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FINAL

REMEDIAL INVESTIGATION
OPERABLE UNIT NO. 16 (SITES 89 AND 93)

MCB CAMP LEJEUNE, NORTH CAROLINA

CONTRACT TASK ORDER 0356
VOLUME I OF II
TEXT

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LIST OF ACRONYMS AND ABBREVIATIONS

AOCs	Areas of Concern
ARARs	Applicable Relevant and Appropriate Requirements
ASTM	American Society for Testing and Materials
AWQC	Ambient Water Quality Criteria
BCF	Bioconcentration Factor
bgs	below ground surface
BRA	Baseline Risk Assessment
CDI	Chronic Daily Intake
CERCLA	Comprehensive Environmental Response, Compensation and Liability Act
CLP	Contract Laboratory Program
COC	Chain-of-Custody
COPC	Contaminants of Potential Concern
CRAVE	Carcinogen Risk Assessment Verification Endeavor
CRDL	Contract Required Detection Limit
CRQL	Contract Required Quantitation Limit
CSF	Carcinogenic Slope Factor
CSFs	Cancer Slope Factors
CT	Central Tendency
CTO	Contract Task Order
cis-DCE	cis-1,2-Dichloroethene
trans-DCE	trans-1,2-Dichloroethene
D.O.	Dissolved Oxygen
DoN	Department of the Navy
DQO	Data Quality Objective
DRMO	Defense Reauthorization and Marketing Office
ECOCs	Ecological Contaminants of Concern
EPA-NCEA	USEPA - National Center for Environmental Assessment Office
°F	degrees Fahrenheit
FFA	Federal Facilities Agreement
FSAP	Field Sampling Analysis Plan
ft	feet
ft^2/day	square feet per day
gpm	gallons per minute
HEAST	Health Effects Assessment Summary Table
HHAG	Human Health Assessment Group
HI	Hazard Index
ICR	Incremental Cancer Risk
IDW	investigation derived waste
IR	Installation Restoration

LIST OF ACRONYMS AND ABBREVIATIONS
(Continued)

IRIS	Integrated Risk Information System
IRP	Installation Restoration Program
LANTDIV	Naval Facilities Engineering Command, Atlantic Division
µg/L	micrograms per liter
µg/kg	micrograms per kilogram
MCB	Marine Corps Base
MCL	maximum contaminant level
MS/MSDs	matrix spike/matrix spike duplicates
MCAS	Marine Corps Air Station
MSL	mean sea level
mg/l	milligrams per liter
mgd	million gallons per day
MI	Mobility Index
NC DENR	North Carolina Department of Environment, and Natural Resources
NCWQS	North Carolina Water Quality Standard
NEESA	Navy Energy and Environmental Support Activity
NFESC	Naval Facilities Engineering Service Center
No.	Number
NOAA	National Oceanic and Atmospheric Administration
NPL	National Priorities List
O&G	Oil and Grease
OU	operable unit
PAHs	Polynuclear Aromatic Hydrocarbons
PCB	polychlorinated biphenyl
PCE	Tetrachloroethene
PID	photoionization detector
ppb	parts per billion
ppm	parts per million
pvc	polyvinyl chloride
QA/QC	quality assurance/quality control
QI	quotient indices
RBC	Risk Based Concentration
RCRA	Resource Conservation and Recovery Act
RfDs	Reference Doses
RI/FS	Remediation Investigation/Feasibility Study
RME	Reasonable Maximum Exposure
ROD	Record of Decision

LIST OF ACRONYMS AND ABBREVIATIONS
(Continued)

S	Solubility
SDWA	Safe Drinking Water Act
SI	Site Inspection
SOPs	standard operating procedures
SPT	standard penetration test
SSV	Sediment Screening Values
SVOA	semivolatile organic analysis
SVOC	semivolatile organic compounds
SWSV	Surface Water Screening Values
TAL	Target Analyte List
TCA	1,1,2,2-tetrachloroethane
TCE	trichloroethene
TCL	Target Compound List
TCLP	Toxicity Characteristics Leaching Procedure
TPH	total petroleum hydrocarbon
UCL	Upper Confidence Limit
USCS	Unified Soil Classification System
USEPA	United States Environmental Protection Agency
USGS	United States Geological Survey
UST	Underground Storage Tank
VOA	volatile organic analysis
VOC	volatile organic compound
VP	vapor pressure
WOE	Weight of Evidence

EXECUTIVE SUMMARY

INTRODUCTION

Marine Corps Base (MCB), Camp Lejeune was placed on the Comprehensive Environmental Response, Compensation, and Liability Act of 1980 (CERCLA) National Priorities List (NPL) effective November 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 Environment and Natural Resources (NC DENR), the United States Department of the Navy (DoN) and the Marine Corps entered into a Federal Facilities Agreement (FFA) for MCB, Camp Lejeune in 1991. The primary purpose of the FFA was to ensure that environmental impacts associated with past and present activities at the MCB are throughly investigated, and that appropriate CERCLA response and Resource Conservation Recovery Act (RCRA) corrective action alternatives are developed and implemented as necessary to protect public health and welfare, and the environment (MCB, Camp Lejeune FFA, 1989). The Fiscal Year 1998 Site Management Plan for MCB, Camp Lejeune, a primary document referenced in the FFA, identifies 42 sites that require Remedial Investigation/Feasibility Study (RI/FS) activities. These 42 sites have been divided into 18 Operable Units (OUs). This report describes the RI conducted at OU No. 16, which is comprised of Sites 89 and 93. OU No. 16 is located in the northwest portion of MCB, Camp Lejeune, within Camp Geiger.

SITE DESCRIPTION AND HISTORY

Site 89

Site 89 is located near the intersection of "G"and Eighth Streets near the Defense Reauthorization and Marketing Office (DRMO) area of Camp Geiger. Site 89 is the larger of the two sites within OU 16. It encompasses a significant portion of Camp Geiger, which includes all of the DRMO and additional area to the south and east. Originally, the site was focused on a small area with in the DRMO which contained an underground storage tank (UST) which was identified as STC-868. The UST was a steel 550-gallon waste oil tank located between Building STC-867 (a soil storage facility) and an elevated wash rack. The tank was installed in 1983 and used for the storage of waste oil. This UST was reportedly closed by removal in 1993.

