab Sample ID: AF3164

Sample wt/vol: 1000 (g/mL) ML

Lab File ID: AF3164

Level: (low/med) LOW

Date Received: 05/11/95

% Moisture: _____ decanted: (Y/N) ___

Date Extracted: 05/12/95

Concentrated Extract Volume: 1000 (uL)

Date Analyzed: 05/17/95

Injection Volume: 2.0(uL)

Dilution Factor: 1.0

GPC Cleanup: (Y/N) N pH: ____

CAS NO.	COMPOUND	CONCENTRATION UNITS: (ug/L or ug/Kg) UG/L	Q
51-28-5	2,4-Dinitrophenol	25	U
100-02-7	4-Nitrophenol	25	U
132-64-9	Dibenzofuran	10	U
121-14-2	2,4-Dinitrotoluene	10	U
84-66-2	Diethylphthalate	10	U
7005-72-3	4-Chlorophenyl-phenylether	10	U
86-73-7	Fluorene	10	U
100-01-6	4-Nitroaniline	25	U
534-52-1	4,6-Dinitro-2-Methylphenol	25	U
86-30-6	N-Nitrosodiphenylamine (1)	10	U
101-55-3	4-Bromophenyl-phenylether	10	U
118-74-1	Hexachlorobenzene	10	U
87-86-5	Pentachlorophenol	25	U
85-01-8	Phenanthrene	10	U
120-12-7	Anthracene	10	U
86-74-8	Carbazole	10	U
84-74-2	Di-n-Butylphthalate	1	BJ
206-44-0	Fluoranthene	10	U
129-00-0	Pyrene	10	U
85-68-7	Butylbenzylphthalate	10	U
91-94-1	3,3'-Dichlorobenzidine	10	U
56-55-3	Benzo(a)Anthracene	10	U
218-01-9	Chrysene	10	U
117-81-7	bis(2-Ethylhexyl)Phthalate	10	U
117-84-0	Di-n-Octyl Phthalate	10	U
205-99-2	Benzo(b)Fluoranthene	10	U
207-08-9	Benzo(k)Fluoranthene	10	U
50-32-8	Benzo(a)Pyrene	10	U
193-39-5	Indeno(1,2,3-cd)Pyrene	10	U
53-70-3	Dibenz(a,h)Anthracene	10	U
191-24-2	Benzo(g,h,i)Perylene	10	U

(1) - Cannot be separated from Diphenylamine

1F

SEMIVOLATILE ORGANICS ANALYSIS DATA SHEET
TENTATIVELY IDENTIFIED COMPOUNDS

EPA SAMPLE NO.

73TK3617

Lab Name: ITAS-KNOXVILLE Contract: BAKER

Lab Code: ITSTU Case No.: 3572 SAS No.: ______ SDG No.: 73TK6

Matrix: (soil/water) WATER

Lab Sample ID: AF3164

Sample wt/vol: 1000 (g/mL) ML

Lab File ID: AF3164

Level: (low/med) LOW

Date Received: 05/11/95

% Moisture: _____ decanted: (Y/N) ___

Date Extracted: 05/12/95

Concentrated Extract Volume: 1000 (uL)

Date Analyzed: 05/17/95

Injection Volume: 2.0 (uL)

Dilution Factor: 1.0

GPC Cleanup: (Y/N) N pH: ____

Number TICs found: 1

CONCENTRATION UNITS:
(ug/L or ug/Kg) UG/L

CAS NUMBER	COMPOUND NAME	RT	EST. CONC.	Q
1.	UNKNOWN HYDROCARBON	16.68	6	J

1D
PESTICIDE ORGANICS ANALYSIS DATA SHEET

EPA SAMPLE NO.

73TK3617

Lab Name: ITAS-KNOXVILLE Contract:

Lab Code: Case No.: WO3573 SAS No.: SDG No.: 73RB19

Matrix: (soil/water) WATER Lab Sample ID: AF3175

Sample wt/vol: 1000 (g/mL) ML Lab File ID:

% Moisture: decanted: (Y/N) Date Received: 05/11/95

Extraction: (SepF/Cont/Sonc) CONT Date Extracted: 05/15/95

Concentrated Extract Volume: 10000 (uL) Date Analyzed: 05/25/95

Injection Volume: 1.00 (uL) Dilution Factor: 1.00

GPC Cleanup: (Y/N) N pH: 7.0 Sulfur Cleanup: (Y/N) N

CAS NO.	COMPOUND	CONCENTRATION UNITS: (ug/L or ug/Kg) UG/L	Q
319-84-6	alpha-BHC	0.050	U
319-85-7	beta-BHC	0.050	U
319-86-8	delta-BHC	0.050	U
58-89-9	gamma-BHC (Lindane)	0.050	U
76-44-8	Heptachlor	0.050	U
309-00-2	Aldrin	0.050	U
1024-57-3	Heptachlor epoxide	0.050	U
959-98-8	Endosulfan I	0.050	U
60-57-1	Dieldrin	0.10	U
72-55-9	4,4'-DDE	0.10	U
72-20-8	Endrin	0.10	U
33213-65-9	Endosulfan II	0.10	U
72-54-8	4,4'-DDD	0.10	U
1031-07-8	Endosulfan sulfate	0.10	U
50-29-3	4,4'-DDT	0.10	U
72-43-5	Methoxychlor	0.50	U
53494-70-5	Endrin ketone	0.10	U
7421-93-4	Endrin aldehyde	0.10	U
5103-71-9	alpha-Chlordane	0.050	U
5103-74-2	gamma-Chlordane	0.050	U
8001-35-2	Toxaphene	5.0	U
12674-11-2	Aroclor-1016	1.0	U
11104-28-2	Aroclor-1221	2.0	U
11141-16-5	Aroclor-1232	1.0	U
53469-21-9	Aroclor-1242	1.0	U
12672-29-6	Aroclor-1248	1.0	U
11097-69-1	Aroclor-1254	1.0	U
11096-82-5	Aroclor-1260	1.0	U

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1

INORGANIC ANALYSES DATA SHEET

EPA SAMPLE NO.

73TK36

Lab Name: QUANTERRA_KNOXVILLE______ Contract: BAKER/CL__
Lab Code: ITSTU_ Case No.: 3572_ SAS No.: ______ SDG No.: N/A___
Matrix (soil/water): WATER Lab Sample ID: AF3165
Level (low/med): LOW__ Date Received: 05/11/95
% Solids: __0.0

Concentration Units (ug/L or mg/kg dry weight): UG/L_

CAS No.	Analyte	Concentration	C	Q	M
7429-90-5	Aluminum	487			P
7440-36-0	Antimony	50.0	U		P
7440-38-2	Arsenic	10.0	U		P
7440-39-3	Barium	24.9	B		P
7440-41-7	Beryllium	1.0	U		P
7440-43-9	Cadmium	5.0	U		P
7440-70-2	Calcium	33300			P
7440-47-3	Chromium	10.0	U		P
7440-48-4	Cobalt	20.0	U		P
7440-50-8	Copper	10.0	U		P
7439-89-6	Iron	437			P
7439-92-1	Lead	3.0	U		P
7439-95-4	Magnesium	2570	B		P
7439-96-5	Manganese	24.8			P
7439-97-6	Mercury	0.20	U		CV
7440-02-0	Nickel	20.0	U		P
7440-09-7	Potassium	2590	B		P
7782-49-2	Selenium	5.0	U		P
7440-22-4	Silver	5.0	U		P
7440-23-5	Sodium	26100			P
7440-28-0	Thallium	10.0	U		P
7440-62-2	Vanadium	10.0	U		P
7440-66-6	Zinc	73.3			P

Color Before: COLORLESS Clarity Before: CLEAR_ Texture: N/A___
Color After: COLORLESS Clarity After: CLEAR_ Artifacts: ______

Comments:
CLIENT_SAMPLE_ID_NO._IS_73-TK-3617.

1A

VOLATILE ORGANICS ANALYSIS DATA SHEET

EPA SAMPLE NO.

73POLY01

Lab Name: ITAS-KNOXVILLE Contract: BAKER

Lab Code: ITSTU Case No.: 3707 SAS No.: ______ SDG No.: 73POLY

Matrix: (soil/water) WATER

Lab Sample ID: AF4795

Sample wt/vol: 5.0 (g/mL) ML

Lab File ID: AF4795

Level: (low/med) LOW

Date Received: 05/24/95

% Moisture: not dec. ____

Date Analyzed: 05/30/95

GC Column: RTX624 ID: 0.530 (mm)

Dilution Factor: 1.0

Soil Extract Volume: ________ (uL)

Soil Aliquot Volume: _____(uL)

CAS NO.	COMPOUND	CONCENTRATION UNITS: (ug/L or ug/Kg) UG/L	Q
74-87-3	Chloromethane	10	U
74-83-9	Bromomethane	10	U
75-01-4	Vinyl Chloride	10	U
75-00-3	Chloroethane	10	U
75-09-2	Methylene Chloride	1	BJ
67-64-1	Acetone	2900	BE
75-15-0	Carbon Disulfide	10	U
75-35-4	1,1-Dichloroethene	10	U
75-34-3	1,1-Dichloroethane	10	U
540-59-0	1,2-Dichloroethene (total)	3	J
67-66-3	Chloroform	10	U
107-06-2	1,2-Dichloroethane	10	U
78-93-3	2-Butanone	1	J
71-55-6	1,1,1-Trichloroethane	10	U
56-23-5	Carbon Tetrachloride	10	U
75-27-4	Bromodichloromethane	10	U
78-87-5	1,2-Dichloropropane	10	U
10061-01-5	cis-1,3-Dichloropropene	10	U
79-01-6	Trichloroethene	3	J
124-48-1	Dibromochloromethane	10	U
79-00-5	1,1,2-Trichloroethane	10	U
71-43-2	Benzene	10	U
10061-02-6	trans-1,3-Dichloropropene	10	U
75-25-2	Bromoform	10	U
108-10-1	4-Methyl-2-Pentanone	1	J
591-78-6	2-Hexanone	10	U
127-18-4	Tetrachloroethene	10	U
79-34-5	1,1,2,2-Tetrachloroethane	10	U
108-88-3	Toluene	10	U
108-90-7	Chlorobenzene	10	U
100-41-4	Ethylbenzene	10	U
100-42-5	Styrene	10	U
1330-20-7	Xylene (total)	10	U

1E

VOLATILE ORGANICS ANALYSIS DATA SHEET
TENTATIVELY IDENTIFIED COMPOUNDS

EPA SAMPLE NO.

73POLY01

Lab Name: ITAS-KNOXVILLE Contract: BAKER

Lab Code: ITSTU Case No.: 3707 SAS No.: ______ SDG No.: 73POLY

Matrix: (soil/water) WATER

Lab Sample ID: AF4795

Sample wt/vol: 5.0 (g/mL) ML

Lab File ID: AF4795

Level: (low/med) LOW

Date Received: 05/24/95

% Moisture: not dec. ____

Date Analyzed: 05/30/95

GC Column: RTX624 ID: 0.530 (mm)

Dilution Factor: 1.0

Soil Extract Volume: ________ (uL)

Soil Aliquot Volume: _____(uL)

CONCENTRATION UNITS:
(ug/L or ug/Kg) UG/L

Number TICs found: 2

CAS NUMBER	COMPOUND NAME	RT	EST. CONC.	Q
1.	UNKNOWN ALCOHOL	3.37	86	J
2. 124-18-5	DECANE	11.13	94	BJN

1A

VOLATILE ORGANICS ANALYSIS DATA SHEET

EPA SAMPLE NO.

73POLY01DL

Lab Name: ITAS-KNOXVILLE Contract: BAKER

Lab Code: ITSTU Case No.: 3707 SAS No.: ______ SDG No.: 73POLY

Matrix: (soil/water) WATER Lab Sample ID: AF4795

Sample wt/vol: 5.0 (g/mL) ML Lab File ID: AF4795D2

Level: (low/med) LOW Date Received: 05/24/95

% Moisture: not dec. ____ Date Analyzed: 05/31/95

GC Column: RTX624 ID: 0.530 (mm) Dilution Factor: 20.0

Soil Extract Volume: ________ (uL) Soil Aliquot Volume: _____(uL)

CAS NO.	COMPOUND	CONCENTRATION UNITS: (ug/L or ug/Kg) UG/L	Q
74-87-3	Chloromethane	200	U
74-83-9	Bromomethane	200	U
75-01-4	Vinyl Chloride	200	U
75-00-3	Chloroethane	200	U
75-09-2	Methylene Chloride	37	BDJ
67-64-1	Acetone	3200	D
75-15-0	Carbon Disulfide	200	U
75-35-4	1,1-Dichloroethene	200	U
75-34-3	1,1-Dichloroethane	200	U
540-59-0	1,2-Dichloroethene (total)	200	U
67-66-3	Chloroform	200	U
107-06-2	1,2-Dichloroethane	200	U
78-93-3	2-Butanone	200	U
71-55-6	1,1,1-Trichloroethane	200	U
56-23-5	Carbon Tetrachloride	200	U
75-27-4	Bromodichloromethane	200	U
78-87-5	1,2-Dichloropropane	200	U
10061-01-5	cis-1,3-Dichloropropene	200	U
79-01-6	Trichloroethene	200	U
124-48-1	Dibromochloromethane	200	U
79-00-5	1,1,2-Trichloroethane	200	U
71-43-2	Benzene	200	U
10061-02-6	trans-1,3-Dichloropropene	200	U
75-25-2	Bromoform	200	U
108-10-1	4-Methyl-2-Pentanone	200	U
591-78-6	2-Hexanone	200	U
127-18-4	Tetrachloroethene	200	U
79-34-5	1,1,2,2-Tetrachloroethane	200	U
108-88-3	Toluene	200	U
108-90-7	Chlorobenzene	200	U
100-41-4	Ethylbenzene	200	U
100-42-5	Styrene	200	U
1330-20-7	Xylene (total)	200	U

1E

VOLATILE ORGANICS ANALYSIS DATA SHEET
TENTATIVELY IDENTIFIED COMPOUNDS

EPA SAMPLE NO.

73POLY01DL

Lab Name: ITAS-KNOXVILLE Contract: BAKER

Lab Code: ITSTU Case No.: 3707 SAS No.: ______ SDG No.: 73POLY

Matrix: (soil/water) WATER

Lab Sample ID: AF4795

Sample wt/vol: 5.0 (g/mL) ML

Lab File ID: AF4795D2

Level: (low/med) LOW

Date Received: 05/24/95

% Moisture: not dec. ____

Date Analyzed: 05/31/95

GC Column: RTX624 ID: 0.530 (mm)

Dilution Factor: 20.0

Soil Extract Volume: ________ (uL)

Soil Aliquot Volume: _____(uL)

Number TICs found: 1

CONCENTRATION UNITS:
(ug/L or ug/Kg) UG/L

CAS NUMBER	COMPOUND NAME	RT	EST. CONC.	Q
1. 124-18-5	DECANE	11.03	1100	BJN

1B

SEMIVOLATILE ORGANICS ANALYSIS DATA SHEET

EPA SAMPLE NO.

73POLY01

I Name: ITAS-KNOXVILLE Contract: BAKER

Lab Code: ITSTU Case No.: 3707 SAS No.: ______ SDG No.: 73POLY

Matrix: (soil/water) WATER

Lab Sample ID: AF4796

Sample wt/vol: 1000 (g/mL) ML

Lab File ID: AF4796

Level: (low/med) LOW

Date Received: 05/24/95

% Moisture: _____ decanted: (Y/N) ___

Date Extracted: 05/25/95

Concentrated Extract Volume: 1000 (uL)

Date Analyzed: 05/31/95

Injection Volume: 2.0 (uL)

Dilution Factor: 1.0

GPC Cleanup: (Y/N) N pH: _____

CAS NO.	COMPOUND	CONCENTRATION UNITS: (ug/L or ug/Kg) UG/L	Q
108-95-2	Phenol	10	U
111-44-4	bis(2-Chloroethyl)Ether	10	U
95-57-8	2-Chlorophenol	10	U
541-73-1	1,3-Dichlorobenzene	10	U
106-46-7	1,4-Dichlorobenzene	10	U
95-50-1	1,2-Dichlorobenzene	10	U
95-48-7	2-Methylphenol	10	U
108-60-1	2,2'-Oxybis(1-Chloropropane)	10	U
106-44-5	4-Methylphenol	10	U
621-64-7	N-Nitroso-Di-n-Propylamine	10	U
67-72-1	Hexachloroethane	10	U
98-95-3	Nitrobenzene	10	U
78-59-1	Isophorone	10	U
88-75-5	2-Nitrophenol	10	U
105-67-9	2,4-Dimethylphenol	2	J
111-91-1	bis(2-Chloroethoxy)Methane	10	U
120-83-2	2,4-Dichlorophenol	10	U
120-82-1	1,2,4-Trichlorobenzene	10	U
91-20-3	Naphthalene	10	U
106-47-8	4-Chloroaniline	10	U
87-68-3	Hexachlorobutadiene	10	U
59-50-7	4-Chloro-3-Methylphenol	10	U
91-57-6	2-Methylnaphthalene	10	U
77-47-4	Hexachlorocyclopentadiene	10	U
88-06-2	2,4,6-Trichlorophenol	10	U
95-95-4	2,4,5-Trichlorophenol	25	U
91-58-7	2-Chloronaphthalene	10	U
88-74-4	2-Nitroaniline	25	U
131-11-3	Dimethylphthalate	10	U
208-96-8	Acenaphthylene	10	U
606-20-2	2,6-Dinitrotoluene	10	U
99-09-2	3-Nitroaniline	25	U
83-32-9	Acenaphthene	10	U

1C

SEMIVOLATILE ORGANICS ANALYSIS DATA SHEET

EPA SAMPLE NO.

73POLY01

Lab Name: ITAS-KNOXVILLE Contract: BAKER

Lab Code: ITSTU Case No.: 3707 SAS No.: ______ SDG No.: 73POLY

Matrix: (soil/water) WATER Lab Sample ID: AF4796

Sample wt/vol: 1000 (g/mL) ML Lab File ID: AF4796

Level: (low/med) LOW Date Received: 05/24/95

% Moisture: _____ decanted: (Y/N) ___ Date Extracted: 05/25/95

Concentrated Extract Volume: 1000 (uL) Date Analyzed: 05/31/95

Injection Volume: 2.0(uL) Dilution Factor: 1.0

GPC Cleanup: (Y/N) N pH: ____

CAS NO.	COMPOUND	CONCENTRATION UNITS: (ug/L or ug/Kg) UG/L	Q
51-28-5	2,4-Dinitrophenol	25	U
100-02-7	4-Nitrophenol	25	U
132-64-9	Dibenzofuran	10	U
121-14-2	2,4-Dinitrotoluene	10	U
84-66-2	Diethylphthalate	10	U
7005-72-3	4-Chlorophenyl-phenylether	10	U
86-73-7	Fluorene	10	U
100-01-6	4-Nitroaniline	25	U
534-52-1	4,6-Dinitro-2-methylphenol	25	U
86-30-6	N-Nitrosodiphenylamine (1)	10	U
101-55-3	4-Bromophenyl-phenylether	10	U
118-74-1	Hexachlorobenzene	10	U
87-86-5	Pentachlorophenol	25	U
85-01-8	Phenanthrene	10	U
120-12-7	Anthracene	10	U
86-74-8	Carbazole	10	U
84-74-2	Di-n-Butylphthalate	10	U
206-44-0	Fluoranthene	10	U
129-00-0	Pyrene	10	U
85-68-7	Butylbenzylphthalate	10	U
91-94-1	3,3'-Dichlorobenzidine	10	U
56-55-3	Benzo(a)Anthracene	10	U
218-01-9	Chrysene	10	U
117-81-7	bis(2-Ethylhexyl)Phthalate	1	J
117-84-0	Di-n-Octyl Phthalate	10	U
205-99-2	Benzo(b)Fluoranthene	10	U
207-08-9	Benzo(k)Fluoranthene	10	U
50-32-8	Benzo(a)Pyrene	10	U
193-39-5	Indeno(1,2,3-cd)Pyrene	10	U
53-70-3	Dibenz(a,h)Anthracene	10	U
191-24-2	Benzo(g,h,i)Perylene	10	U

(1) - Cannot be separated from Diphenylamine

1F

SEMIVOLATILE ORGANICS ANALYSIS DATA SHEET
TENTATIVELY IDENTIFIED COMPOUNDS

EPA SAMPLE NO.

73POLY01

L Name: ITAS-KNOXVILLE Contract: BAKER

Lab Code: ITSTU Case No.: 3707 SAS No.: ____ SDG No.: 73POLY

Matrix: (soil/water) WATER Lab Sample ID: AF4796

Sample wt/vol: 1000 (g/mL) ML Lab File ID: AF4796

Level: (low/med) LOW Date Received: 05/24/95

% Moisture: ____ decanted: (Y/N) ____ Date Extracted: 05/25/95

Concentrated Extract Volume: 1000 (uL) Date Analyzed: 05/31/95

Injection Volume: 2.0(uL) Dilution Factor: 1.0

GPC Cleanup: (Y/N) N pH: ____

Number TICs found: 28

CONCENTRATION UNITS:
(ug/L or ug/Kg) UG/L

CAS NUMBER	COMPOUND NAME	RT	EST. CONC.	Q
1. 141-79-7	3-PENTEN-2-ONE, 4-METHYL-	1.82	28	JN
.	UNKNOWN	2.03	4	AJ
. 123-42-2	2-PENTANONE, 4-HYDROXY-4-MET	2.57	15	ABJN
4.	UNKNOWN	2.90	3	J
5. 124-07-2	OCTANOIC ACID	7.65	7	JN
6. 7112-02-9	OCTANAMIDE, N-(2-HYDROXYETHY	9.53	11	JN
7.	UNKNOWN (SUBSTITUTED ORGANIC	9.65	4	J
8.	UNKNOWN	10.03	8	J
9. 7726-08-1	DECANAMIDE, N-(2-HYDROXYETHY	11.87	7	JN
10. 143-07-7	DODECANOIC ACID	12.27	25	JN
11. 134-62-3	BENZAMIDE, N,N-DIETHYL-3-MET	12.58	8	JN
12. 74381-40-1	PROPANOIC ACID, 2-METHYL-, 1	12.65	4	JN
13.	UNKNOWN	13.03	6	J
14. 142-78-9	DODECANAMIDE, N-(2-HYDROXYET	13.95	26	JN
15.	UNKNOWN	14.10	4	J
16.	UNKNOWN	14.20	2	J
17.	UNKNOWN	14.37	19	J
18.	UNKNOWN	15.03	2	J
19.	UNKNOWN (ALKYL AMIDE, N-(2-H	15.83	2	J
20.	UNKNOWN	16.07	4	J
21.	UNKNOWN	16.27	12	J
22.	UNKNOWN	16.92	4	J
23.	UNKNOWN	17.32	3	J
24.	UNKNOWN	17.78	4	J
25.	UNKNOWN	18.02	36	J
26.	UNKNOWN	19.35	3	J
27.	UNKNOWN	19.68	4	J
.	UNKNOWN	20.17	3	J

1D

PESTICIDE ORGANICS ANALYSIS DATA SHEET

EPA SAMPLE NO.

73POLY01

Lab Name: ITAS-KNOXVILLE Contract:

Lab Code: Case No.: W03711 SAS No.: SDG No.: POLY01

Matrix: (soil/water) WATER Lab Sample ID: AF4894

Sample wt/vol: 1000 (g/mL) ML Lab File ID:

% Moisture: decanted: (Y/N) Date Received: 05/24/95

Extraction: (SepF/Cont/Sonc) CONT Date Extracted: 05/25/95

Concentrated Extract Volume: 10000 (uL) Date Analyzed: 06/12/95

Injection Volume: 1.00 (uL) Dilution Factor: 1.00

GPC Cleanup: (Y/N) N pH: 7.0 Sulfur Cleanup: (Y/N) N

CAS NO.	COMPOUND	CONCENTRATION UNITS: (ug/L or ug/Kg) UG/L	Q
319-84-6	alpha-BHC	0.050	U
319-85-7	beta-BHC	0.050	U
319-86-8	delta-BHC	0.050	U
58-89-9	gamma-BHC (Lindane)	0.050	U
76-44-8	Heptachlor	0.050	U
309-00-2	Aldrin	0.050	U
1024-57-3	Heptachlor epoxide	0.050	U
959-98-8	Endosulfan I	0.050	U
60-57-1	Dieldrin	0.10	U
72-55-9	4,4'-DDE	0.10	U
72-20-8	Endrin	0.10	U
33213-65-9	Endosulfan II	0.10	U
72-54-8	4,4'-DDD	0.10	U
1031-07-8	Endosulfan sulfate	0.10	U
50-29-3	4,4'-DDT	0.10	U
72-43-5	Methoxychlor	0.50	U
53494-70-5	Endrin ketone	0.10	U
7421-93-4	Endrin aldehyde	0.10	U
5103-71-9	alpha-Chlordane	0.050	U
5103-74-2	gamma-Chlordane	0.050	U
8001-35-2	Toxaphene	5.0	U
12674-11-2	Aroclor-1016	1.0	U
11104-28-2	Aroclor-1221	2.0	U
11141-16-5	Aroclor-1232	1.0	U
53469-21-9	Aroclor-1242	1.0	U
12672-29-6	Aroclor-1248	1.0	U
11097-69-1	Aroclor-1254	1.0	U
11096-82-5	Aroclor-1260	1.0	U

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INORGANIC ANALYSES DATA SHEET

EPA SAMPLE NO.

73-POLY-01

Lab Name: QUANTERRA_KNOXVILLE
Contract: BAKER_CL
Lab Code: ITSTU
Case No.: 3707
SAS No.:
SDG No.: N/A
Matrix (soil/water): WATER
Lab Sample ID: AF4797
Level (low/med): LOW
Date Received: 05/24/95
% Solids: 0.0

Concentration Units (ug/L or mg/kg dry weight): UG/L

CAS No.	Analyte	Concentration	C	Q	M
7429-90-5	Aluminum	860			P
7440-36-0	Antimony	50.0	U		P
7440-38-2	Arsenic	10.0	U		P
7440-39-3	Barium	43.4	B		P
7440-41-7	Beryllium	1.0	U		P
7440-43-9	Cadmium	5.0	U		P
7440-70-2	Calcium	34400			P
7440-47-3	Chromium	10.0	U		P
7440-48-4	Cobalt	20.0	U		P
7440-50-8	Copper	14.1	B		P
7439-89-6	Iron	3150			P
7439-92-1	Lead	3.0	U		P
7439-95-4	Magnesium	2450	B		P
7439-96-5	Manganese	90.3			P
7439-97-6	Mercury	0.20	U		CV
7440-02-0	Nickel	20.0	U		P
7440-09-7	Potassium	4490	B		P
7782-49-2	Selenium	5.0	U		P
7440-22-4	Silver	5.0	U		P
7440-23-5	Sodium	20300			P
7440-28-0	Thallium	10.0	U		P
7440-62-2	Vanadium	10.0	U		P
7440-66-6	Zinc	48.7			P

Color Before: COLORLESS
Clarity Before: CLEAR
Texture: N/A
Color After: COLORLESS
Clarity After: CLEAR
Artifacts:

Comments:

FORM I - IN

ILM02.1

TOTAL SUSPENDED SOLIDS ANALYSIS

Laboratory Name:	Quanterra-Knoxville	Job Number:	3707
Contract Name:	Baker Camp Lejeune	Analysis Date:	05/25/95
Sample Matrix:	Water	Concentration Units:	mg/l

Client Sample ID	Lab Sample ID	Result	Qualifier
Method Blank	AF5017	1	U
73-POLY-01	AF4798	40	+

\+ - Positive result.

U - Compound was analyzed for but not detected. The number is the detection limit for the sample.

TCLP VOLATILE ORGANICS ANALYSIS

Laboratory Name:	Quanterra-Knoxville	Job Number:	3573
Contract Name:	Baker Camp Lejeune	TCLP Date:	05/23/95
Client Sample ID:	73RX01	Analysis Date:	05/31/95
Lab Sample ID:	AF3317	Concentration Units:	mg/liter in the leachate
Sample Matrix:	Leachate		

Compound	Concentration	Qualifier	Detection Limit
benzene	0.025	U	0.025
carbon tetrachloride	0.025	U	0.025
chlorobenzene	0.025	U	0.025
chloroform	0.025	U	0.025
1,2-dichloroethane	0.025	U	0.025
1,1-dichloroethene	0.025	U	0.025
methyl ethyl ketone	0.050	U	0.050
tetrachloroethene	0.025	U	0.025
trichloroethene	0.025	U	0.025
vinyl chloride	0.050	U	0.050

- Compound was analyzed for but not detected. The number is the detection limit for the sample.

TCLP SEMIVOLATILE ORGANICS ANALYSIS

Laboratory Name:	Quanterra-Knoxville	Job Number:	3573
Contract Name:	Baker Camp Lejeune	TCLP Date:	05/23/95
Client Sample ID:	73-RX-01	Extraction Date:	05/24/95
Lab Sample ID:	AF3318	Analysis Date:	06/04/95
Sample Matrix:	Leachate	Concentration Units:	mg/liter in the leachate

Compound	Concentration	Qualifier	Reporting Limit
total cresols	0.04	U	0.04
1,4-dichlorobenzene	0.04	U	0.04
2,4-dinitrotoluene	0.04	U	0.04
hexachlorobenzene	0.04	U	0.04
hexachloro-1,3-butadiene	0.04	U	0.04
hexachloroethane	0.04	U	0.04
nitrobenzene	0.04	U	0.04
pentachlorophenol	0.20	U	0.20
pyridine	0.40	U	0.40
2,4,5-trichlorophenol	0.20	U	0.20
2,4,6-trichlorophenol	0.04	U	0.04

U - Compound was analyzed for but not detected. The number is the reporting limit for the sample.

TCLP PESTICIDES ANALYSIS

Laboratory Name:	Quanterra-Knoxville	Job Number:	3573
Contract Name:	Baker Camp Lejeune	TCLP Date:	05/23/95
Client Sample ID:	73-RX-01	Extraction Date:	05/24/95
Lab Sample ID:	AF3318	Analysis Date:	05/30/95
Sample Matrix:	Leachate	Concentration Units:	mg/liter in the leachate

Compound	Concentration	Qualifier	Reporting Limit
lindane	0.008	U	0.008
heptachlor	0.001	U	0.001
heptachlor epoxide	0.001	U	0.001
endrin	0.004	U	0.004
methoxychlor	0.08	U	0.08
chlordane	0.006	U	0.006
toxaphene	0.1	U	0.1

Surrogate Recovery Acceptance Limits:	tetrachloro-m-xylene (23-128%)	dibutylchlorendate (64-132%)
Lab Sample ID: AF3318	89	112

U - Compound was analyzed for but not detected. The number is the reporting limit for the sample.

1D
PESTICIDE ORGANICS ANALYSIS DATA SHEET

EPA SAMPLE NO.

73RX01

Lab Name: ITAS-KNOXVILLE Contract:

Lab Code: Case No.: WO3573 SAS No.: SDG No.: 73RB19

Matrix: (soil/water) SOIL Lab Sample ID: AF3315

Sample wt/vol: 30.1 (g/mL) G Lab File ID:

% Moisture: 24 decanted: (Y/N) N Date Received: 05/11/95

Extraction: (SepF/Cont/Sonc) SONC Date Extracted: 05/17/95

Concentrated Extract Volume: 5000 (uL) Date Analyzed: 06/01/95

Injection Volume: 1.00 (uL) Dilution Factor: 1.00

GPC Cleanup: (Y/N) Y pH: 7.4 Sulfur Cleanup: (Y/N) N

CAS NO.	COMPOUND	CONCENTRATION UNITS: (ug/L or ug/Kg) UG/KG	Q
319-84-6	alpha-BHC	2.2	U
319-85-7	beta-BHC	2.2	U
319-86-8	delta-BHC	2.2	U
58-89-9	gamma-BHC (Lindane)	2.2	U
76-44-8	Heptachlor	2.2	U
309-00-2	Aldrin	2.2	U
1024-57-3	Heptachlor epoxide	2.2	U
959-98-8	Endosulfan I	2.2	U
60-57-1	Dieldrin	4.3	U
72-55-9	4,4'-DDE	4.3	U
72-20-8	Endrin	4.3	U
33213-65-9	Endosulfan II	4.3	U
72-54-8	4,4'-DDD	49	P
1031-07-8	Endosulfan sulfate	4.3	U
50-29-3	4,4'-DDT	4.3	U
72-43-5	Methoxychlor	22	U
53494-70-5	Endrin ketone	4.3	U
7421-93-4	Endrin aldehyde	4.3	U
5103-71-9	alpha-Chlordane	2.2	U
5103-74-2	gamma-Chlordane	2.2	U
8001-35-2	Toxaphene	220	U
12674-11-2	Aroclor-1016	43	U
11104-28-2	Aroclor-1221	88	U
11141-16-5	Aroclor-1232	43	U
53469-21-9	Aroclor-1242	43	U
12672-29-6	Aroclor-1248	43	U
11097-69-1	Aroclor-1254	43	U
11096-82-5	Aroclor-1260	43	U

U.S. EPA - CLP

1
INORGANIC ANALYSES DATA SHEET

EPA SAMPLE NO.