The major finding of the initial UST investigation at Site 89 was the detection of chlorinated solvents in the groundwater. The presence of chlorinated compounds demonstrated that impact to the groundwater involved compounds not normally associated with a petroleum UST site. Historical records of the area show that the a base motor pool was in operation until approximately 1988. The base motor pool was then relocated to an asphalt paved area immediately north of the DRMO facility where it is in current operation.

The discovery of chlorinated solvents led to the inclusion of Site 89 into MCB, Camp Lejeune's IR Program. The current area of Site 89 has expanded to include more than the former UST area. The site presently includes the entire DRMO and additional area outside the DRMO fence, including the wooded areas to the south and the east.

The majority of the western portion of Site 89 is primarily covered by asphalt, roads, and gravel parking areas. The eastern portion of Site 89, is heavily wooded as is the area immediately south of the DRMO. Edwards Creek is the nearest surface water body, located along the western and southern portions of the site. The stream is located approximately 525 feet south of the former UST location. The land surface of Site 89 slopes in the direction of Edwards Creek, which begins as a series of drainage ditches within Camp Geiger. The stream begins near 8th Street and flows south for a short distance before turning the west, where it tends to widen as it flows through the wooded area of Site 89. The eastern portion of the stream flows through a low lying swampy area.

Site 93

Site 93 is located near Building TC-942 at the intersection of Ninth and "E" Streets within Camp Geiger. The buildings in this portion of Camp Geiger were constructed during the Korean War. Building TC-942 currently functions as a supply room for the Marine Infantry School. Items such as field jackets, ponchos, and canteens are stored in the building. Other buildings in the area serve as classrooms for the school and barracks. Associated with Building TC-942 was a 550-gallon oil storage UST located at the southwest corner of the building.

The UST at Site 93 was installed in 1983 and permanently closed as part of a tank removal in December 1993. Based on elevated concentrations of oil and grease discovered at the time of tank removal, a release is suspected to have occurred. Upon removal of the tank, an investigation was conducted in June 1995 by R.E. Wright. The investigation included the installation of five monitoring wells around the former UST and the collection of soil and groundwater samples. The site now includes the area to the north, south, east, and west of Buildings TC-940 and TC-942.

NATURE AND EXTENT OF CONTAMINATION

Site 89

Investigative activities at Site 89 included the collection of soil and groundwater samples in the area of the DRMO and the wooded area east of White Street Extension. Surface water and sediment samples were collected from Edwards Creek near the DRMO facility and from downstream portions of the stream as it flows to the New River.

Soil

Detected volatile organic compounds (VOCs) include 1,1,2,2-tetrachloroethane, 1,2-dichloroethene (total), 2-butanone, acetone, benzene, carbon disulfide, tetrachloroethene, toluene, and trichloroethene. Of the compounds detected, 1,1,2,2-tetrachloroethane, 1,2-dichloroethene (total), benzene, tetrachloroethene, toluene, and trichloroethene are believed to be related to previous site operations.

Semivolatile organics (SVOCs) were detected sporadically across the study area. Their presence in soil is likely to be related to various anthropogenic processes rather than to specific site activities.

Three pesticides were detected in the soil samples. Historical basewide applications of pesticides have been documented at MCB, Camp Lejeune. These organic compounds tend to be quite stable in the environment and are relatively immobile. The presence of pesticides at Site 89 is not unusual based on the fact that these compounds have been detected in various background areas and their documented historic use at the base. Their presence in the soil samples is not considered to be related to specific activities at Site 89.

Inorganics were detected across the site in a uniform pattern. The presence of inorganics in the soil is considered to be a result of natural soil conditions and not site operations or disposal activities. Elevated concentrations above background, of inorganics were detected in the soil but the distribution does not indicate specific disposal activities.

In general, the data demonstrate that contaminated soil occurs at depth, and is most likely due to volatile organic compounds which are present in the groundwater affecting the local soil conditions. The majority of the maximum detections occur form the samples collected from approximately 11 to 13 feet bgs, which is within the saturated zone. Impacted soil is primarily concentrated in the area of the DRMO and is in general, present at depths of approximately 10 to 15 feet bgs.

Groundwater

The groundwater investigation at Site 89 entailed the collection of groundwater samples from temporary and permanent monitoring wells.

VOCs detected in the groundwater samples collected at Site 89 include; 1,1,1-trichloroethane, 1,1,2,2-tetrachloroethane, 1,1,2-trichloroethane, 1,1-dichloroethene, 1,2-dichloroethene (total), chloroform, cis-1,2-dichloroethene, tetrachloroethene, toluene, trans-1,2-dichloroethene, trichloroethene, and vinyl chloride.

The majority of these volatile compounds are considered to be a result of previous site operations, however, the detections of chloroform in the groundwater samples is not considered to be site related. The presence of chloroform in the groundwater samples is most likely related to the potable water source used during drilling operations of the temporary monitoring wells.

Inorganics were detected in the majority of the groundwater samples obtained from Site 89. The presence of inorganics in groundwater, particularly iron and manganese, are a result of the natural site conditions, and not due to site operations.

Groundwater in the surficial and upper portions of the Castle Hayne aquifers at Site 89 has been impacted by VOCs. This includes groundwater to depths of approximately 40 to 50 feet bgs. The majority of the VOCs detected in samples collected from the shallow monitoring wells at Site 89 are concentrated in the area of the DRMO facility and to the south in the direction of Edwards Creek. Areas to the west and slightly north (hydraulically upgradient) of the DRMO have also been impacted, but at lower concentrations compared to down gradient locations. The shallow groundwater in the wooded area east of the DRMO and White Street Extension has not been significantly effected. The contaminant plume has migrated beyond White Street Extension at this portion of the site. However additional sample points east of the road demonstrate that the shallow groundwater plume is mostly limited to the area beneath the DRMO.