73RX01

Lab Name: QUANTERRA_KNOXVILLE Contract: BAKER_CL
Lab Code: ITSTU Case No.: 3573 SAS No.: SDG No.: 73RX01
Matrix (soil/water): WATER Lab Sample ID: AF3318
Level (low/med): LOW Date Received: 06/12/95
% Solids: 0.0

Concentration Units (ug/L or mg/kg dry weight): UG/L

CAS No.	Analyte	Concentration	C	Q	M
7440-38-2	Arsenic	200	U		P
7440-39-3	Barium	286			P
7440-43-9	Cadmium	50.0	U		P
7440-47-3	Chromium	100	U		P
7439-92-1	Lead	200	U		P
7439-97-6	Mercury	2.0	U		CV
7782-49-2	Selenium	200	U		P
7440-22-4	Silver	50.0	U		P

Color Before: Clarity Before: Texture:
Color After: Clarity After: Artifacts:

Comments:
TCLP

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QUANTERRA

73-RX-01

WO #: A4J4D
LAB #: C5E130014-009
MATRIX: SOLID

DATE SAMPLED: 5/09/95

DATE RECEIVED: 5/13/95

- - - - - - - - - - - - - - - - - - **INORGANIC ANALYTICAL REPORT** - - - - - - - - - - - - - - - - -

PARAMETER	RESULT	REPORTING LIMIT	UNIT	METHOD	PREPARATION - ANALYSIS DATE	QC BATCH
Flash Point Closed Cup	**<200**		**deg F**	**SW846 1010**	**5/31/95**	**5151069**
pH Non-Aqueous	**7.8**	**1.0**	**su**	**SW846 9045**	**5/16/95**	**5136132**
Reactive Cyanide	ND	50.0	mg/kg	SW846 7.3.3.2	5/15- 5/17/95	5137077
Sulfide Reactive	ND	50.0	mg/kg	SW846 7.3.4.2	5/15- 5/16/95	5135119

NOTE: AS RECEIVED
ND NOT DETECTED AT THE STATED REPORTING LIMIT

TCLP HERBICIDES ANALYSIS

Laboratory Name:	Quanterra-Knoxville	Job Number:	3573
Contract Name:	Baker Camp Lejeune	TCLP Date:	05/23/95
Client Sample ID:	73-RX-01	Extraction Date:	05/30/95
Lab Sample ID:	AF3318	Analysis Date:	06/02/95
Sample Matrix:	Leachate	Concentration Units:	mg/liter in the leachate

Compound	Concentration	Qualifier	Reporting Limit
2,4D	0.1	U	0.1
2,4,5-TP (silvex)	0.02	U	0.02

Surrogate Recovery	2,4-DCPA
Lab Sample ID: AF3318	41

U - Compound was analyzed for but not detected. The number is the reporting limit for the sample.

Baker

Baker Environmental, Inc.
Airport Office Park, Building 3
420 Rouser Road
Coraopolis, Pennsylvania 15108

(412) 269-6000
FAX (412) 269-2002

September 12, 1995

Commander
Atlantic Division
Naval Facilities Engineering Command
1510 Gilbert Street (Building N-26)
Norfolk, Virginia 23511-6299

Attn: Mr. Lance Laughmiller
Navy Technical Representative
Code 18235

Re: Contract N62470-89-D-4814
Navy CLEAN, District III
Contract Task Order (CTO) 0312
IDW Removal
Operable Unit No. 9 (Site 73)
MCB, Camp Lejeune, North Carolina

Dear Mr. Laughmiller:

This letter report summarizes the investigative-derived waste (IDW) disposal activities conducted at Operable Unit No. 9 (Site 73), Marine Corps Base, Camp Lejeune, North Carolina. The IDW was generated during the remedial investigation activities conducted from April 3 through May 25, 1995, and was contained in two (6,500-gallon) tankers, one (1,000 gallon) polyethylene tanker, and one roll-off box (20 cubic yards).

The water in one of the tankers, was discharged on-site on June 20, 1995, since no contaminants were detected which would result in increased human health or ecological risks.

In a letter dated August 2, 1995, Baker Environmental provided details concerning sample collection and analytical findings of the remaining IDW, and provided conclusions and recommendations with respect to handling and disposal. The recommendations were subsequently approved by the Navy/Marine Corps. One addition to the recommendations was that the water contained in the remaining tankers was unable to be treated by the Hadnot Point Shallow Aquifer Remedial Action System. However, this water was able to be taken off-base as a nonhazardous waste water and transported to HOH Corporation, a Treatment Storage Disposal Facility (TSDF) located in Winston-Salem North Carolina. The remainder of this letter report provides a summary of the disposal activities conducted under this CTO.

DISPOSAL

Based on LANTDIV/MCB Camp Lejeune approval, Baker arranged for the disposal of the following:

- 6,678 gallons of nonhazardous well development and purge water
- 20 cubic yards of nonhazardous drilling and mud cuttings

Based on the nonhazardous determination of the IDW, the roll-off box contents were emptied on site and then graded. The roll-off box was then removed from Site 73. The development and purge water was removed via a vacuum truck and transported to HOH Corporation for disposal. Two trips were necessary to deplete all of the waste water. Both the 6,500-gallon and the 1,000-gallon polyethylene tankers were removed from Site 73. The Nonhazardous Profile Sheet, along with the Nonhazardous Waste Manifests, are provided in Attachment A.

Baker appreciates the opportunity to serve LANTDIV on this important project. If you have any questions, please do not hesitate to call me at (412) 269-4695.

Sincerely,

BAKER ENVIRONMENTAL, INC.

Malcolm W. Petroccia
Project Manager

MWP/PAM/lq

Attachments

cc: Mr. Neal Paul, IRP Director, MCB Camp Lejeune (w/attachments)
Mr. John Riggs Environmental Control Specialist, MCB Camp Lejeune (w/attachments)
Ms. Lee Ann Rapp, Code 1832 (w/o attachments)
Ms. Beth Collier, Code 02115 (w/o attachments)

Attachment A

HOH CORP
Environmental Management

MATERIAL PROFILE

1701 Vargrave St., Winston-Salem, NC 27107 • 910-727-4644 • Fax 910-727-8840

Name of Waste Stream Groundwater (Ref. 73 TK615 / 73 POLY 01)

Approved ☐ Yes ☐ No Date ______ Initials ______

Generator Name Marine Corps Base - Camp Lejeune
Facility Address Sneads Ferry Base
Camp Lejeune
Site 73
City Camp Lejeune
State NC Zip 28542
EPA Identification Number NC6170022580
County: Onslow

Technical Contact ~~John Riggs~~ Ken Webb
Title ~~EMD - MCB Camp Lejeune~~ c/o Shamrock Env. Corp.
Phone (910) 451-5068 Ext. 910 375 1989
Fax (910) 451-5948 Ext. 910 375 1801
Billing Address Shamrock Environmental Corp.
PO Box 14987
City Greensboro
State NC Zip 27415

Physical Characteristics at 70°F

Physical State: Liquid ✓ Semisolid ______ Solid ______
Layers: None ✓ Two ______ Multilayers ______
Free Liquids (%) 100 Precipitated Solids (%) <1
Viscosity: Low ✓ Medium ______ High ______
Is Material Pumpable? Yes ✓ No ______ Polymerizable? Yes ______ No ✓
Specific Weight (lbs/gal) 8.34 or Specific Gravity (g/cc) ______
Appearance clear (slight sediment) Odor NA
Flash Point (cc): Exact ______ ≤60°F ______ 61°F - 100°F ______ 101°F - 140°F ______
141°F - 200°F ______ >200°F X
BTU/lb. NONE Ash (%) <1% Water (%) >99%
pH (avg) 7 Range ______ to ______
Reactivity (Reactive with): NA

Is Sample Available Upon Request?
Yes ✓
No ______

Process Generating Waste
Rate of Generation one time Container Type/Size 5000 gal tanker EPA Waste No. NONE State Waste No. NONE

1. Does this waste contain spent solvents? (F001 through F005) Y ______ N ✓
2. Is this waste listed for Dioxin as defined in 40 CFR 262.31? (F020 and F026-28) Y ______ N ✓
3. Is this waste INFECTIOUS? Y ______ N ✓
   Is it RADIOACTIVE? Y ______ N ✓
   Does it contain PCB's > 50 ppm? Y ______ N ✓
4. If you answered yes to questions 1, 2 or 3, DO NOT CONTINUE.
   Please contact your HOH Technical Sales Representative for assistance.

All below Regulatory Limits

Metals (ppm)			Metals (ppm)			Metals (ppm)			
	Total	TCLP		Total	TCLP		Total		Total
As			CR (Total)			Be		Si	
Ag			CR (Hex)			Ti		Na	
Cd			Hg			Sb		Ni	
Ba			Se			S		Cu	
Pb			Other			P		Zn	

Chemical Constituents (Must Total 100%)

Water, from groundwater	>99%
Sediment	<1%

(from monitoring well development)

(Please Attach All MSDS's, Sample Analysis and Additional Info.)

Other: (Specify in PPM)

Free Cyanide 0 PCB's 0

Free Sulfide 0

Phenolics 0

Total Organic Halogens (%)

Fluorine 0 Bromine 0

Chlorine 0

Frequency of Generation

7000-8000 Gallons per

Tons per

Drums per

Other

___ Week

___ Month

___ Quarter

___ Year

✓ One Time

I certify that all information on this form is complete and factual (including attached information) and is an accurate representation of the known and suspected hazards of the waste to be disposed.

Generator's Signature

95 08 16

Date

HOH CORP
Environmental Management

NON-HAZARDOUS WASTE MANIFEST

1701 Vargrave St., Winston-Salem, NC 27107 • 910-727-4644 • Fax 910-727-8840

Bill to: Shamrock Env. Corp (Return manifest to K. Webb)
Job # 95-R0012

Manifest # 081501
Date: 8/15/95

Generator: Marine Corps Base, Camp Lejeune
IR Division - EMD Building 67
MCB Camp Lejeune, NC 28542

Phone No: (910) 451-5068
EPA ID No: NC6170022580.
Contact: John Riggs - MCB/EMD

Process which generated waste:

I certify that the materials described below are properly described, classified, packaged, marked and labeled, and are in proper condition to be transported in commerce under the applicable regulations of the State, the Environmental Protection Agency and the Department of Transportation. I certify that the waste described below is non-hazardous. I certify that the specific waste was delivered to the carrier named below for legal treatment, storage, or disposal at the site indicated.

Date 8/15/95 Signature

Description of Waste	Circle Form	Quantity	Circle Units	Container	
				No.	Type
Groundwater from	Solid		Cu. Yards/Drums/Tons		
development of	[✓ Liquid]	5230	[✓ Gallons] Drums	1	TT
monitoring wells	Gas		Pounds		
(Lab SO# 73TK615	Sludge		Cu. Yards/Drums/Tons		

73POLY01)

Transporter:
Shamrock Environmental Corp.
PO Box 14987 Greensboro, NC 27415
Vehicle License Tag Number(s) LZ 5016 NC

Unit Numbers: RT3/RT2
Phone No: (910) 375-1989
EPA ID No: NC0000942144
Container: tanker RT2

I certify that the specified waste was transferred in a registered (licensed) vehicle to the disposal treatment, storage, or disposal facility named below and was accepted.

Pick-up Driver's Signature 8-15-95 *Date*
Delivering Driver's Signature 8-15-95 *Date*

Facility: HOH Corp
1701 Vargrave St.
Winston-Salem, NC 27107

Phone No: 910-727-4644
Permit No: 34-11TP
Contact: David Bryant

Handling Method:

I certify that the Transporter above delivered the specified material to this facility and was accepted and properly handled in the above manner. We are authorized and qualified by the State of NC to handle this material.

Date 8/15/95 Signature

ORIGINAL - Destination Retain WHITE
COPY 2 - Return to Generator YELLOW
COPY 3 - Transporter Retain PINK
COPY 4 - Generator Retain GOLDENROD

NON-HAZARDOUS WASTE MANIFEST

HOH CORP Environmental Management

1701 Vargrave St., Winston-Salem, NC 27107 • 910-727-4644 • Fax 910-727-8840

Bill to : Shamrock Environmental Corp
Job # 95-R0012

Manifest # 081601
Date: 8/16/95
Generator: Marine Corps Base, Camp Lejeune
IR Division - EMD Building 67
MCB Camp Lejeune, NC 28542
Phone No: (910) 451-5068
EPA ID No: NC 6170022580
Contact: John Riggs - MCB/EMD

Process which generated waste:

I certify that the materials described below are properly described, classified, packaged, marked and labeled, and are in proper condition to be transported in commerce under the applicable regulations of the State, the Environmental Protection Agency and the Department of Transportation. I certify that the waste described below is non-hazardous. I certify that the specific waste was delivered to the carrier named below for legal treatment, storage, or disposal at the site indicated.

Date 8/16/95 Signature

Description of Waste	Circle Form	Quantity	Circle Units	Container	
				No.	Type
Groundwater from	Solid		Cu. Yards/Drums/Tons		
development of	[✓ Liquid]	1,448	[✓ Gallons]/Drums	1	TT
monitoring wells	Gas		Pounds		
(Task ID 73TK615)	Sludge		Cu. Yards/Drums/Tons		

Transporter:
Shamrock Environmental Corp.
PO Box 14987 Greensboro, NC 27415
Vehicle License Tag Number(s) LX-1561

Unit Numbers:
Phone No: (910) 375 1939
EPA ID No: NC 0000 942144
Container: VT-2 VAC TRUCK

I certify that the specified waste was transferred in a registered (licensed) vehicle to the disposal treatment, storage, or disposal facility named below and was accepted.

8-16-95
Pick-up Driver's Signature Date
Delivering Driver's Signature Date

Facility: HOH Corp
1701 Vargrave St.
Winston-Salem, NC 27107

Phone No: 910-727-4644
Permit No: 34-11TP
Contact: David Bryant

Handling Method:

I certify that the Transporter above delivered the specified material to this facility and was accepted and properly handled in the above manner. We are authorized and qualified by the State of NC to handle this material.

Date 8/18/95 Signature

ORIGINAL - Destination Retain WHITE
COPY 2 - Return to Generator YELLOW
COPY 3 - Transporter Retain PINK
COPY 4 - Generator Retain GOLDENROD

APPENDIX G
SUMMARY OF GROUNDWATER DATA AND AQUIFER CHARACTERISTICS

SUMMARY OF GROUNDWATER DATA AND AQUIFER CHARACTERISTICS
MARINE CORPS BASE, CAMP LEJEUNE
JACKSONVILLE, NORTH CAROLINA

SUMMARY

This study examines the utility of exploratory aquifer tests (pump tests) at investigation sites across Marine Corps Base, Camp Lejeune (MCB-CL). The study reviews the available information on the relevant water-bearing layers, considers the general characteristics and applicability of aquifer tests, and concludes:

- That available information is satisfactorily complete to allow appropriate designs of groundwater systems in the main operating areas of MCB-CL;
- That quantified characterization of the water-bearing layers in explored areas of MCB-CL can be extended to other areas having similar geologic terrane;
- That exploratory tests are no longer routinely required or advisable;
- That reconnaissance testing (well-head tests or slug tests) of each newly installed or otherwise uncharacterized data station is highly advisable; and,
- That performance testing of groundwater extraction systems should be the recommended form of evaluating and adjusting withdrawal systems.

BACKGROUND

This study considers the aquifer characteristics (especially, the Coefficient of Transmissivity) and the production capacities (available discharge rates) of the two water-bearing layers relevant to the studies at MCB-CL. These water-bearing layers are the (shallow or surficial) water table and the Upper Castle Hayne Aquifer.

The water table at MCB-CL occupies the water-bearing zone within 25 to 35 feet of the surface; the Castle Hayne, immediately below this. However, the separation of the water table and the Castle Hayne is not always obvious. Usually, this separation is effected only by the low permeability material of the water table transiting to the significantly more permeable material of the Upper Castle Hayne; there is rarely an aquiclude or aquitard of vertically extensive clay separating the water table from the Castle Hayne.

The data available for this summary derive from three main sources:

- Assessment of Hydrologic and Hydrogeologic Data at Camp Lejeune Marine Corps Base, North Carolina; U.S. Geological Survey, Water-Resources Investigation Report 89-4096; 1989
- Wellhead Management Program Engineering Study 91-36; Geophex, Ltd.; 22Jan91
- Various site investigations by Baker Environmental, Inc., and reported to LANTDIV and MCB-CL

DISTRIBUTION OF DATA

The data available from the various sources have been compiled on Tables 1, 2 and 3, with Table 3 summarizing the relevant flow information. The accompanying map indicates the distribution of stations from which data are available.

The tabulated data indicate the main characteristics of each water-bearing layer:

- There is low available production from the water table.
- There is an excessive availability of production from the Castle Hayne compared to the probably acceptable levels of treatment volumes foreseeable in groundwater remediation systems.

The water table had production capacities of less than 5 gallons per minute (gpm) in all cases tested. The specific capacities of the discharge wells were always less than 1 gallon per minute per foot of drawdown (gpm/ft). The transmissivities calculated were generally near or below 1000 gallons per day per foot of drawdown (gpd/ft); only the deeper wells, which intercepted at least part of the Castle Hayne, had transmissivities in a range indicative of an acceptably producing zone. The hydraulic conductivity values were commonly in the range of tenths of feet per day (ft/d). The low production rates, low transmissivities and low hydraulic conductivities indicate that the water table is only marginally, at best, under Darcian conditions. Calculations based on these data would, therefore, be highly unreliable. However, the available information all indicate an expectably low rate of groundwater discharge, which in turn would produce only a narrow radius of effect around an individual production well:

> The standard equation for calculation of the radius of capture around an individual well is $r_c=720Q/\pi Ti$. With a discharge rate (Q) of 3 gpm, a transmissivity (T) of 500 gpd/ft and a representative gradient of 0.005, the radius of capture would be 275 ft. However, this calculation applies only to Darcian conditions in a homogeneous medium; the water table at MCB-CL is marginally Darcian and is highly non-homogeneous. The calculation of radius must, therefore, be in some degree of error, with no more usable data or calculation possible.

The Castle Hayne has production capacities generally ranging above 200 gpm. The estimated transmissivities are at least in the range of several tens of thousands gpd/ft, with specific capacities usually about 5 to 10 gpm/ft. The calculated hydraulic conductivities are usually in the scores of feet per day. The available discharge from the Castle Hayne is, therefore, much greater than that from the water table. The limiting factor in remediation schemes for the Castle Hayne then becomes the amount of water that can be treated by an affordable system, usually less than 500 gpm; this value of 500 gpm would be available from one or two wells in the Castle Hayne. The high values of aquifer parameters, the relatively low total discharge and the low number of production wells would conspire to limit the radius of effect available to a remediation scheme:

> The standard equation for calculation of the radius of capture around an individual well is $r_c=720Q/\pi Ti$. With a Q of 500 gpm, a T of 50000 gpd/ft and a representative gradient of 0.005, the radius of capture would be only 460 ft.

COMPARABILITY OF DATA ACROSS MCB-CL

The stratigraphic sequences of MCB-CL containing the water table and the Upper Castle Hayne have been well characterized. The available information indicates that the lithology and the hydrologic conditions can be correlated stratigraphically across the base (Tables 1 and 2). From these correlations, aquifer performance can be predicted sufficiently for an engineering design whose final criteria for suitability are performance-based.

The upper water-bearing zone is a highly variable layering and intercalation of clay, silt and sand. This variability, however, is found within recognizable limits. These limits correspond to the range of hydrologic characteristics described previously. Similar correlation is available for the lithology and hydrology of the Upper Castle Hayne.

In areas not near stations catalogued in Tables 1, 2 and 3, a reconnaissance comparison of well-head tests (slug tests) and an examination of lithologic descriptions will likely be sufficient to support the engineering evaluation of the site. There is ample demonstration that lithology has a significant influence on the hydrology of a site, and that, for a given geologic terrane, the influence is fairly consistent. The geologic terrane of MCB-CL has been broadly characterized and correlated between lithologic (stratigraphic descriptions) and hydrologic (aquifer tests and well-head tests) sequences. Lithologic descriptions can now provide a good indication of hydrologic conditions at MCB-CL in areas of similar terrane.

GENERAL APPLICABILITY OF AQUIFER TESTS

Aquifer (pump) tests are an extremely dangerous activity at contamination sites. While the information available from aquifer tests is required for engineering design of withdrawal systems, aquifer tests should not be a reconnaissance or an initial step in the investigation. Full consideration must be made of the redistribution of contaminants expectable from the test, of the change in structural support of disposal features by relaxation or increase of hydrostatic loading, and so forth.

Consideration must also be made of alternative sources of acceptable data on the aquifer. In the case of MCB-CL, alternatives to exploratory aquifer tests are available from the tabulation and correlation of aquifer characteristics, production performance and geologic terrane presently available.

From the available information and in light of the relative consistency of the geologic terrane of MCB-CL, exploratory tests at MCB-CL are not generally required. Therefore, exploratory tests are not advisable and should not form part of the initial investigation of a site. While they may be useful in certain circumstances after the initial investigation of a site, they should not, in the general case, be part of the investigation. Sufficiently satisfactory information is presently available to allow the initial engineering design of a groundwater response.

While exploratory aquifer tests are not advisable, performance tests of a newly installed system are highly recommended. These tests, to some extent, are a normal part of the initial operation of a system. Only minor additional monitoring and modification of the system during operation would provide data directly relevant to the long-term operation of that system.

In the Coastal Plain of MCB-CL, the information from an exploratory data station not coincident with the long-term extraction system is not fully transferable. That is, if the test station and the recovery station are not the same, the aquifer parameters and calculations based on those parameters will differ. This means that data from an exploratory station are no more reliably usable that the data presently available, unless the exploratory station is collocated with the recovery system. However, if the exploratory and recovery stations are identical, and considering that alternative sources of acceptable data on the aquifer are available and that a performance test must be run as part of the initial operation of a recovery system, the exploratory test represents a superfluous duplication of effort.

TABLE 1
CAMP LEJEUNE PUMP TEST DATA

Well Number	Well Depth (ft,BGS)	Well Diameter (in)	Total Aquifer Thickness (ft)	Screened Length (ft)	Screened Interval (ft,BGS)	Water-level Drawdown During Pumping (ft,BGS)	Pumping Rate (Recovery wells) GPM	Duration of Pumping (min)	Specific Capacity (pumping rate/ drawdown)	T (square ft/ day)	K (ft/day)	S	Soils (ft,BGS)
013RW-01*	23	2	15	20	3-23	8.773	1	480	0.11	7.17	0.48	NA	0-10 silt/clay, 10-23 sand.
013MW-18	13	2	15	10	3-13	0.297	NA	480	NA	105.98	7.06	1.40E-02	0-7 silt/clay, 7-13 sand.
013MW-21	14	2	15	10	4-14	0.31	NA	480	NA	82.27	5.48	2.77E-02	0-4 silt/sand, 0-14 clay/silt
108RW-01*	15	2	9	9.1	2.45-11.55	6.38	0.5	485	0.08	5.30	0.59	NA	very fine sand
108MW-04		2	9				NA	485	NA	118.63	13.18	1.33E-02	
108MW-15	12.5	2	9	9.03	2.79-11.82		NA	485	NA	56.78	6.31	7.33E-03	0-8 sand/silt, 8-10 silt/clay
109MW-15		2	15			0.939	NA	460	NA	76.26	5.08	1.11E-02	
109MW-17	14.5	2	15	10	4.5-14.5	0.545	NA	460	NA	163.10	10.87	7.30E-03	0-15 fine sand
109RW-01*	15	2	15	9.5	2-11.5	6.265	3	460	0.48	7.80	0.52	NA	0-4 sand, 4-8 silt, 8-15 sand
110RW-01* (Drawdown,Theis)	21.8	2	50	19.2	2-21.2	9.53	3	475	0.31	200.02	4.00	NA	0-10.5 sand/silt, 10.5-15 sand/clay, 15-21.5 sand/clay, 21.5- sand
110RW-01* (Drawdown,Cooper)										161.86	3.24	NA	
110RW-01* Recovery(Theis)										106.06	2.12	NA	
110DW-01 (Drawdown,Theis)	30.3	2	50	4.8	24.9-29.7	0.02	3	475	NA	7080.48	142.00	4.52E-03	0-4 sand/silt, 4-10.5 clay, 10.5-15.5 sand/silt,15.5-20.5 clay, 20.5-on sand
110DW-01 (Drawdown,Cooper)									NA	7099.20	142	4.51E-03	
110DW-02 (Drawdown,Theis)	30	2	50	4.7	24.7-29.4	0.52	NA	475	NA	5398.56	108.00	1.51E-03	0-3 sand and silt with clay layers, 3-11 sand and silt, 11-30 sand with some limited clay layers
110DW-02 (Drawdown,Cooper)									NA	5400.00	108	1.51E-03	
110DW-03 (Drawdown,Theis)	30	2	50	4.9	24.5-29.4	0.47	NA	475	NA	2952.00	59.00	7.48E-02	0-6 sand and silt , 6-12 sand, 12-23 sand/clay, 23-30 sand
110DW-03 (Drawdown,Cooper)									NA	3225.60	64	5.85E-02	

T = Transmissivity
K = Hydraulic Conductivity
S = Storativity
* = Pumping well
NA - Not applicable

TABLE 2
HYDRAULIC CONDUCTIVITY TEST RESULTS (SLUG TEST)

Well Number	Well Depth (ft,BGS)	Well Diameter (in)	Saturated Aquifer Thickness* (ft)	Screened Length (ft)	Screened Interval (ft,BGS)	K Rising (ft/day)	Soils (ft,BGS)
013MW-03	14	2	1	9.8	4-13.8	0.75	0-6 clay, 6-14 silt
013MW-04	14	2	8.13	9.8	4-13.8	0.27	0-8 clay, 8-14 silt
013MW-11	16	2	9.14	10	6-16	0.37	0-4 sand/silt, 4-14 clay, 14-16 sand
013MW-21	14	2	9.2	10	4-14	0.46	0-4 silt/sand, 4-14 clay
108MW-08	12.8	2	8.83	9.7	2.7-12.4	0.59	0-8 very fine sand, 8-12 clayey peat, 12-13 sandy clay
108MW-09	12.8	2	7.81	9.7	2.8-12.5	0.53	0-13 silt/sand
108MW-13	10.8	2	NA	9.02	0.69-9.71	0.061	0-2 very fine sand, 8-9.5 sandy clay
108MW-17	13.1	2	NA	9.03	3.39-12.42	0.59	0-8 fine grained sand, 8-9 clayey peat, 9-12.5 sandy clay
109MW-17	14.5	2	9.04	10	4.5-14.5	9.00	0-15 fine sand
109MW-18	14	2	10.19	10	4.5-14.5	5.70	0-3 sand, 3-10 silt, 10-14 sand
110MW-07	11.96	2	9	9.8	1.5-11.3	0.0115	0-2 clay/silt, 2-4 clay/sand, 4-6 sand, 6-10 silt/clay, 10-14 silt /sand
110MW-09	14.2	2	9.47	9.8	3.8-13.6	0.16	0-6 sand/silt, 6-9 clay/silt, 9-12 sand/silt, 12-14 clay
110DW-03	30	6	22.04	4.9	24.5-29.4	1.07	0-3 sand, 3-4 clay, 4-10 sand/silt, 10-12 sand, 12-13 clay,13-22 silt/clay, 22-30 sand
41GW-07	20.5	2	12.03	10	10.5-20.5	1.15	1-5 silty sand, 5-9 clay, 9-10 silty sand, 10-12 fill, 12-16 silty sand with 1 ft clay layer,16-21 sand
41GW-08	15	2	9.48	10	5-15	0.14	0-1 silty sand, 1-6 sand, 6-14 clay with sand and silt, 14-16 silty sand
41GW-09	21	2	11.89	10	11-21	3.67	0-5 clay and sand, 5-21 silty sand
41GW-10	13	2	8.59	10	3-13	0.94	0-2 silty sand, 2-7 sand, 7-9 silty sand and clay, 9-12 lithified sandstone, 12-13 sand. 13-14 lithified sandstone
41GW-12	16	2	12.45	10	6-16	4.57	0-4 silty sand, 4-14 sand, 14-17 lithified sandstone
69GW-09	20.5	2	14.22	10	10.5-20.5	1.7	1-4 Sand/silt, 4-10 clay some sand, 10-21 sand/silt
69GW-10	16	2	10.5	10	6-16	0.17	1-17 sand/silt
69GW-12	12.5	2	11.27	10.5	2-12.5	0.12	0-13.5 sand/silt
69GW-02D	125	2	22.1	10	40-50	0.29	0-125 silty sand **
69GW-12D	58	2	53.83	10	48-58	6.66	0-58 silty sand **
74GW-03A	18	2	13.58	10	8-18	0.59	0-17 silty sand, 17-18.5 sandy clay
74GW-06	16.5	2	8.18	9.74	15.5-26	6.33	1-26 sand/silt
74GW-08	23	2	10.51	10	13-23	3.55	0-1 silty sand, 1-24 sand

* Values taken from AQTESOL results. (Bottom of screened interval- water level)

** Due to depth, soils were very generally described.

K = Hydraulic Conductivity

TABLE 3

B-CL5 CTO-232 CL5-1B1.wks 8SEP94 MCB-CAMP LEJEUNE

STATION	b ft	Q gpm	Sc gpm/ft	T ft-sq/d	T gpd/ft	K ft/d
013RW-01	15	1.0	0.11	7.2	54	0.5
013MW-1	15			106.0	793	7.1
013MW-2	15			82.3	615	5.5
013MW-03	1					0.8
013MW-04	8					0.3
013MW-11	9					0.4
013MW-21	8					0.5
41GW-07						1.2
41GW-08						0.1
41GW-09						3.7
41GW-10						0.9
41GW-12						4.6
69GW-09						1.7
69GW-10						0.2
69GW-12						0.1
69GW-02DW						0.3
69GW-12DW						6.7
74GW-03A						0.6
74GW-06						6.3
74GW-08						3.6
108RW-01	9	0.5	0.08	5.3	40	0.6
8MW-0	9			118.6	887	13.2
108MW-1	9			56.8	425	6.3
108MW-08	9					0.6
108MW-09	8					0.5
108MW-13	8					0.1
108MW-17	8					0.6
109MW-1	15			76.3	570	5.1
109MW-1	15			163.1	1220	10.9
109RW-01	15	3.0	0.48	7.8	58	0.5
109MW-17	15					9.0
109MW-18	15					5.7
110RW-01	50	3.0	0.31	200.0	1496	4.0
110RW-01	50	3.0	0.31	161.9	1211	3.2
110RW-01	50	3.0		106.1	793	2.1
110DW-01	50			7080	52962	142.0
110DW-01	50			7099	53102	142.0
110DW-02	50			5399	40381	108.0
110DW-02	50			5400	40392	108.0
110DW-03	50			2952	22081	59.0
110DW-03	50			3226	24127	64.0
110MW-07	9					0.1
110MW-09	9					0.2
110DW-03	22					5.8

STATION	b ft	Q gpm	Sc gpm/ft	T ft-sq/d	T gpd/ft	K ft/d
BB-43	275	170	5.0	8900	66572	32.4
BB-44	275	450	10.0	17900	133892	65.1
BB-222	275	329	9.4	10600	79288	38.5
HP-612	285	275	5.4	7900	59092	27.7
HP-614	285	323	4.9	6600	49368	23.2
HP-621	300	200	9.1	24500	183260	81.7
HP-628	320	160	3.4	6400	47872	20.0
HP-629	300	210	5.7	7900	59092	26.3
HP-634	300	163	4.5	4300	32164	14.3
HP-636	300	211	6.8	6900	51612	23.0
HP-643	295	278	5.3	9700	72556	32.9
HP-644	300	246	4.3	8100	60588	27.0
HP-646	305	304	10.6	20200	151096	66.2
HP-647	305	500	9.8	18700	139876	61.3
HP-648	310	250	2.9	5600	41888	18.1
HP-649	310	257	2.6	5000	37400	16.1
HP-651	305	270	3.8	7300	54604	23.9
HP-652	320	218	2.2	4400	32912	13.8
HP-663	325	350	4.8	6400	47872	19.7
HP-699	275	250	5.7	7700	57596	28.0
HP-700	270	250	6.8	11500	86020	42.6
HP-701	275	250	7.2	12400	92752	45.1
HP-705	295	250	9.0	13100	97988	44.4
HP-706	300	250	3.8	4700	35156	15.7
HP-709	310	200	4.4	8500	63580	27.4
HP-710	310	200	5.1	9900	74052	31.9
HP-711	320	200	6.8	10700	80036	33.4
LCH-4006	295	540	10.0	14500	108460	49.2
LCH-4007	295	275	11.8	13700	102476	46.4
M-267	260	170	7.7	10300	77044	39.6
M-628	260	70	3.0	6100	45628	23.5
RR-229	290	429	12.2	19400	145112	66.9
TT-25	280	150	5.0	7200	53856	25.7

STATION	PUMPING LEVEL	Q gpm	Sc gpm/ft
HP-602	44	154	3.5
HP-603	30	129	4.3
HP-606	38	267	7.0
HP-607	46	246	5.3
HP-608	21	208	9.9
HP-609	45	199	4.4
HP-610	14	214	15.3
HP-613	17	157	9.2
HP-616	15	178	11.9
HP-620	9	224	24.9
HP-622	55	330	6.0
HP-623	30	210	7.0
HP-628	45	172	3.8
HP-629	45	216	4.8
HP-632	21	224	10.7
HP-633	18	205	11.4
HP-634	36	219	6.1
HP-635	33	151	4.6
HP-636	35	149	4.3
HP-637	40	130	3.3
HP-638	84	201	2.4
HP-639	52	[--]	0.0
HP-640	28	210	7.5
-641	44	351	8.0
HP-642	32	[--]	0.0
HP-643	35	269	7.7
HP-644	52	230	4.4
HP-645	40	192	4.8
HP-646	11	154	14.0
HP-647	26	302	11.6
HP-648	84	263	3.1
HP-649	80	100	1.3
HP-650	75	480	6.4
HP-651	69	242	3.5
HP-652	82	216	2.6
HP-653	29	197	6.8
HP-654	30	175	5.8
HP-655		[--]	ERR
HP-660		150	ERR
HP-661	37	275	7.4
HP-662	53	148	2.8
HP-663	23	100	4.3
HP-698	33	216	6.5
HP-699	21	140	6.7

STATION	PUMPING LEVEL	Q gpm	Sc gpm/ft
HP-700	39	192	4.9
HP-701	36	236	6.6
HP-703	33	293	8.9
HP-704	38	159	4.2
HP-705	25	214	8.6
HP-706	33	214	6.5
HP-707	51	50	1.0
HP-708	42	219	5.2
HP-709	52	239	4.6
HP-710	29	115	4.0
HP-711	56	235	4.2
HP-5186	38	336	8.8
LCH-4007	34	150	4.4
LCH-4009	22	349	15.9
TT-23	36	160	4.4
TT-25	22	130	5.9
TT-26	32	127	4.0
TT-31	28	111	4.0
TT-52	18	236	13.1
TT-54	20	119	6.0
TT-67	29	119	4.1
RR-45	11	192	17.5
RR-47	5	140	28.0
RR-97	14	170	12.1
RR-229	35	[--]	0.0
BB-44	11	125	11.4
BB-47	6	341	56.8
BB-218	17	192	11.3
BB-220	13	119	9.2
BB-221	19	230	12.1
TC-325	8	100	12.5
TC-502	1	180	180.0
TC-504	35	203	5.8
TC-600	32	172	5.4
TC-604	16	137	8.6
TC-700	28	125	4.5
TC-901	37	[--]	0.0
TC-1000	25	110	4.4
TC-1001	16	160	10.0
TC-1251	6	150	25.0
TC-1253	5	128	25.6
TC-1254	3	122	40.7
TC-1255	36	104	2.9
TC-1256	48	108	2.3