Data indicates that VOCs have migrated as far south as Edwards Creek. Based upon these results and the presence of VOCs in surface water, it appears that Edwards Creek acts as a intercept for contaminants moving with shallow groundwater. Groundwater samples from temporary wells located further south did not detect contaminants which exceeded the water quality standards. In addition, historical analytical data from permanent monitoring wells located in the housing area in the southeast portion of the aired photograph have not detected volatile organics in the groundwater. These analytical results indicate that Edwards Creek is acting as a natural barrier for the majority of VOCs migrating south of the DRMO facility.

VOCs are present in the groundwater at the intermediate depth in the area of the DRMO and in the wooded area, east of White Street Extension. The eastern boundary of groundwater contamination at the intermediate depth has been confirmed by both temporary and permanent monitoring well clusters. The samples collected in the wooded portion of Site 89 have established the eastern most edge of the plume to extend approximately 1,500 feet from the DRMO source area.

Permanent deep monitoring wells extending to depths of approximately 70 feet below ground surface (bgs) were installed. VOCs were not detected in any groundwater samples collected from deep monitoring wells. The absence of VOCs in the deep monitoring wells establishes the vertical extent of groundwater contamination to the depth of the intermediate wells (i.e., approximately 40 to 50 feet bgs).

Surface Water

The most frequently detected compounds in the 11 surface water samples collected from Edwards Creek were cis-1,2-dichloroethene and trichloroethene. The sample stations recording the highest number of maximum detections were sample stations located south and hydraulically downgradient of the DRMO area. The sample station located to the west of the DRMO area and at the headwaters of Edwards Creek, was the only station in which VOCs were not detected.

There were no SVOCs or pesticides/PCBs detected in the surface water samples collected from Edwards Creek. Given the nature of the soils and the detected concentrations, the presence of metals is most likely attributed to natural conditions. Metals in the surface water is not considered to be a result of site operations.

Edwards Creek appears to be receiving VOC contamination which has migrated through the shallow groundwater. Analytical findings indicate that the creek is acting as a natural barrier, which significantly limits the migration of VOCs in the shallow groundwater to the south.

Sediment

Sediment samples were collected within Edwards Creek. Two samples were taken at each station, one from 0 to 6 inches and a second from 6 to 12 inches. Volatile organic compounds were detected in the sediment samples collected from the stream bed. The majority of the detections occurred in the samples collected from the 0 to 6 inch sample depth. However, there were detections of volatile organic compounds in the samples taken from 6 to 12 inches.

Ten of the sediment samples were analyzed for SVOCs, and each of the samples exhibited detections. However, the SVOCs which were detected are ubiquitous in the environment and can be a result of decomposition of organic material or combustion of fossil fuels. Further, the concentrations detected are similar to what is normally expected in environments where soil has a high organic content.

There were no PCBs detected in the samples, however pesticide compounds which were historically applied at MCB, Camp Lejeune were present. Their presence in the sediment samples is most likely due to overland runoff or over application.

Inorganic analyses were conducted on sediment samples. Based upon the natural occurrence of metals in soil and sediment, occasional exceedences of relative standards are to be expected.

Site 93

The investigation at Site 93 involved the collection of soil and groundwater samples in the vicinity of Building TC-942.

Soil

VOCs detected in the soil samples collected from Site 93, including 2-butanone and acetone which are not believed to be related to specific site operations. They are typically a result of laboratory and/or field procedures and are not considered to be related to site conditions.

SVOCs detected in the soil are believed to be anthropogenic and ubiquitous in nature. Pesticide levels can be attributed to historical applications conducted on a base wide basis.

Inorganics were detected across the site in a uniform pattern and are indicative of naturally occurring background levels.

Groundwater

The groundwater investigation at Site 93 entailed the collection of groundwater samples from temporary and permanent monitoring wells installed in the surficial and Castle Hayne aquifer.

The most frequently detected VOC in groundwater was trichloroethene. The highest concentration was detected in the sample collected from the gravel parking area, immediately south of Building TC-942 and the original UST location.

Two semivolatile compounds including bis(2-ethylhexyl)phthalate and naphthalene were detected in the groundwater samples obtained from the monitoring wells at Site 93. There were no pesticides/PCBs detected in any of the groundwater samples from Site 93.

Inorganics were detected in groundwater samples obtained from Site 93. Iron, manganese and lead were detected at concentrations above the Federal MCLs and NCWQS.

Impact to the groundwater at Site 93 is concentrated in the shallow aquifer in the area of the former UST near Building TC-942. Analytical findings indicate contaminated groundwater is confined to this area and has not migrated substantially from the original source area. In addition, low concentrations of VOCs were detected in groundwater samples collected from the intermediate wells, demonstrating that very little vertical migration of the contaminants has occurred. Impact of the shallow groundwater was evident south and west of the site, but decreased readily in these directions.

HUMAN HEALTH RISK ASSESSMENT

Current and future potential receptors at the site included current adult and child residents (Site 89 only), future adult and child residents (Sites 89 and 93), and future construction workers (Sites 89 and 93). Exposure to surface water and sediment was assessed for the current receptors. Groundwater, surface water, and sediment exposure were evaluated for the future residents. Subsurface soil exposure was evaluated for the future construction worker.

Current and future potential receptors evaluated for potential exposure to Site 89 media included current adult and child residents, future adult and child residents, and future construction workers. The risks calculated for all exposure pathways for the current on-site residents and future construction workers were within acceptable risk ranges. In the Site 89 groundwater exposure scenario, there are potential carcinogenic risks and noncarcinogenic adverse health effects from ingestion for the future residential adult and child receptor. The total groundwater carcinogenic risk levels for the future adult and child resident at Site 89 were $3.1\text{x}10^{-3}$ and $1.4\text{x}10^{-3}$, respectively. Primarily, vinyl chloride in groundwater contributed to this risk. The total groundwater noncarcinogenic effect levels were 12.5 and 28, respectively. This was due primarily to the presence of trichloroethene, 1,2-dichloroethene (total), cis-1,2-dichloroethene, and iron in the groundwater.