STATION	PUMPING LEVEL	Q gpm	Sc gpm/ft
AS-108	8	226	28.3
AS-131	11	310	28.2
AS-190	60	220	3.7
AS-191	16	220	13.8
AS-203	19	220	11.6
AS-4140	6	110	18.3
AS-4150	10	128	12.8
AS-5001	27	185	6.9
AS-5009	53	111	2.1
BA-164	21	214	10.2
BA-190	17	303	17.8

APPENDIX H
RAINFALL DATA FROM MCAS NEW RIVER

Weather Service
H&HS MCAS New River
Jacksonville, NC 28545-1002
(910)451-6828/6968 DSN 484-6828/6968
Fax: (910)451-6351 DSN 484-6351

FAX TRANSMISSION COVER SHEET

Date: 950911
To: JAMES CULP
Fax: (412) 269-2002
Subject: RAINFALL DATA
Sender: CPL LYNN, WEATHER ADMIN CLERK

YOU SHOULD RECEIVE [4] PAGE(S), INCLUDING THIS COVER SHEET. IF YOU DO NOT RECEIVE ALL THE PAGES, PLEASE CALL (910)451-6828/6968 DSN 484-6828/6968

NOTES:

[redacted]

Weather Service Section

MCAS New River
Jacksonville, NC

Compiler: CPL LYNN Month. JUNE Year: 1995

	Temperatures			Precip.		Wind Summary			TRW	Field Summary			RH%	
	High	Low	Avg	Amt	Type*	Avg Dir	Avg Speed	Peak Speed	Hours	Hrs BM	Hrs IFR	Hrs VFR	Avg	High
1	86	64	75	0.00		SE	5	14	0.00	0.00	0.00	24.00	69	84
2	85	70	77.5	0.05	R	S	4	14	1.63	0.00	0.00	24.00	80	87
3	79	71	75	1.35	R	SW	3	14	1.07	0.00	3.53	20.47	83	93
4	89	71	80	0.00		SW	3	13	0.00	0.00	0.00	24.00	78	90
5	78	72	75	2.54	R	SE	7	22	0.00	0.00	7.47	16.53	86	93
6	79	71	75	1.87	R	W	10	30	1.08	0.00	11.30	12.70	86	90
7	94	68	81	0.44	R	WSW	6	34	1.87	0.00	3.32	20.68	77	94
8	96	71	83.5	0.00		W	6	28	0.00	0.00	0.00	24.00	66	87
9	96	71	83.5	0.28	R	NNW	6	22	2.67	0.00	0.20	23.80	66	85
10	88	71	79.5	0.15	R	SE	5	14	0.00	0.00	0.00	24.00	77	87
11	89	73	81	0.01	R	S	6	18	1.18	0.00	4.40	19.60	77	90
12	88	68	78	0.54	R	S	7	27	8.95	0.00	0.47	23.53	80	87
13	74	62	68	T	L	N	8	21	0.00	0.00	5.00	19.00	74	87
14	83	56	69.5	0.00		W	6	21	0.00	0.00	0.00	24.00	58	81
15	88	58	73	0.00		SE	3	14	0.00	0.00	0.00	24.00	59	80
16	85	64	74.5	0.00		NE	6	13	0.00	0.00	0.00	24.00	58	81
17	84	62	73	0.17	R	N	5	23	0.75	0.00	0.00	24.00	64	81
18	77	68	72.5	0.79	R	NE	6	18	0.50	0.00	0.00	24.00	75	87
19	83	68	75.5	0.55	R	E	8	23	3.48	0.00	8.75	15.25	79	89
20	85	68	76.5	0.00		SW	5	14	0.00	0.00	0.00	24.00	73	88
21	78	71	74.5	0.13	R	SE	4	15	0.00	0.00	0.62	23.38	83	87
22	80	71	75.5	0.02	R,L	E	5	17	0.00	0.30	5.52	18.18	83	90
23	90	71	80.5	T	L	SSW	3	13	0.00	0.00	0.00	24.00	75	91
24	90	71	80.5	0.05	R	SE	4	13	0.00	1.23	1.27	21.50	78	94
25	90	73	81.5	T	R	SW	3	16	1.75	0.00	4.00	20.00	78	90
26	91	72	81.5	0.03	R	S	4	16	1.50	0.00	0.00	24.00	76	94
27	90	71	80.5	0.15	R	VRB	4	28	2.33	2.84	2.88	18.28	82	91
28	87	73	80	0.42	R	E	5	16	1.58	0.00	3.43	20.57	78	90
29	86	73	79.5	T	R	SE	5	10	0.00	0.00	0.00	24.00	77	87
30	90	69	79.5	0.00		E	3	7	0.00	0.00	0.00	24.00	69	87
31			ERR											

	Temp		Precip.	Winds			TRW	BM	IFR	VFR	RH%	
	High	Low	Amount	Avg Dir.	Avg Spd.	Peak Spd.	Total Hrs.	Total Hrs.	Total Hrs.	Total Hrs.	Avg.	High
Absolute	96	56	9.54			34	30.34	4.37	62.16	653.47		94
Average	86	69	0.32	SSE	5			0.15	2.07	21.08	74.80	

*: R - RAIN OR RAIN SHOWERS
L - DRIZZLE
S - SNOW OR SNOW SHOWERS
H - HAIL

ZL - FREEZING DRIZZLE
ZR - FREEZING RAIN
IP - ICE PELLETS

Weather Service Section

MCAS New River
Jacksonville, NC

Compiler: CPL LYNN **Month:** JULY **Year:** 1995

	Temperatures			Precip.		Wind Summary			TRW	Field Summary			RH%	
	High	Low	Avg	Amt	Type*	Avg Dir	Avg Speed	Peak Speed	Hours	Hrs BM	Hrs IFR	Hrs VFR	Avg	High
1	90	71	80.5	0.21	R	SSW	5	22	2.00	0.00	0.48	23.52	77	87
2	88	72	80	0.31	R	NW	3	14	0.00	0.00	2.42	21.58	74	87
3	89	73	81	0.20	R	SE	3	15	4.85	0.00	0.00	24.00	79	87
4	91	72	81.5	0.00		E	4	16	0.42	0.00	0.00	24.00	75	90
5	91	73	82	0.20	R	SE	4	18	1.30	0.00	0.00	24.00	73	90
6	91	71	81	T	R	E	5	26	0.32	0.00	0.00	24.00	69	84
7	87	70	78.5	0.19	R	SW	4	28	1.08	0.00	0.55	23.45	75	84
8	93	72	82.5	0.00		W	5	14	0.00	0.00	0.00	24.00	68	87
9	93	71	82	0.00		NW	3	12	0.00	0.00	0.00	24.00	69	87
10	91	70	80.5	0.01	R	E	4	25	3.52	0.00	0.00	24.00	77	87
11	93	71	82	0.06	R	S	4	16	1.83	0.00	0.30	23.70	78	87
12	90	74	82	0.00		E	5	17	0.00	0.00	0.00	24.00	71	88
13	90	72	81	0.05	R	E	3	19	0.00	0.00	2.00	22.00	75	87
14	91	73	82	0.28	R	S	5	19	0.92	0.00	0.00	24.00	77	87
15	94	74	84	0.00		SSW	7	15	0.00	0.00	0.00	24.00	74	91
16	93	76	84.5	T	R	S	4	15	0.00	0.00	0.00	24.00	79	88
17	91	77	84	0.53	R	S	4	16	1.15	0.00	0.50	23.50	77	87
18	91	74	82.5	0.00		SW	5	17	3.50	0.00	0.00	24.00	78	88
19	91	73	82	0.02	R	SW	1	6	0.00	0.00	0.00	24.00	78	87
20	97	74	85.5	0.00		S	2	16	0.00	0.00	0.00	24.00	72	87
21	93	75	84	0.05	R	SSW	6	22	2.68	0.00	0.00	24.00	76	87
22	94	74	84	0.26	R	SW	5	16	3.00	0.00	0.00	24.00	76	88
23	97	79	88	0.00		SW	6	23	0.00	0.00	2.00	22.00	72	90
24	97	72	84.5	0.00		SW	6	18	0.60	0.00	0.00	24.00	72	85
25	93	73	83	0.00		S	8	21	0.00	0.00	0.00	24.00	73	87
26	94	78	86	0.00		SW	7	24	0.00	0.00	0.00	24.00	76	87
27	91	78	84.5	T	R	S	6	19	0.48	0.00	0.00	24.00	75	85
28	91	75	83	0.00		S	5	18	0.00	0.00	0.00	24.00	72	87
29	93	74	83.5	0.00		S	6	17	0.00	0.00	0.00	24.00	74	88
30	95	74	84.5	0.00		SE	4	17	0.00	0.00	0.00	24.00	70	87
31	93	76	84.5	T	R	SE	3	15	0.00	0.00	0.00	24.00	71	84

	Temp		Precip.	Winds			TRW	BM	IFR	VFR	RH%	
	High	Low	Amount	Avg Dir.	Avg Spd.	Peak Spd.	Total Hrs.	Total Hrs.	Total Hrs.	Total Hrs.	Avg.	High
Absolute	97	70	2.37			28	27.65	0.00	8.25	735.75		91
Average	92	74	0.08	SSW	5			0.00	0.27	23.73	74.26	

*: R - RAIN OR RAIN SHOWERS
L - DRIZZLE
S - SNOW OR SNOW SHOWERS
H - HAIL
ZL - FREEZING DRIZZLE
ZR - FREEZING RAIN
IP - ICE PELLETS

Weather Service Section

MCAS New River
Jacksonville, NC

Compiler: CPL LYNN Month: AUGUST Year: 1995

	Temperatures			Precip.		Wind Summary			TRW	Field Summary			RH%	
	High	Low	Avg	Amt	Type*	Avg Dir	Avg Speed	Peak Speed	Hours	Hrs BM	Hrs IFR	Hrs VFR	Avg	High
1	94	74	84	0.00		SE	5	14	0.00	0.00	0.00	24.00	68	91
2	92	75	83.5	T	R	SSE	6	24	0.85	0.00	0.00	24.00	70	84
3	93	76	84.5	0.03	R	ESE	8	20	0.00	0.00	0.00	24.00	75	94
4	93	74	83.5	0.00		SSE	5	16	0.00	0.00	0.00	24.00	72	87
5	95	75	85	0.00		SW	6	18	0.00	0.00	0.00	24.00	72	87
6	96	76	86	0.17	R	SW	8	27	0.00	0.00	0.00	24.00	67	86
7	86	69	77.5	0.00		NE	7	19	0.00	0.00	0.00	24.00	70	88
8	85	65	75	0.00		NNE	6	18	0.00	0.00	0.00	24.00	68	79
9	88	71	79.5	2.91	R	NNE	5	13	1.50	0.00	6.37	17.63	83	90
10	86	74	80	0.08	R,L	NE	6	23	0.92	0.00	1.13	22.87	80	90
11	89	71	80	0.02	L	NNW	8	19	0.00	0.00	5.02	18.98	73	87
12	95	68	81.5	0.00		SW	4	13	0.00	0.00	0.00	24.00	71	87
13	100	75	87.5	0.00		SW	4	12	0.00	0.00	0.00	24.00	73	87
14	95	77	86	0.00		ESE	4	13	0.00	0.00	0.32	23.68	71	87
15	92	72	82	0.00		NNE	7	19	0.00	0.00	0.00	24.00	59	91
16	91	70	80.5	T	R	NW	10	26	0.00	0.00	4.15	19.85	68	89
17	97	77	87	0.00		NW	7	20	0.00	0.00	0.00	24.00	65	85
18	96	75	85.5	0.00		N	5	17	0.00	0.00	0.00	24.00	65	88
19	89	69	79	0.00		NW	9	18	0.00	0.00	0.00	24.00	59	75
20	87	63	75	0.00		NNW	5	16	0.00	0.00	0.00	24.00	66	84
21	89	65	77	0.00		SW	4	19	0.00	0.00	0.00	24.00	67	89
22	92	69	80.5	0.00		S	5	14	0.00	0.00	0.00	24.00	70	89
23	88	74	81	0.03	R	SE	6	20	0.00	0.00	1.08	22.92	77	90
24	92	75	83.5	0.00		ESE	8	18	0.00	0.00	0.00	24.00	73	87
25	91	74	82.5	0.07	R	SE	8	18	0.00	0.00	0.00	24.00	74	90
26	78	76	77	1.86	R	E	8	21	0.00	0.00	3.20	20.80	86	90
27	83	75	79	1.87	R	SSE	6	20	3.37	0.00	2.32	21.68	83	90
28	82	72	77	0.35	R,L	NNE	8	23	0.00	0.00	7.33	16.67	84	94
29	86	70	78	0.00		NNE	7	19	0.00	0.00	0.00	24.00	70	84
30	89	67	78	0.00		NE	5	14	0.00	0.00	0.00	24.00	66	84
31	89	69	79	0.00		S	4	14	0.00	0.00	0.00	24.00	72	87

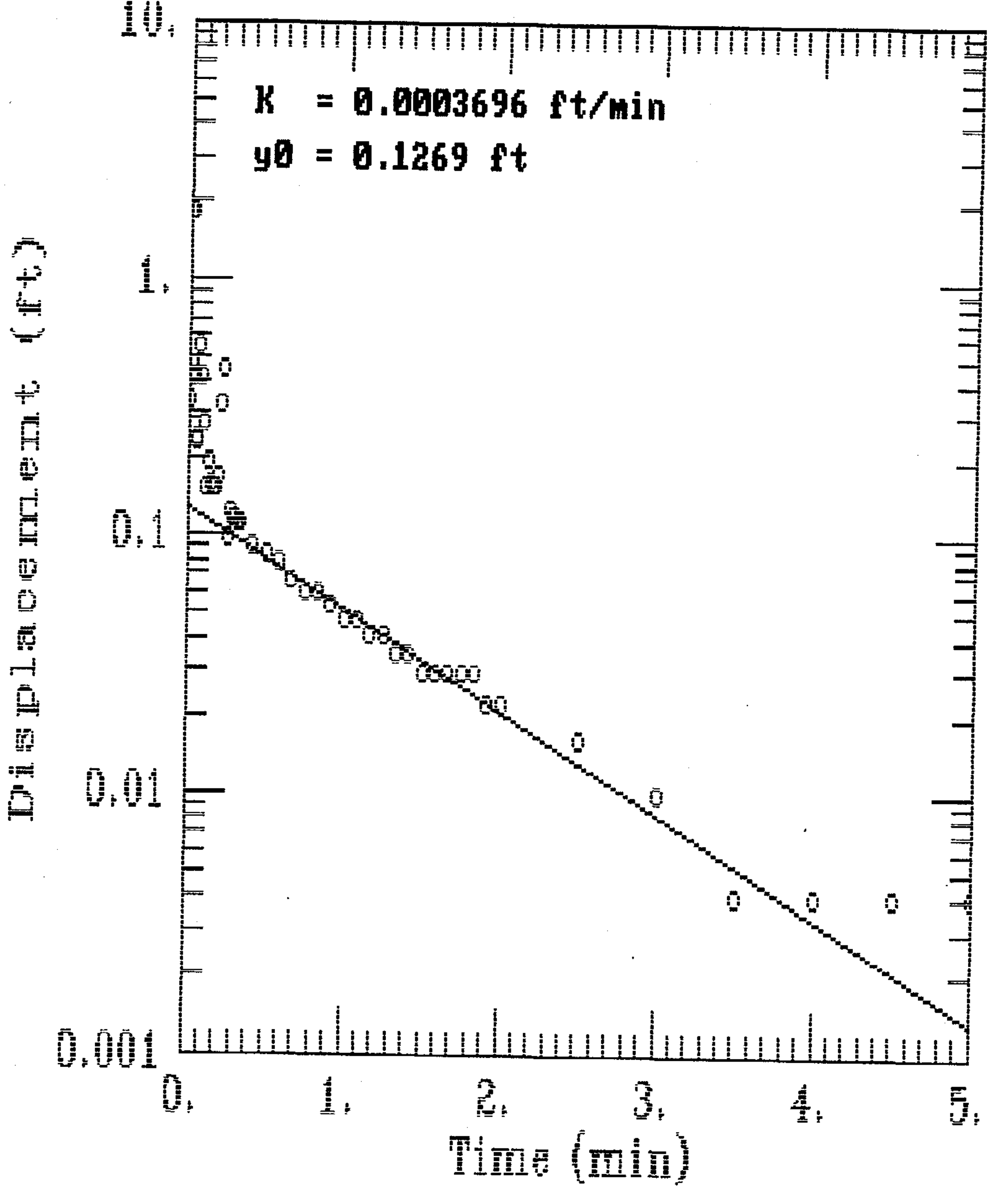
	Temp		Precip.	Winds			TRW	BM	IFR	VFR	RH%	
	High	Low	Amount	Avg Dir.	Avg Spd.	Peak Spd.	Total Hrs.	Total Hrs.	Total Hrs.	Total Hrs.	Avg.	High
Absolute	100	63	7.49			27	6.64	0.00	30.92	713.08		94
Average	90	72	0.24	E	6			0.00	1.00	23.00	71.52	

* : R - RAIN OR RAIN SHOWERS
L - DRIZZLE
S - SNOW OR SNOW SHOWERS
H - HAIL

ZL - FREEZING DRIZZLE
ZR - FREEZING RAIN
IP - ICE PELLETS

APPENDIX I
HYDRAULIC CONDUCTIVITY DATA

SITE 65 - 65MW-04A FALLING HEAD TEST



AQTESOLV

GERAGHTY
& MILLER, INC.