Future potential receptors evaluated for potential exposure to Site 93 media included future adult and child residents and future construction workers. The risks calculated for all exposure pathways for the future construction workers were within acceptable risk ranges. The total site carcinogenic risk to the future residential child at Site 93 was within the USEPA's acceptable risk range. In the Site 93 groundwater exposure scenario, there are potential carcinogenic risks from ingestion for the future residential adult receptor and noncarcinogenic adverse health effects from ingestion for the future residential adult and child receptors. The total groundwater carcinogenic risk level for the adult was $1.3\text{x}10^{-4}$. This was due primarily to the presence of arsenic and tetrachloroethene in groundwater. The total groundwater noncarcinogenic effect levels for the future residential adult and child at Site 93 were 2.8 and 6.4, respectively. This was due primarily to the presence of manganese and cis-1,2-dichloroethene.

ECOLOGICAL RISK ASSESSMENT

Surface Water

Surface water concentrations detected in Edwards Creek were evaluated by a comparison to benchmark screening values for the protection of aquatic species. Total quotient indices (QIs) for the surface water at Site 89 were calculated at 2 for North Carolina values, 0.79 for acute Region IV values, and 9 for chronic Region IV values. The QI values were primarily a result of surface water concentrations of aluminum, iron, and lead. In addition, surface water concentrations of 1,2-DCE (cis- and total), TCE, vinyl chloride, antimony, barium, and magnesium may also pose a risk to the aquatic environment; however, there are no screening values available to assess the detected concentrations.

Sediment

Sediment concentrations detected in Edwards Creek were evaluated by a comparison to benchmark screening values for the protection of benthic macroinvertebrate species. Total QIs for sediment at Site 89 were calculated at 173 for Region IV values and 34 for USEPA Ecotox values. QI values greater than one were calculated for pesticides, 1,1,2,2-tetrachloroethane, trichloroethene, benzo(a)pyrene, fluoranthene, cadmium, copper, and lead. The primary contributors to the elevated QIs at Site 89 were sediment concentrations of pesticides. Sediment concentrations of dichloroethene, 1,1,2-trichloroethane, vinyl chloride, benzofluoranthenes, benzo(g,h,i)perylene, bis(2-ethylhexyl)phthalate, indeno(1,2,3-cd)pyrene, aluminum, barium, beryllium, iron, manganese and vanadium may also pose a risk to the aquatic environment. However, there are no screening values available to assess the detected concentrations.

The VOC concentrations detected in the shallow sediment were higher than the concentrations detected in the deeper sediments, with the exception of vinyl chloride. There were no VOCs detected in the sediment collected downstream of the site. The VOCs detected are not likely to bioconcentrate in the aquatic food.

The SVOCs in the sediment were detected at one station immediately downstream of the railroad tracks. Pesticides were only analyzed at one station (two depths) in Edwards Creek. The pesticide concentrations were higher in the deeper sediment collected. The majority of the inorganic ECOCs were detected in the deep sediment sample collected immediately downstream of the site. It is noted that the highest cadmium concentration was detected in the shallow sediment collected upstream of Site 89.

1.0 INTRODUCTION

Marine Corps Base (MCB) Camp Lejeune was placed on the Comprehensive Environmental Response, Compensation, and Liability Act of 1980 (CERCLA) National Priorities List (NPL) effective November 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 Environment and Natural Resources (NC DENR), the United States Department of the Navy (DoN) and the Marine Corps entered into a Federal Facilities Agreement (FFA) for MCB Camp Lejeune in 1991. The primary purpose of the FFA was to ensure that environmental impacts associated with past and present activities at the MCB are throughly investigated, and that appropriate CERCLA response and Resource Conservation Recovery Act (RCRA) corrective action alternatives are developed and implemented as necessary to protect public health and welfare, and the environment (MCB Camp Lejeune FFA, 1989). The fiscal year 1998 Site Management Plan for MCB, Camp Lejeune, a primary document referenced in the FFA, identifies 42 sites that require Remedial Investigation/Feasibility Study (RI/FS) activities. These 42 sites have been divided into 18 Operable Units (OUs).

1.1 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 group of sites. As mentioned above, there are currently 42 Installation Restoration (IR) Program sites at MCB, Camp Lejeune which have been grouped into 18 operable units. Figure 1-1 depicts the locations of all 18 OUs and 42 sites at MCB, Camp Lejeune. This report describes the RI conducted at OU No. 16, which is comprised of Sites 89 and 93. As shown on Figure 1-1, OU No. 16 (Sites 89 and 93) is located in the northwest portion of MCB Camp Lejeune, within Camp Geiger.

1.2 Report Organization

This RI report is divided into eight sections, including:

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

The appendices referenced throughout the document include Appendices A through P. All of these appendices are included in Volume II of the RI report.

1.3 Site Description and History

The sections below summarize information concerning the site description and history. Further information of this type can be found in the final Project Plans (Baker, 1996). Since OU 16 is comprised of two sites (89 and 93) each is discussed separately.

1.3.1 Site 89

Site 89 is located near the intersection of "G" and Eighth Streets near the Defense Reauthorization and Marketing Office (DRMO) area of Camp Geiger (Figure 1- 2). Site 89 is the larger of the two sites within OU 16. It encompasses a significant portion of Camp Geiger, which includes all of the DRMO and additional area to the south and east (Figure 1-2). Originally, the site was focused on a small area with in the DRMO which contained an underground storage tank (UST) which was identified as STC-868. The UST was a steel 550-gallon waste oil tank located between Building STC-867 (a soil storage facility) and an elevated wash rack. The tank was installed in 1983 and used for the storage of waste oil. This UST was reportedly closed by removal in 1993. Initially, two monitoring wells were installed in the area of the former UST by R.E. Wright Associates, Inc. (R.E. Wright). Based upon elevated levels of both total petroleum hydrocarbons (TPH) and oil and grease (O&G), a third well was installed in June 1994.

The major finding of the initial UST investigation at Site 89 was the detection of several chlorinated solvents in the groundwater. The presence of chlorinated compounds during the initial investigation demonstrated that impact to the groundwater involved compounds not normally associated with a petroleum UST site. Historical records research of the area show that the site operated as a base motor pool until approximately 1988. The base motor pool was then relocated to an asphalt paved area immediately north of the DRMO facility where it is in current operation.

The findings of the initial UST investigation led to the inclusion of Site 89 into MCB Camp Lejeune's IR Program. The IR Program focuses on non UST sites and provides the framework for more complex and detailed environmental investigations at the base. The current area of Site 89 has expanded to include more than the former UST area. The site presently includes the entire DRMO and additional area outside the DRMO fence, including the wooded areas to the south and the east. The approximate site boundary is displayed on Figure 1-2.

The majority of the western portion of Site 89 is primarily covered by asphalt, roads, and gravel parking areas. The eastern portion of Site 89, is heavily wooded as is the area immediately south of the DRMO. Edwards Creek is the nearest surface water body, located along the western and southern portions of the site. The stream is located approximately 525 feet south of the former UST location. The land surface of Site 89 slopes in the direction of Edwards Creek, which begins as a series of drainage ditches within Camp Geiger. The stream begins near 8th Street and flows south for a short distance before turning the west, where it tends to widen as it flows through the wooded area of Site 89. The eastern ortion of the stream flows through a low lying swampy area.

1.3.2 Site 93

Site 93 is located near Building TC-942 at the intersection of Ninth and "E" Streets within Camp Geiger (Figure 1-3). The total area of Site 93 is much smaller than Site 89. The buildings in this portion of Camp Geiger were constructed during the Korean War. Building TC-942 currently functions as a supply room for the Marine Infantry School. Items such as field jackets, ponchos, and canteens are stored in the building. Other buildings in the area serve as classrooms for the school and barracks. Site 93 originally had a 550-gallon oil storage UST associated with it. The tank was located at the southwest corner of Building TC-942.

The UST at Site 93 was permanently closed as part of a tank removal in December 1993. There is no documentation available concerning the installation date of the UST. Based on elevated concentrations of oil and grease at the time of tank removal, a release is suspected to have occurred. Upon removal of the tank, an investigation was conducted in June 1995 by R.E. Wright. The investigation included the installation of five monitoring wells around the former UST and the collection of soil and groundwater samples. The results of the sampling are summarized in Section 1.4. Since the time of the UST investigation, the area of Site 93 has been expanded to determine if there are any other sources for the observed contamination. The site now includes the area to the north, south, east, and west of Buildings TC-940 and TC-942 of where the former UST was located.

1.4 Previous Investigations

The following sections provide information concerning the previous UST investigations completed at Sites 89 and 93. The information is summarized in this RI report for the purpose of providing the reader with the historical framework from which the sites have been investigated. The initial UST assessment activities conducted at Sites 89 and 93 identified subsurface soil and groundwater contamination. The type of contamination identified (i.e., chlorinated solvents) required that future assessment activities at Sites 89 and 93 be completed under the IR Program.

1.4.1 Site 89

The former UST at Site 89 was installed in 1983 and was reportedly used until 1993 for the storage of waste oil. The tank was removed in 1993 and an initial investigation was conducted by installing two monitoring wells. Sampling activities at the site revealed elevated levels of both TPH and oil and grease.

An additional one well site check was conducted in June 1994 by R.E. Wright to determine if a release had occurred. This investigation included one soil boring southeast of the tank excavation area which was converted to a monitoring well. One soil sample was analyzed for oil and grease and halogenated solvents. Groundwater samples were collected from the new and existing monitoring wells and analyzed for volatile organic compounds (VOCs), semivolatile organic compounds (SVOCs), and Toxicity Characteristic Leaching Procedure (TCLP) metals. The results from this sampling effort are summarized below:

- The soil sample detected 1,400,000 micrograms per kilogram (µg/kg) of oil and grease.

- Halogenated solvents in the soil samples were below the detection limits for all parameters.

- Three groundwater samples indicated concentrations of several chlorinated solvents:

cis-1,2-dichloroethene	2,130 µg/L
trans-1,2-dichloroethene	1,580 µg/L
1,1,2,2-tetrachloroethane	8,600 µg/L
trichloroethene	1,500 µg/L

- SVOCs and TCLP analyses were below the method detection limit in all samples.

1.4.2 Site 93

One 550-gallon UST was removed from this site in December 1993. Based on elevated levels of oil and grease at the time of tank removal, a release was suspected to have occurred.

A subsequent investigation was conducted in June 1995 by R.E. Wright which included the installation of five monitoring wells around the former UST excavation and the collection of soil and groundwater samples. Soil samples were analyzed for oil and grease and halogenated solvents. Groundwater samples were analyzed for VOCs, SVOCs, and TCLP metals. The results of the sampling are summarized below:

- Oil and grease results from the soil samples ranged from 56,100 to 8,126,000 μg/kg.
- Naphthalene and tetrachloroethene were detected in the soil sample at 0.049 and 20 μg/kg, respectively.
- Groundwater samples detected concentrations of several chlorinated solvents:

cis-1,2-dichloroethene	250 μg/L
chlorobenzene	90 μg/L
tetrachloroethene	90 μg/L
trichloroethene	30 μg/L

- Several SVOCs were detected at concentrations which were below regulatory limits.
- Total cadmium concentrations in each well and lead concentrations in one well exceeded regulatory levels. It should be noted that, soils found within the coastal plain of North Carolina are naturally rich in metals. The observed total metal concentrations in groundwater are typically due more to geologic conditions (i.e., naturally occurring metals bound to unconsolidated soil particles) and sample acquisition methods than to mobile metal concentrations in groundwater. The presence of these metals are suspected to be a result of existing natural conditions, and not site operations.