Modeling Group

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                                   Version  1.10

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================================================================================
                                TEST DESCRIPTION

Data set........... a:\65mw04af.dat
Data set title..... SITE 65 - 65MW-04A FALLING HEAD TEST

Knowns and Constants:
   No. of data points.................. 50
   Radius of well casing............... 0.083
   Radius of well...................... 0.875
   Aquifer saturated thickness......... 8.86
   Well screen length.................. 15
   Static height of water in well...... 8.86
   Log(Re/Rw).......................... 1.764
   A, B, C.............................  0.000,  0.000,  1.571

================================================================================
                                ANALYTICAL METHOD

Bouwer-Rice (Unconfined Aquifer Slug Test)

================================================================================
                      RESULTS FROM STATISTICAL CURVE MATCHING


STATISTICAL MATCH PARAMETER ESTIMATES

           Estimate           Std.  Error
   K  =   3.6962E-004 +/-    1.4462E-005
   y0 =   1.2689E-001 +/-    4.5294E-003


ANALYSIS OF MODEL RESIDUALS

residual = calculated - observed
weighted residual = residual * weight

Weighted Residual Statistics:
   Number of residuals............... 21
   Number of estimated parameters.... 2
   Degrees of freedom................ 19
   Residual mean..................... 0.0002106
   Residual standard deviation....... 0.002938
   Residual variance................. 8.633E-006


Model Residuals:

     Time          Observed      Calculated      Residual        Weight
 -------------  -------------  -------------  -------------  -------------
          0.5          0.085       0.080414      0.0045862              1
       0.5833          0.079       0.074529      0.0044706              1
       0.6666          0.066       0.069076     -0.0030755              1
         0.75           0.06       0.064015     -0.0040149              1
       0.8333           0.06        0.05933     0.00066953              1
```

```
     0.9166          0.054       0.054989    -0.00098883              1
          1          0.047        0.05096     -0.0039602              1
     1.0833          0.047       0.047231    -0.00023111              1
     1.1666          0.041       0.043775     -0.0027749              1
       1.25          0.041       0.040568     0.00043217              1
     1.3333          0.035       0.037599     -0.0025992              1
     1.4166          0.035       0.034848     0.00015222              1
        1.5          0.029       0.032295     -0.0032948              1
     1.5833          0.029       0.029932    -0.00093152              1
     1.6666          0.029       0.027741      0.0012588              1
       1.75          0.029       0.025709      0.0032912              1
     1.8333          0.029       0.023828      0.0051725              1
     1.9166          0.022       0.022084     -8.39E-005              1
          2          0.022       0.020466       0.001534              1
        2.5          0.016        0.01297      0.0030302              1
          3           0.01      0.0082193      0.0017807              1

================================================================================
                        RESULTS FROM VISUAL CURVE MATCHING

VISUAL MATCH PARAMETER ESTIMATES

              Estimate
   K  =     3.6962E-004
   y0 =     1.2689E-001

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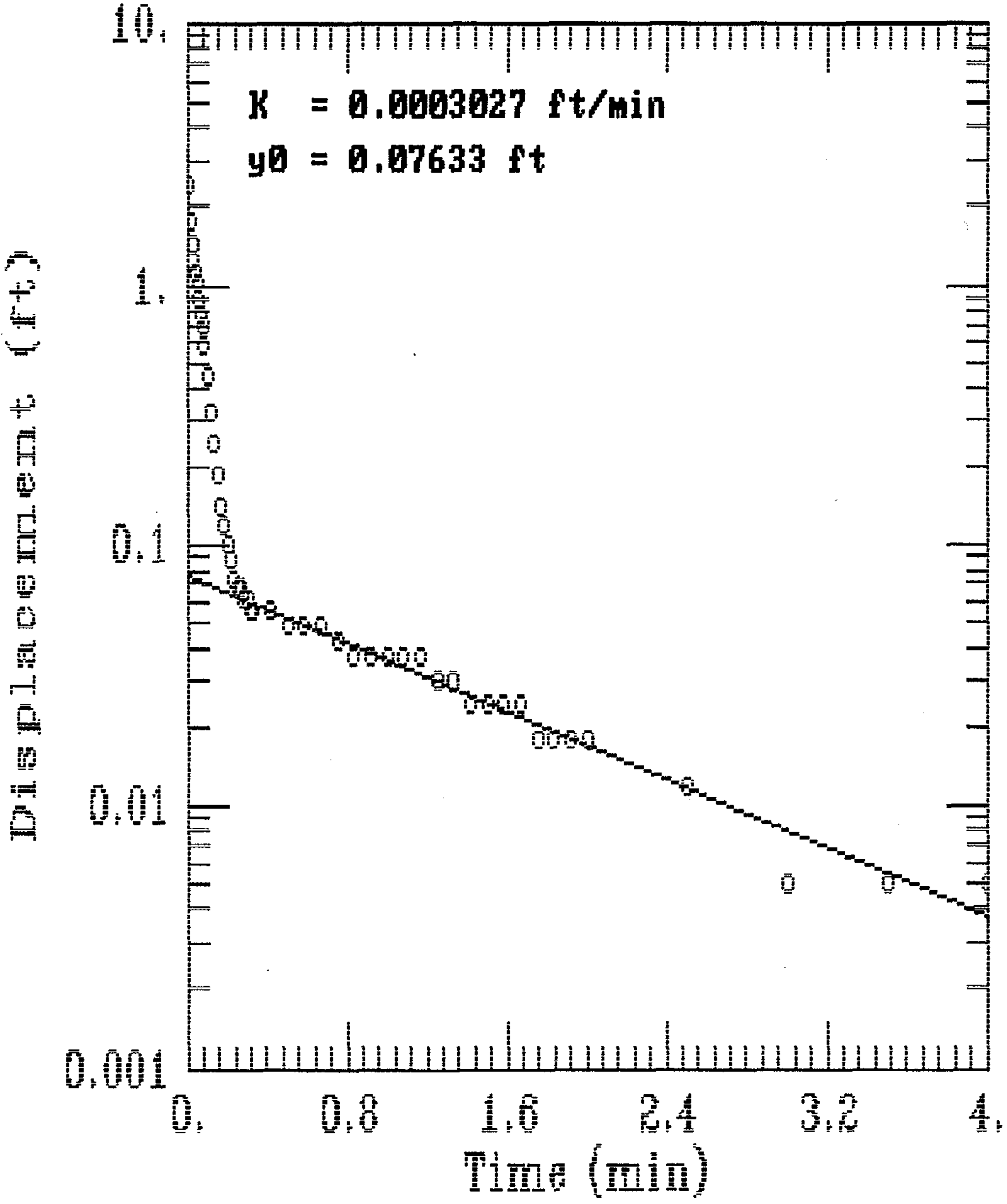
SITE 65 - 65MW04A RISING HEAD TEST



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================================================================================
                               TEST DESCRIPTION

Data set........... a:\65mw04ar.dat
Data set title..... SITE 65 - 65MW04A RISING HEAD TEST

Knowns and Constants:
   No. of data points.................. 49
   Radius of well casing............... 0.083
   Radius of well...................... 0.875
   Aquifer saturated thickness......... 8.86
   Well screen length.................. 15
   Static height of water in well...... 8.86
   Log(Re/Rw).......................... 1.764
   A, B, C.............................  0.000,  0.000,  1.571


================================================================================
                                ANALYTICAL METHOD

Bouwer-Rice (Unconfined Aquifer Slug Test)


=============================================================================
                    RESULTS FROM STATISTICAL CURVE MATCHING


STATISTICAL MATCH PARAMETER ESTIMATES

           Estimate          Std.  Error
   K  =   3.0271E-004 +/-   1.2099E-005
   y0 =   7.6326E-002 +/-   1.7034E-003


ANALYSIS OF MODEL RESIDUALS

residual = calculated - observed
weighted residual = residual * weight

Weighted Residual Statistics:
   Number of residuals.............. 27
   Number of estimated parameters.... 2
   Degrees of freedom............... 25
   Residual mean.................... 8.63E-006
   Residual standard deviation....... 0.002822
   Residual variance................ 7.966E-006


Model Residuals:

     Time         Observed      Calculated      Residual        Weight
 -------------  -------------  -------------  -------------  -------------
         0.25          0.068       0.063322      0.0046778              1
       0.2666          0.068       0.062542      0.0054583              1
       0.2833          0.062       0.061766     0.00023377              1
          0.3          0.062          0.061     0.00099963              1
       0.3166          0.055       0.060248     -0.0052485              1
```

```
       0.3333          0.055       0.059501     -0.0045014              1
       0.4166          0.055       0.055911    -0.00091122              1
          0.5          0.049       0.052534     -0.0035337              1
       0.5833          0.049       0.049364    -0.00036391              1
       0.6666          0.049       0.046385      0.0026146              1
         0.75          0.043       0.043583    -0.00058329              1
       0.8333          0.037       0.040954     -0.0039535              1
       0.9166          0.037       0.038482     -0.0014825              1
            1          0.037       0.036158      0.0008422              1
       1.0833          0.037       0.033976      0.0030239              1
       1.1666          0.037       0.031926       0.005074              1
         1.25           0.03       0.029997    2.5721E-006              1
       1.3333           0.03       0.028187      0.0018126              1
       1.4166          0.024       0.026487     -0.0024866              1
          1.5          0.024       0.024887    -0.00088663              1
       1.5833          0.024       0.023385     0.00061499              1
       1.6666          0.024       0.021974       0.002026              1
         1.75          0.018       0.020647     -0.0026466              1
       1.8333          0.018       0.019401     -0.0014008              1
       1.9166          0.018        0.01823    -0.00023018              1
            2          0.018       0.017129     0.00087108              1
          2.5          0.012       0.011789     0.00021054              1

================================================================================
                       RESULTS FROM VISUAL CURVE MATCHING