1.5 Remedial Investigation Objectives

The scope of the RI is to evaluate the nature and extent of the threat to public health and the environment caused by the release or threatened release of hazardous substances, pollutants, or contaminants. The RI also provides data required to establish feasible alternatives for consideration during preparation of the Record of Decision (ROD). The RI was conducted through the sampling of environmental media including groundwater, subsurface soil, surface water, and sediment, evaluating the resultant analytical and geologic data, and performing a qualitative assessment of the findings. The remedial objectives presented in this section have been identified through review and evaluation of existing background information, assessment of potential risks to public health and environment, and consideration of feasible remediation technologies and alternatives. Table 1-1 presents both the RI objectives identified for OU 16 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. The different media investigations conducted at the sites are described in Section 2.0 of this report.

1.6 References

Baker 1996. Final Project Plans OU No. 16 (Sites 89 and 93) Marine Corps Base, Camp Lejeune North Carolina.

Baker November, 1996. Phase I Investigation Report Operable Unit No. 16 (Sites 89 and 93) Marine Corps Base, Camp Lejeune, North Carolina.

Federal Facilities Agreement (FFA) Between United States Environmental Protection Agency, Region IV: The North Carolina Department of Environment, Health and Natural Resources and North Carolina. North Carolina Natural Heritage Program, Division of Parks and Recreation, Department of Environment, Health, and Natural Resources, Raleigh, North Carolina.

SECTION 1.0 TABLES

TABLE 1-1

SUMMARY OF REMEDIAL INVESTIGATION OBJECTIVES
OPERABLE UNIT NO. 16 (SITES 89 AND 93)
REMEDIAL INVESTIGATION, CTO-0356
MCB, CAMP LEJEUNE, NORTH CAROLINA

Medium or Area of Concern	RI Objective	Criteria for Meeting Objective	Investigation/Study
1. Soil	1a. Assess the extent of soil contamination at Sites 89 and 93.	Characterize contaminant levels in subsurface soils.	Soil Investigation
	1b. Assess human health and ecological risks associated with exposure to soils at the site.	Characterize contaminant levels soils at the study area.	Soil Investigation Risk Assessment
	1c. Determine whether contamination from soils is migrating to groundwater.	Characterize subsurface soil and leaching potential. Characterize shallow and intermediate groundwater.	Soil Investigation Groundwater Investigation
	1d. Evaluate treatment alternatives, if required.	Characterize areas of concern above action levels. Evaluate effectiveness and implementability of technologies.	Soil Investigation Feasibility Study Bench or Pilot-Scale Testing
2. Groundwater	2a. Assess health risks posed by potential future usage of shallow and intermediate groundwater.	Evaluate groundwater quality and compare to groundwater criteria and risk-based action levels.	Groundwater Investigation Risk Assessment
	2b. Assess nature and extent of shallow and intermediate groundwater contamination.	Characterize groundwater quality. Compare to relevant North Carolina and Federal groundwater standards.	Groundwater Investigation
	2c. Define hydrogeologic characteristics for fate and transport evaluation and remedial technology evaluation, if required.	Estimate hydrogeologic characteristics of the aquifer (flow direction/velocity).	Groundwater Investigation

TABLE 1-1 (Continued)

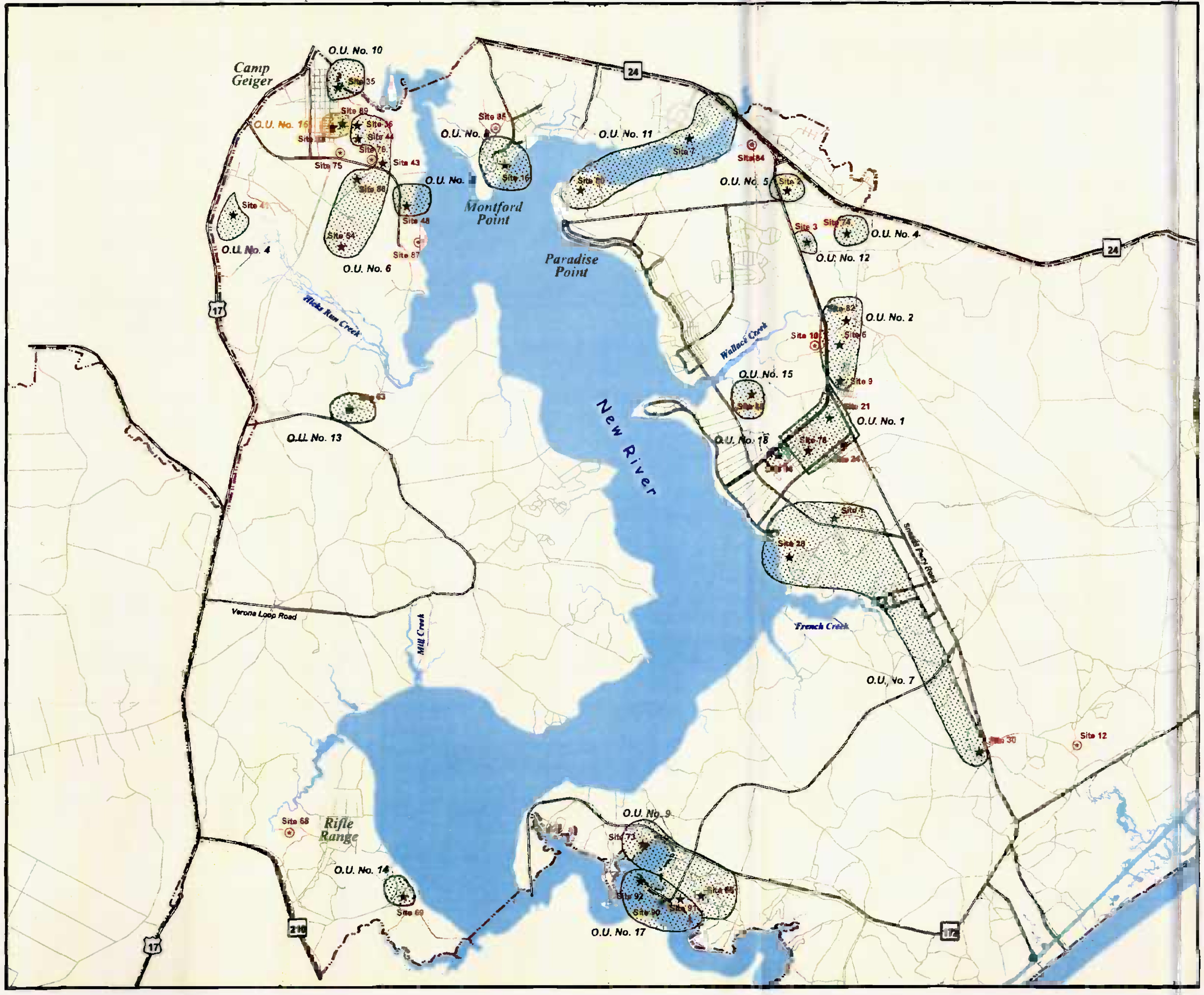
SUMMARY OF REMEDIAL INVESTIGATION OBJECTIVES
OPERABLE UNIT NO. 16 (SITES 89 AND 93)
REMEDIAL INVESTIGATION, CTO-0356
MCB, CAMP LEJEUNE, NORTH CAROLINA

Medium or Area of Concern	RI Objective	Criteria for Meeting Objective	Investigation/Study
3. Surface Water(1)	3a. Assess the presence or absence of surface water contamination in Edwards Creek.	Determine surface water quality in Edwards Creek, using USEPA Ambient Water Quality Standards.	Surface Water Investigation of Edwards Creek Ecological Risk Screening
4. Sediment(1)	4a. Determine extent of sediment contamination for purposes of identifying areas of concern.	Identify extent of sediment contamination where contaminant levels exceed risk-based action levels or USEPA Region IV criteria.	Sediment Investigation in Edwards Creek Ecological Risk Screening

Notes:

(1) Site 89 only

SECTION 1.0 FIGURES



LEGEND

★ Remedial Investigation Site

⊙ Pre-Remedial Investigation Site

▨ Operable Unit Boundary

▨ Operable Unit No. 16 Boundary

Secondary Highway

Primary Highway

Light Duty Road

Camp Lejeune Boundary

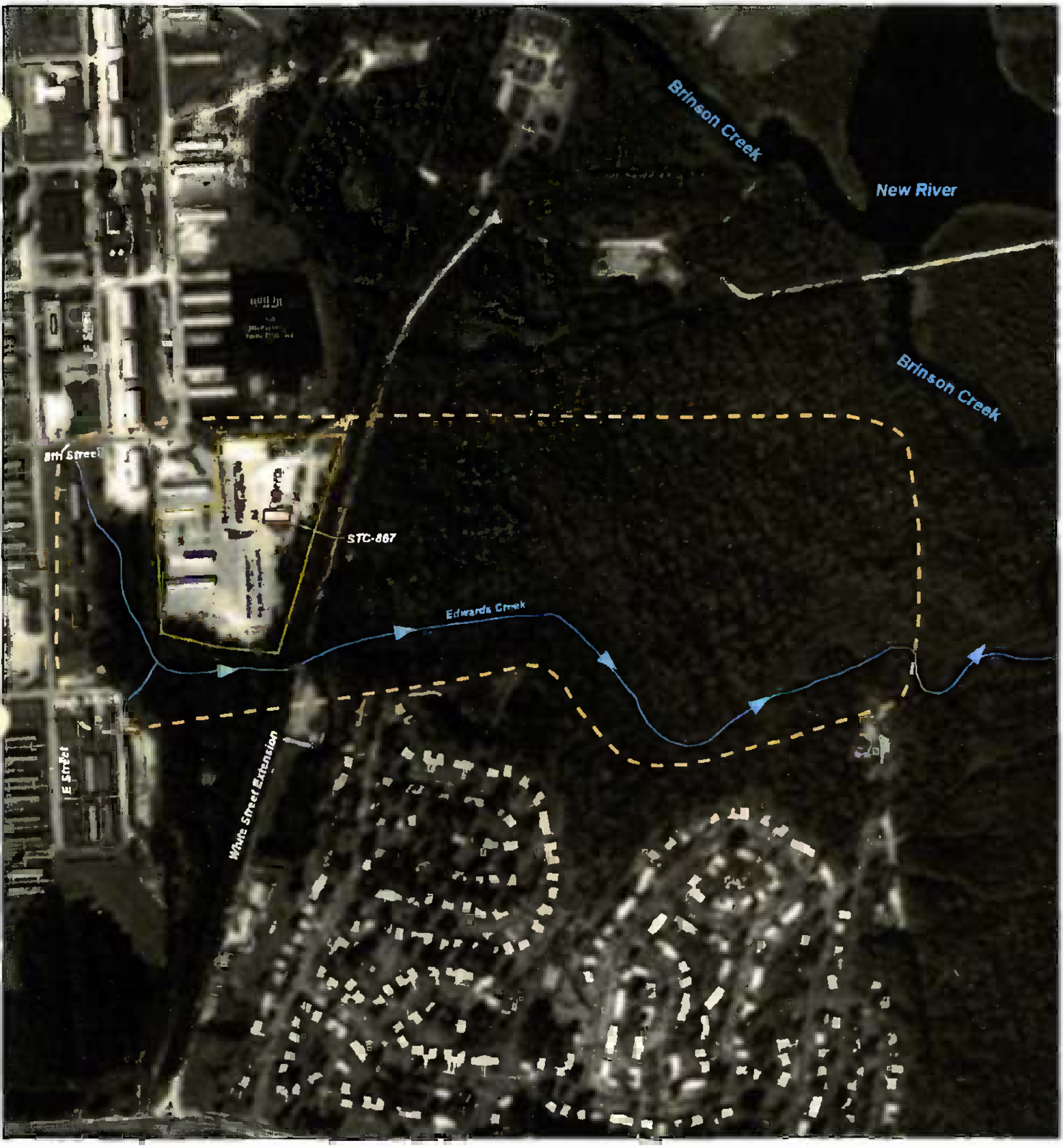
MARINE CORPS BASE, CAMP LEJEUNE
NORTH CAROLINA

OPERABLE UNITS and SITE LOCATIONS
REMEDIAL INVESTIGATION
CTO 0356

Baker

FIGURE 1 - 1

02020N25Y



LEGEND

―	DRMO Fence Line
―▶―	Edwards Creek with Flow Direction
- - -	Approximate Site Boundary
☐	Building STC-867