VISUAL MATCH PARAMETER ESTIMATES

           Estimate
   K  =   3.0271E-004
   y0 =   7.6326E-002

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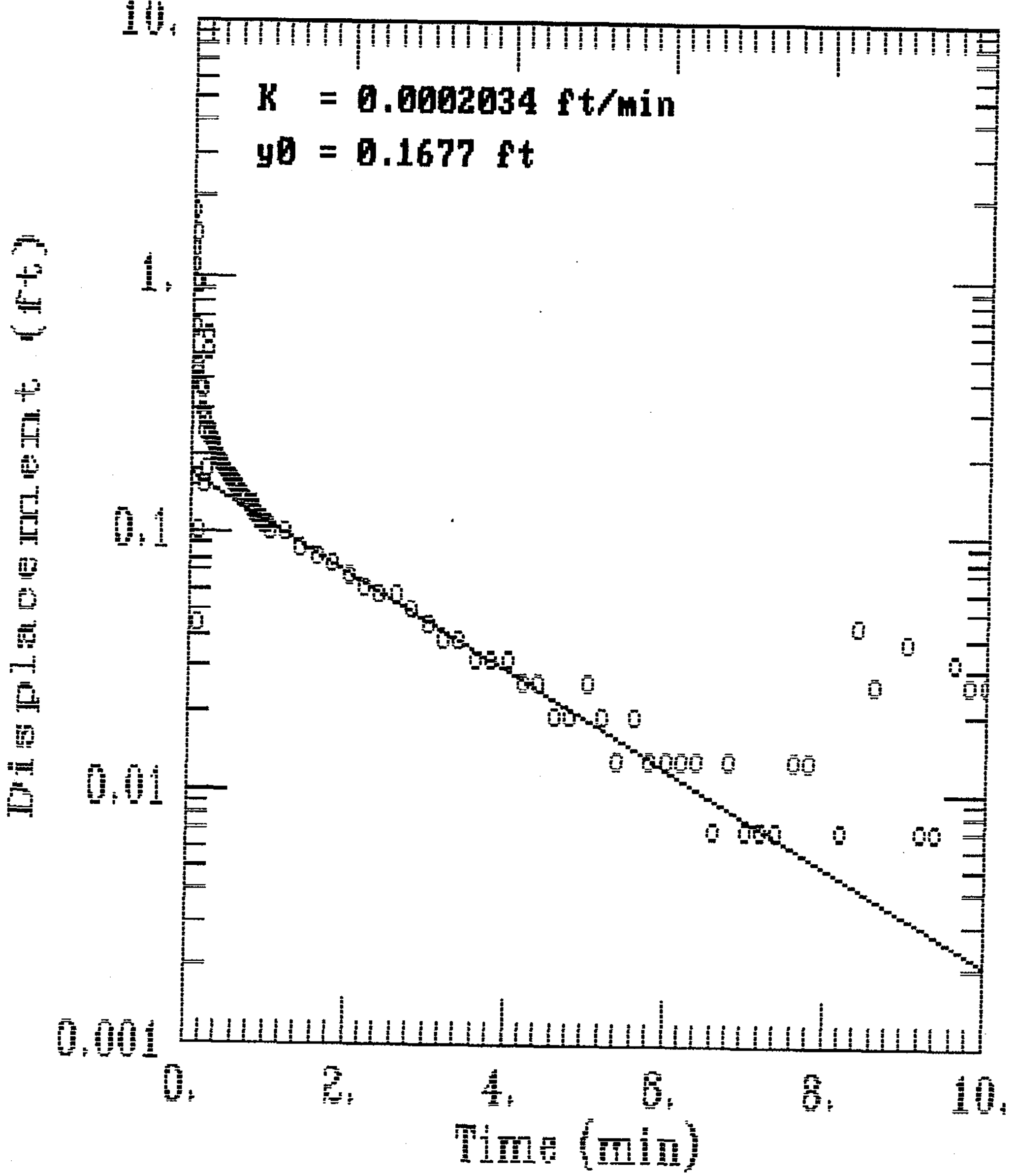
```

SITE 65 - 65MW-05A FALLING HEAD TEST



AQTESOLV

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                        A Q T E S O L V   R E S U L T S
                                Version  1.10

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================================================================================
                                TEST DESCRIPTION

Data set........... a:\65mw05af.dat
Data set title..... SITE 65 - 65MW-05A FALLING HEAD TEST

Knowns and Constants:
   No. of data points.................. 121
   Radius of well casing............... 0.083
   Radius of well...................... 0.875
   Aquifer saturated thickness......... 13.36
   Well screen length.................. 15
   Static height of water in well...... 13.36
   Log(Re/Rw).......................... 2.019
   A, B, C.............................  0.000,  0.000,  1.571

================================================================================
                               ANALYTICAL METHOD

Bouwer-Rice (Unconfined Aquifer Slug Test)

================================================================================
                      RESULTS FROM STATISTICAL CURVE MATCHING


STATISTICAL MATCH PARAMETER ESTIMATES

           Estimate         Std. Error
   K  =   2.0335E-004 +/-   6.2009E-006
   y0 =   1.6772E-001 +/-   5.9447E-003


ANALYSIS OF MODEL RESIDUALS

residual = calculated - observed
weighted residual = residual * weight

Weighted Residual Statistics:
   Number of residuals.............. 16
   Number of estimated parameters.... 2
   Degrees of freedom............... 14
   Residual mean.................... -0.0003441
   Residual standard deviation...... 0.007285
   Residual variance................ 5.307E-005


Model Residuals:

     Time         Observed      Calculated      Residual          Weight
 ------------- ------------- ------------- ------------- -------------
          1.2         0.101      0.099095      0.0019047             2
          1.4         0.088      0.090775     -0.0027747             2
          1.6         0.082      0.083153     -0.0011527             2
          1.8         0.076      0.076171    -0.00017073             2
            2         0.069      0.069775    -0.00077501             2
```

```
            2.2             0.063       0.063916    -0.0009163              2
            2.4             0.057        0.05855    -0.0015495              2
            2.6             0.057       0.053633     0.0033666              4
            2.8             0.051        0.04913       0.00187              4
              3             0.044       0.045005    -0.0010048              4
            3.2             0.038       0.041226    -0.0032259              4
            3.4             0.038       0.037764    0.00023565              4
            3.6             0.032       0.034593    -0.0025934              4
            3.8             0.032       0.031689    0.00031122              4
              4             0.032       0.029028      0.002972              4
            4.2             0.026       0.026591   -0.00059065              4

================================================================================
                         RESULTS FROM VISUAL CURVE MATCHING

VISUAL MATCH PARAMETER ESTIMATES

           Estimate
   K  =   2.0335E-004
   y0 =   1.6772E-001

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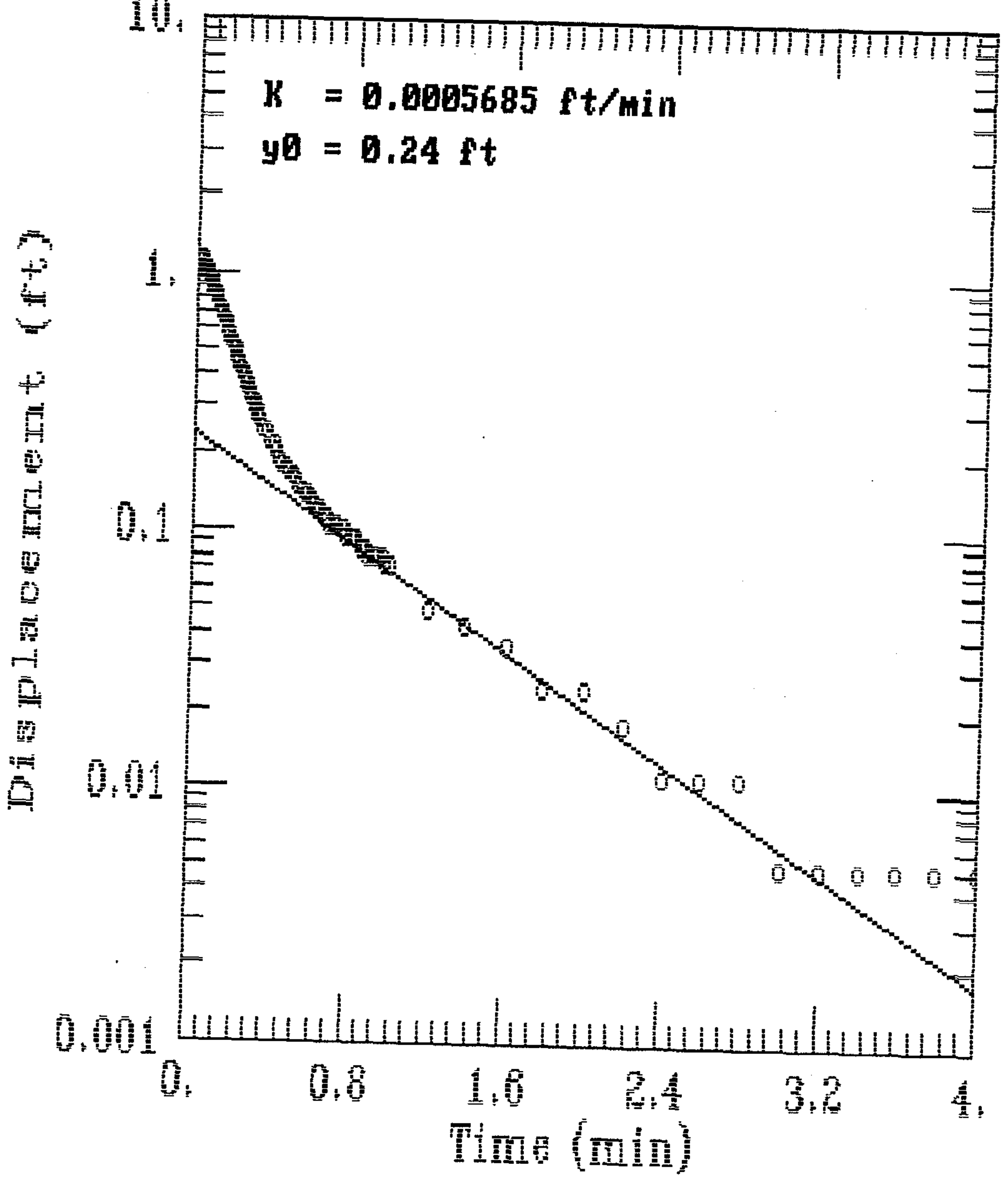
SITE 65 - 65MW-05A RISING HEAD TEST



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                                   Version  1.10

06/19/95                                                                16:52:17

================================================================================
                                TEST DESCRIPTION

Data set........... a:\65mw05ar.dat
Data set title..... SITE 65 - 65MW-05A RISING HEAD TEST

Knowns and Constants:
   No. of data points.................. 94
   Radius of well casing............... 0.083
   Radius of well...................... 0.875
   Aquifer saturated thickness......... 13.36
   Well screen length.................. 15
   Static height of water in well...... 13.36
   Log(Re/Rw).......................... 2.019
   A, B, C.............................  0.000,  0.000,  1.571

================================================================================
                                ANALYTICAL METHOD

Bouwer-Rice (Unconfined Aquifer Slug Test)

================================================================================
                      RESULTS FROM STATISTICAL CURVE MATCHING

STATISTICAL MATCH PARAMETER ESTIMATES

           Estimate         Std. Error
   K  =   5.6853E-004 +/-   4.5843E-005
   y0 =   2.3995E-001 +/-   3.1171E-002

ANALYSIS OF MODEL RESIDUALS

residual = calculated - observed
weighted residual = residual * weight

Weighted Residual Statistics:
   Number of residuals............... 8
   Number of estimated parameters.... 2
   Degrees of freedom................ 6
   Residual mean..................... 8.694E-005
   Residual standard deviation....... 0.00361
   Residual variance................. 1.303E-005

Model Residuals:

    Time         Observed       Calculated      Residual        Weight
 -------------  -------------  -------------  -------------  -------------
            1          0.074        0.07042      0.0035796              1
          1.2          0.049       0.055108     -0.0061077              1
          1.4          0.043       0.043125    -0.00012471              1
          1.6          0.036       0.033747      0.0022526              1
          1.8          0.024       0.026409     -0.0024091              1
```

```
           2           0.024        0.020667       0.0033335                     1
         2.2           0.018        0.016173       0.0018273                     1
         2.4           0.011        0.012656      -0.001656                      1

   ===============================================================================
                          RESULTS FROM VISUAL CURVE MATCHING

VISUAL MATCH PARAMETER ESTIMATES

           Estimate
   K  =   5.6853E-004
   y0 =   2.3995E-001

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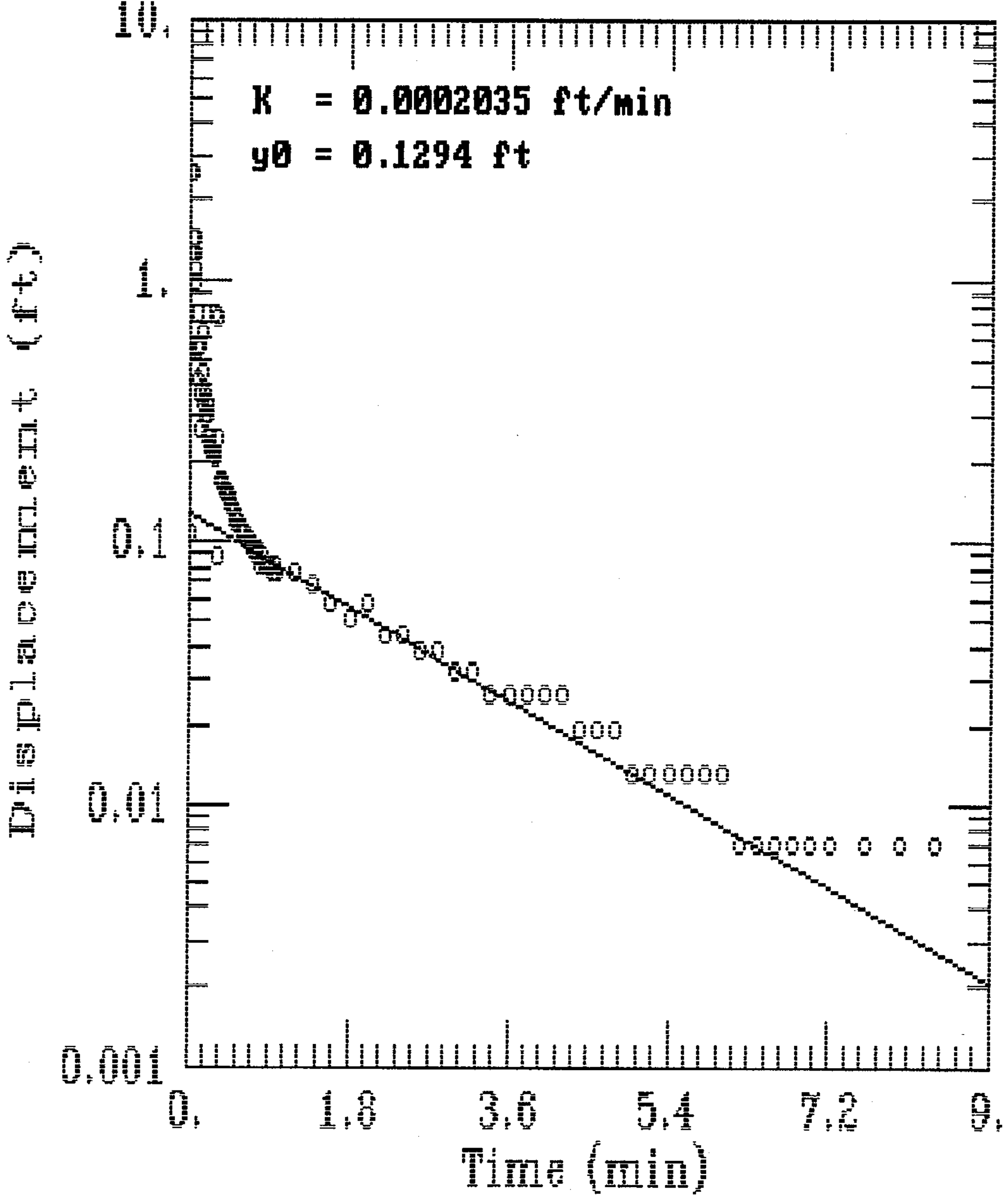
SITE 65 - 65MW-07A FALLING HEAD TEST



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                       A Q T E S O L V   R E S U L T S
                                  Version  1.10

06/19/95                                                                17:06:18

================================================================================
                               TEST DESCRIPTION

Data set........... a:\65mw07af.dat
Data set title..... SITE 65 - 65MW-07A FALLING HEAD TEST

Knowns and Constants:
   No. of data points.................. 112
   Radius of well casing............... 0.083
   Radius of well...................... 0.875
   Aquifer saturated thickness......... 11.7
   Well screen length.................. 15
   Static height of water in well...... 11.7
   Log(Re/Rw).......................... 1.939
   A, B, C.............................  0.000,  0.000,  1.571

================================================================================
                                ANALYTICAL METHOD

Bouwer-Rice (Unconfined Aquifer Slug Test)


================================================================================
                    RESULTS FROM STATISTICAL CURVE MATCHING


STATISTICAL MATCH PARAMETER ESTIMATES

           Estimate          Std.  Error
   K  =  2.0353E-004 +/-   8.7869E-006
   y0 =  1.2945E-001 +/-   2.8737E-003


ANALYSIS OF MODEL RESIDUALS

residual = calculated - observed
weighted residual = residual * weight

Weighted Residual Statistics:
   Number of residuals............... 43
   Number of estimated parameters.... 2
   Degrees of freedom................ 41
   Residual mean..................... 0.0002757
   Residual standard deviation....... 0.00522
   Residual variance................. 2.725E-005


Model Residuals:

     Time          Observed       Calculated       Residual          Weight
 -------------  -------------  -------------  -------------  -------------
       0.6166          0.113       0.097649       0.015351              1
       0.6333          0.107       0.096906       0.010094              1
         0.65          0.101       0.096169      0.0048309              1
       0.6666          0.101       0.095442       0.005558              1
       0.6833          0.101       0.094716       0.006284              1
```

```
         0.7          0.101        0.093996      0.0070044              1
      0.7166          0.094        0.093285     0.00071504              1
      0.7333          0.094        0.092575      0.0014246              1
        0.75          0.094        0.091871      0.0021287              1
      0.7666          0.094        0.091177      0.0028233              1
      0.7833          0.088        0.090483     -0.0024832              1
         0.8          0.082        0.089795      -0.007795              1
      0.8166          0.088        0.089116     -0.0011161              1
      0.8333          0.088        0.088438    -0.00043825              1
        0.85          0.082        0.087766     -0.0057656              1
      0.8666          0.082        0.087102      -0.005102              1
      0.8833          0.082         0.08644     -0.0044395              1
         0.9          0.082        0.085782     -0.0037821              1
      0.9166          0.082        0.085133     -0.0031335              1
      0.9333          0.076        0.084486      -0.008486              1
        0.95          0.076        0.083843     -0.0078433              1
      0.9666          0.082        0.083209     -0.0012094              1
      0.9833          0.076        0.082577     -0.0065765              1
           1          0.076        0.081948     -0.0059485              1
         1.2          0.076        0.074788      0.0012124              1
         1.4          0.069        0.068252     0.00074754              1
         1.6          0.057        0.062288     -0.0052884              1
         1.8          0.051        0.056845     -0.0058455              1
           2          0.057        0.051878      0.0051218              1
         2.2          0.044        0.047345     -0.0033449              1
         2.4          0.044        0.043208     0.00079221              1
         2.6          0.038        0.039432     -0.0014322              1
         2.8          0.038        0.035986      0.0020135              1
           3          0.032        0.032842     -0.0008419              1
         3.2          0.032        0.029972      0.0020279              1
         3.4          0.026        0.027353      -0.001353              1
         3.6          0.026        0.024963      0.0010371              1
         3.8          0.026        0.022782      0.0032185              1
           4          0.026        0.020791      0.0052092              1
         4.2          0.026        0.018974      0.0070259              1
         4.4          0.019        0.017316      0.0016839              1
         4.6          0.019        0.015803       0.003197              1
         4.8          0.019        0.014422       0.004578              1

================================================================================
                        RESULTS FROM VISUAL CURVE MATCHING

VISUAL MATCH PARAMETER ESTIMATES

            Estimate
   K  =    2.0353E-004
   y0 =    1.2945E-001

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```
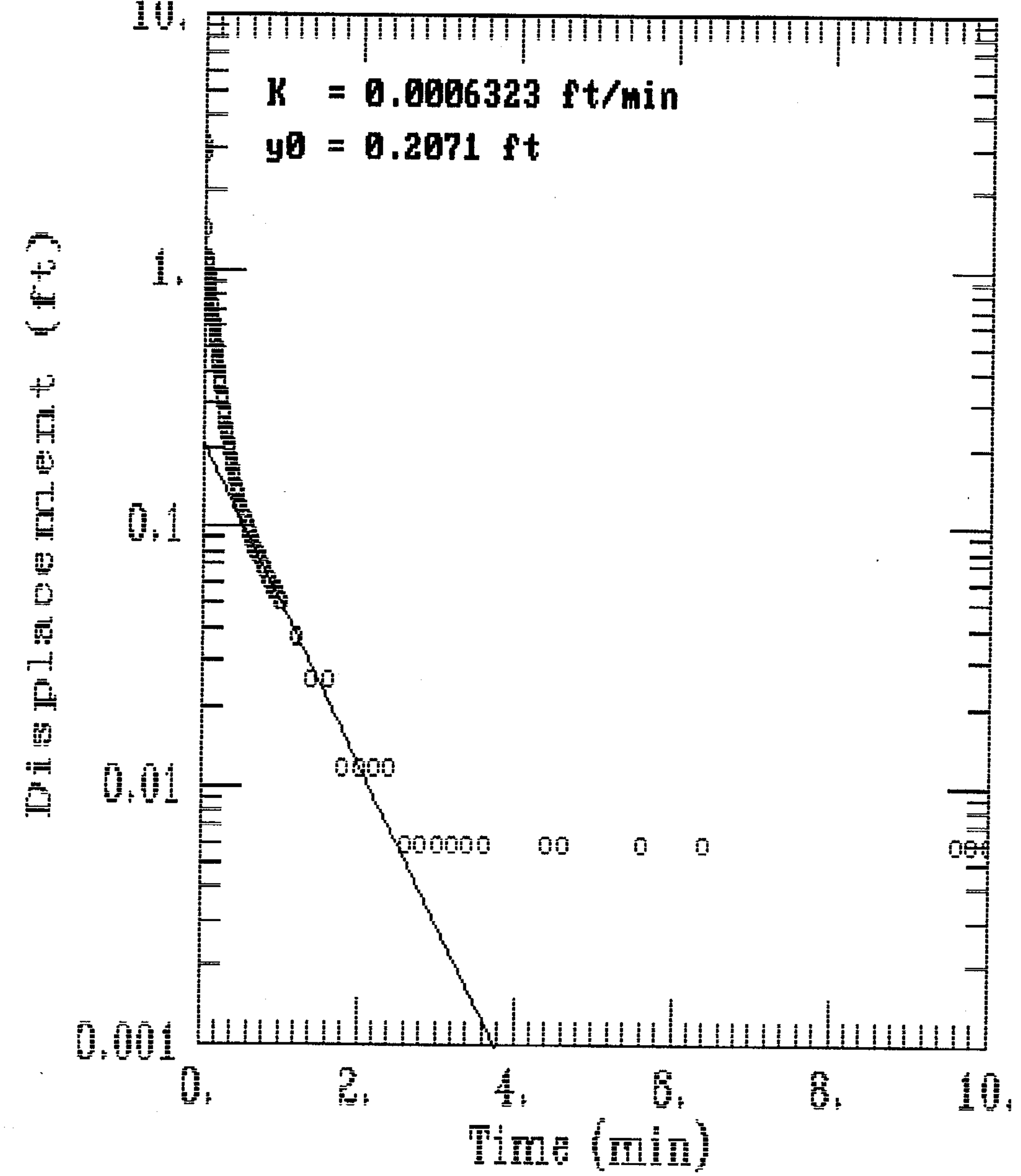

SITE 65 - 65MW-07A RISING HEAD TEST



AQTESOLV

GERAGHTY
& MILLER, INC.

Modeling Group

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                      A Q T E S O L V   R E S U L T S
                                Version  1.10

06/19/95                                                                 17:08:10

==================================================================================
                                TEST DESCRIPTION

Data set........... a:\65mw07ar.dat
Data set title..... SITE 65 - 65MW-07A RISING HEAD TEST

Knowns and Constants:
   No. of data points.................. 100
   Radius of well casing............... 0.083
   Radius of well...................... 0.875
   Aquifer saturated thickness......... 11.7
   Well screen length.................. 15
   Static height of water in well...... 11.7
   Log(Re/Rw).......................... 1.939
   A, B, C.............................  0.000,  0.000,  1.571

==================================================================================
                                ANALYTICAL METHOD

Bouwer-Rice (Unconfined Aquifer Slug Test)


==================================================================================
                      RESULTS FROM STATISTICAL CURVE MATCHING


STATISTICAL MATCH PARAMETER ESTIMATES

           Estimate           Std.  Error
   K  =   6.3231E-004 +/-    1.8899E-005
   y0 =   2.0706E-001 +/-    7.0572E-003


ANALYSIS OF MODEL RESIDUALS

residual = calculated - observed
weighted residual = residual * weight

Weighted Residual Statistics:
   Number of residuals............... 32
   Number of estimated parameters.... 2
   Degrees of freedom................ 30
   Residual mean..................... 0.0001437
   Residual standard deviation....... 0.002325
   Residual variance................. 5.404E-006


Model Residuals:

     Time          Observed       Calculated       Residual          Weight
 -------------  -------------  -------------  -------------  -------------
       0.6166          0.087       0.086248     0.00075208              1
       0.6333          0.087       0.084226      0.0027738              1
         0.65          0.081       0.082252     -0.0012518              1
       0.6666          0.081       0.080335     0.00066482              1
       0.6833          0.081       0.078452       0.002548              1
```

```
      0.7          0.075       0.076613    -0.001613          1
   0.7166          0.075       0.074828   0.00017222          1
   0.7333          0.075       0.073074    0.0019263          1
     0.75          0.068       0.071361   -0.0033608          1
   0.7666          0.068       0.069698    -0.001698          1
   0.7833          0.068       0.068064  -6.4161E-005          1
      0.8          0.068       0.066469    0.0015313          1
   0.8166          0.062        0.06492   -0.0029198          1
   0.8333          0.062       0.063398    -0.001398          1
     0.85          0.062       0.061912   8.8104E-005          1
   0.8666          0.062       0.060469    0.0015308          1
   0.8833          0.056       0.059052   -0.0030517          1
      0.9          0.056       0.057668   -0.0016675          1
   0.9166          0.056       0.056324  -0.00032373          1
   0.9333          0.056       0.055003   0.00099656          1
     0.95          0.056       0.053714    0.0022859          1
   0.9666          0.056       0.052462    0.0035376          1
   0.9833           0.05       0.051233   -0.0012327          1
        1           0.05       0.050032  -3.1727E-005          1
      1.2          0.037       0.037659  -0.00065945          1
      1.4          0.025       0.028347   -0.0033467          1
      1.6          0.025       0.021337    0.0036631          1
      1.8          0.012       0.016061   -0.0040605          1
        2          0.012       0.012089  -8.8936E-005          1
      2.2          0.012      0.0090995    0.0029005          1
      2.4          0.012      0.0068493    0.0051507          1
      2.6          0.006      0.0051555   0.00084447          1

=====================================================================
                 RESULTS FROM VISUAL CURVE MATCHING

UAL MATCH PARAMETER ESTIMATES

        Estimate
K  =   6.3231E-004
y0 =   2.0706E-001

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APPENDIX J
INVENTORY OF THE RARE SPECIES, NATURAL COMMUNITIES, AND CRITICAL AREAS OF THE CAMP LEJEUNE MARINE CORPS BASE, NORTH CAROLINA

INVENTORY OF THE RARE SPECIES, NATURAL COMMUNITIES, AND CRITICAL AREAS OF THE CAMP LEJEUNE MARINE CORPS BASE, NORTH CAROLINA

By

Richard J. LeBlond
John O. Fussell
and
Alvin L. Braswell

Edited by
Inge K. Smith

For the

North Carolina Natural Heritage Program
Division of Parks and Recreation
Department of Environment, Health, and Natural Resources
Raleigh, North Carolina 27611

February 1994

Table 2. Endangered and rare animal species documented from Camp Lejeune.

Scientific Name/Common Name	Federal Status	North Carolina Status
Accipiter cooperii Cooper's Hawk	-	Special Concern
Aimophila aestivalis Bachman's Sparrow	Candidate	Special Concern
Alligator mississippiensis American Alligator	-	Threatened
Caretta caretta American Loggerhead Turtle	Threatened	Threatened
Charadrius melodus Piping Plover	Threatened	Threatened
Chelonia mydas Green Turtle	Threatened	Threatened
Crotalus adamanteus Eastern Diamondback Rattlesnake	-	Significantly Rare
Falco peregrinus Peregrine Falcon	Endangered	Endangered
Heterodon simus Southern Hognose Snake	Candidate	Significantly Rare
Malaclemys terrapin Diamondback Terrapin	Candidate	Special Concern
Micrurus fulvius Eastern Coral Snake	-	Significantly Rare
Picoides borealis Red-cockaded Woodpecker	Endangered	Endangered
Rana capito capito Carolina Gopher Frog	Candidate	Special Concern
Sistrurus miliarius Pigmy Rattlesnake	-	Significantly Rare
Ursus americanus Black Bear	-	Significantly Rare

Table 3. Endangered and rare plant species documented from Camp Lejeune.

Scientific Name/Common Name	Federal Status	North Carolina Status
Agalinis aphylla Scale-leaf Gerardia	-	Candidate
Agalinis linifolia Flaxleaf Gerardia	-	Significantly Rare
Agalinis virgata Branched Gerardia	-	Candidate
Amaranthus pumilus Seabeach Amaranth	Candidate	Threatened
Amphicarpum purshii Pinebarrens Goober Grass	-	Significantly Rare
Aristida palustris Longleaf Three-awn	-	Significantly Rare
Asclepias pedicellata Stalked Milkweed	-	Candidate
Calamovilfa brevipilis Pinebarrens Sandreed	-	Endangered
Carex chapmanii Chapman's Sedge	Candidate	Threatened
Carex verrucosa Warty Sedge	-	Significantly Rare
Cladium mariscoides Smooth Sawgrass	-	Significantly Rare
Cornus asperifolia Roughleaf Dogwood	-	Candidate
Cyperus lecontei Leconte's Flatsedge	-	Significantly Rare
Dichanthelium erectifolium Erectleaf Witchgrass	-	Significantly Rare
Dichanthelium species 1 Hirst's Witchgrass	Candidate	Candidate

Table 3 con't

Dionaea muscipula Venus Flytrap	*1	Candidate- Special Concern
Eleocharis elongata Elongate Spikerush	-	Candidate
Eleocharis equisetoides Horsetail Spikerush	-	Significantly Rare
Eleocharis melanocarpa Blackfruit Spikerush	-	Candidate
Eleocharis montevidensis Sand Spikerush	-	Significantly Rare
Eleocharis robbinsii Robbins's Spikerush	-	Candidate
Litsea aestivalis Pondspice	Candidate	Candidate
Lobelia boykinii Boykin's Lobelia	Candidate	Candidate
Ludwigia linifolia Flaxleaf Seedbox	-	Significantly Rare
Lysimachia asperulifolia Rough-leaf Loosestrife	Endangered	Endangered
Muhlenbergia torreyana Torrey's Muhley	-	Endangered
Myriophyllum laxum Loose Watermilfoil	Candidate	Threatened
Oxypolis ternata Savanna Cowbane	Candidate	Candidate
Panicum tenerum Southeastern Panic Grass	-	Significantly Rare
Peltandra sagittifolia Spoonflower	-	Significantly Rare
Polygala hookeri Hooker's Milkwort	-	Candidate
Ponthieva racemosa Shadow-witch	-	Significantly Rare

Table 3 con't

Rhexia aristosa Awned Meadow-beauty	Candidate	Threatened
Rhexia cubensis West Indies Meadow-beauty	-	Significantly Rare
Rhynchospora harperi Harper's Beakrush	-	Candidate
Rhynchospora oligantha Feather-bristle Beakrush	-	Candidate
Rhynchospora pallida Pale Beakrush	-	Significantly Rare
Rhynchospora pleiantha Coastal Beakrush	-	Candidate
Rhynchospora scirpoides Longbeak Baldsedge	-	Significantly Rare
Rhynchospora tracyi Tracy's Beakrush	-	Significantly Rare
Sageretia minutiflora Small-flowered Buckthorn	-	Candidate
Sagittaria graminea var. chapmanii Chapman's Arrowhead	-	Candidate
Scirpus etuberculatus Canby's Bulrush	-	Significantly Rare
Scirpus lineatus Drooping Bulrush	-	Candidate
Scleria georgiana Georgia Nutrush	-	Candidate
Scleria minor Slender Nutrush	-	Significantly Rare
Scleria reticularis (sensu stricto) Netted Nutrush	-	Candidate
Solidago pulchra Carolina Goldenrod	Candidate	Endangered
Solidago species 1 Lejeune Goldenrod	-	Significantly Rare

Table 3 con't

Spiranthes laciniata Lace-lip Ladies'-tresses	-	Candidate
Sporobolus species 1 Carolina Dropseed	Candidate	Threatened
Tofieldia glabra Carolina Asphodel	Candidate	Candidate
Utricularia olivacea Dwarf Bladderwort	-	Threatened
Xyris elliottii Elliott's Yellow-eyed Grass	-	Significantly Rare
Xyris flabelliformis Savanna Yellow-eyed Grass	-	Candidate

---

*1 - Dionaea muscipula had been recommended for upgrading to Federal Candidate (level 2) at the time of this report.

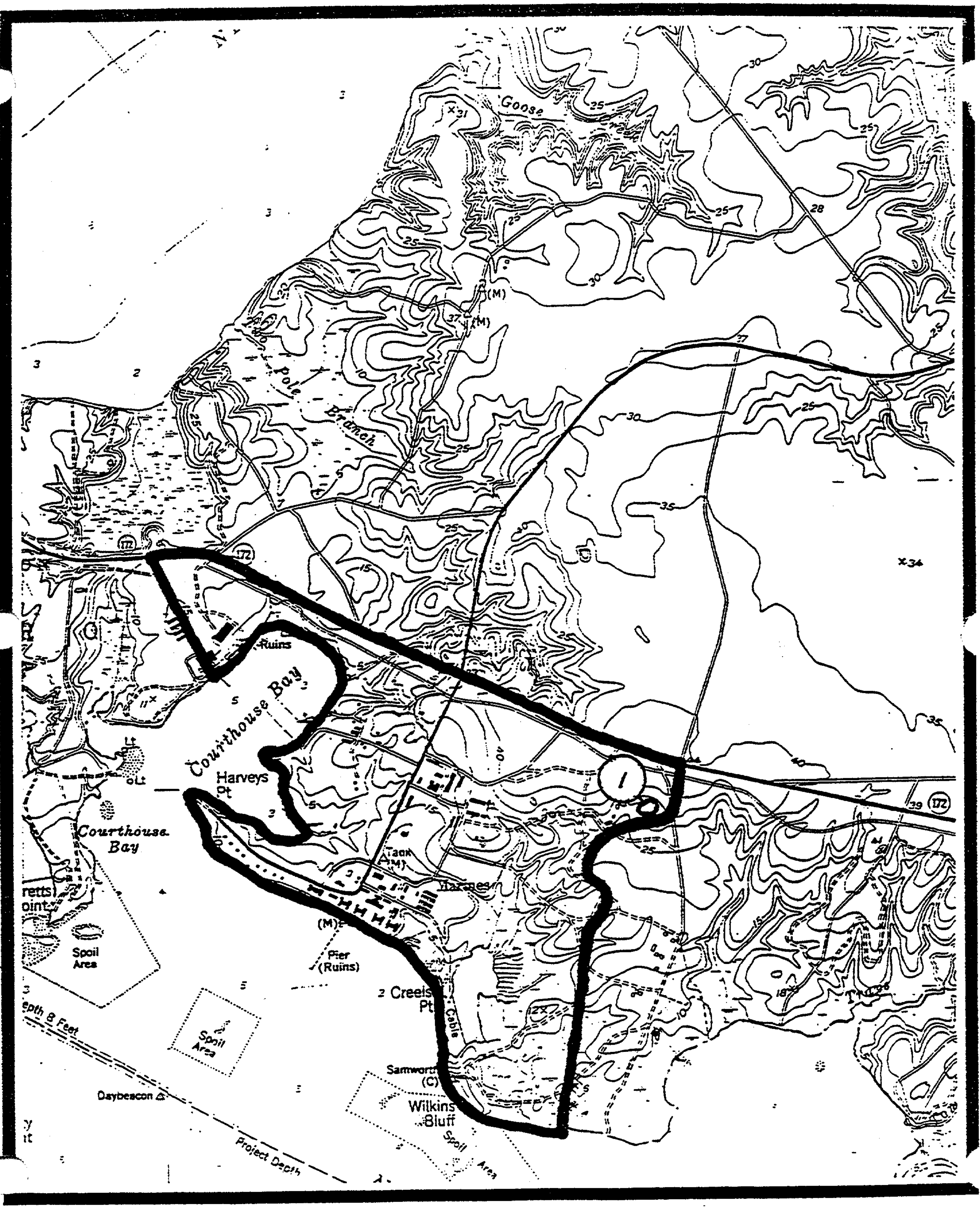
Table 4. Distribution of rare plants in Camp Lejeune by primary natural community types.

Community Types:
A - Calcareous Coastal Fringe Forest
B - Coastal Plain Small Stream Swamp (Blackwater Subtype)
C - Cypress Savanna
D - Depression Meadow
E - Maritime Evergreen Forest
F - Maritime Wet Grassland
G - Pine Savanna
H - Pond Pine Woodland
I - Small Depression Pocosin
J - Small Depression Pond
K - Streamhead Pocosin
L - Upper Beach
M - Vernal Pool
N - Wet Pine Flatwoods
O - undetermined (intermediate between Mesic Mixed Hardwood Forest and Maritime Deciduous Forest)

Species	Status	Community Types														
	US,NC	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O
Agalinis aphylla	C							x								
A. linifolia	SR			x	x						x			x		
A. virgata	C							x						x	x	
Amaranthus pumilus	C2,T												x			
Amphicarpum purshii	SR							x		x		x			x	
Aristida palustris	SR			x	x						x			x		
Asclepias pedicellata	C							x							x	
Calamovilfa brevipilis	E							x							x	
Carex chapmanii	C2,T	x	x													
Carex verrucosa	SR			x	x						x					
Cladium mariscoides	SR										x					
Cornus asperifolia	C	x														
Cyperus lecontei	C														x	
Dichanthelium erectifolium	SR			x	x						x					
D. species 1	C2,C			x	x											
Dionaea muscipula	C							x		x		x			x	
Eleocharis elongata	C										x					
E. equisetoides	SR			x	x						x					
E. melanocarpa	C				x						x					
E. montevidensis	SR						x									
E. robbinsii	C										x					
Litsea aestivalis	C2,C				x					x	x					
Lobelia boykinii	C2,C			x	x											
Ludwigia linifolia	SR				x						x					
Lysimachia asperulifolia	E,E								x	x						
Muhlenbergia torreyana	E			x	x											
Myriophyllum laxum	C2,T										x					

Table 4 con't

Oxypolis ternata	C2,C					x					x	
Panicum tenerum	SR		x	x				x				
Peltandra sagittifolia	SR						x					
Polygala hookeri	C					x						
Ponthieva racemosa	SR	x										
Rhexia aristosa	C2,T		x	x				x		x		
R. cubensis				x				x		x		
Rhynchospora harperi	C		x	x				x				
R. oligantha	C					x						
R. pallida	SR					x	x		x		x	
R. pleiantha	C							x				
R. scirpoides	SR							x				
R. tracyi	SR		x	x				x				
Sageretia minutiflora	C				x							
Sagittaria graminea var. chapmanii	C							x				
Scirpus etuberculatus	SR							x				
S. lineatus	C	x										
Scleria georgiana	C		x	x								
S. minor	SR										x	
S. reticularis	C			x				x				
Solidago pulchra	C2,E					x			x		x	
S. species 1	SR											x
Spiranthes laciniata	C		x	x				x				
Sporobolus species 1	C2,T					x	x				x	
Tofieldia glabra	C2,C					x			x		x	
Utricularia olivacea	T							x				
Xyris elliottii	SR					x					x	
X. flabelliformis	C					x					x	



Significant sites in Training Area CB.

Camp Lejeune Report NC NHP 1994

B. CRITICAL AREA DESCRIPTIONS AND MAPS

SITE NAME: CB-1 Courthouse Bay Area.

UTM COORDINATES: 844290.
QUAD: New River Inlet.
SIZE: 1 acre.
DATE OF INVESTIGATION: 1990-7-19.
OBSERVER: R.J. LeBlond.
NATURAL COMMUNITY: Small Depression Pond.

LOCATION: Along west side of powerline corridor 0.15 mile due south of NC 172 0.1 mile east of junction with Plexiglass Road.

QUALITY AND INTEGRITY OF NATURAL COMMUNITY: Low quality pond community heavily impacted by dredging for creation of a fishing pond. The Eleocharis melanocarpa population is primarily restricted to the shelf above the steeply-sloped margin along the north and northeast shores.

EVIDENT AND POTENTIAL DISTURBANCES AND THREATS: Habitat greatly altered by dredging and filling associated with construction of fishing pond.

MANAGEMENT NEEDS: Site has value only as a refugium for rare species.

ELEMENT OCCURRENCES
 PLANTS
  NC: Eleocharis melanocarpa.

REPORT REFERENCE: Chapter IV for Small Depression Pond community description.