Scale

400 0 400 800 Feet

N
W E
S

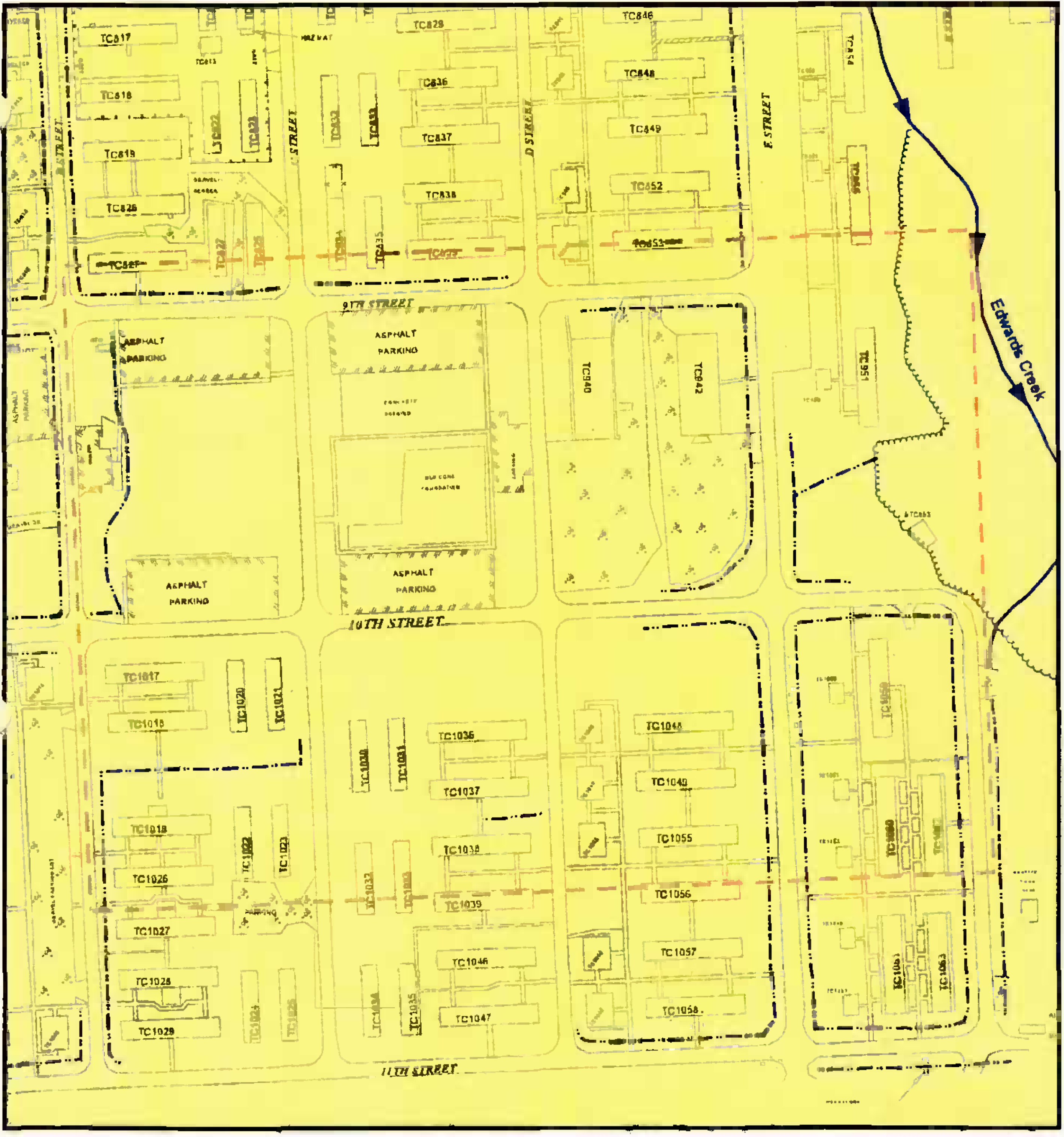
MARINE CORPS BASE, CAMP LEJEUNE
NORTH CAROLINA

SITE PLAN
OPERABLE UNIT NO. 16 (SITE 89)
REMEDIAL INVESTIGATION
CTO 0356

Baker

FIGURE 1- 2

02020N26Y



LEGEND

Swale

Edwards Creek with Flow Direction

Approximate Site Boundary

Wooded Area

Scale

200 0 200 400 Feet

N
W E
S

MARINE CORPS BASE, CAMP LEJEUNE
NORTH CAROLINA

SITE PLAN
OPERABLE UNIT NO. 16 (SITE 93)
REMEDIAL INVESTIGATION
CTO 0356

Baker

FIGURE 1-3

2.0 FIELD INVESTIGATION

This section discusses the site-specific remedial investigation (RI) field activities that were conducted to fulfill the objectives identified in Section 1.5. The RI field investigation activities for Sites 89 and 93 were conducted in two phases. The initial phase of RI field investigation sampling activities commenced on July 26, 1996, and continued through August 21, 1996. The second phase of RI field investigation sampling activities commenced on April 18, 1997, and continued through June 2, 1997. The RI field program activities at Sites 89 and 93 consisted of a site survey, subsurface soil investigation, and groundwater investigation. The surface water and sediment investigation was completed for Site 89 only.

Previous UST investigations at Sites 89 and 93 confirmed that the contaminants of concern were VOCs in the subsurface (i.e., subsurface soil and groundwater). Therefore, characterization of surface soil was not necessary. In addition, a large majority of the sites are covered with asphalt and hardpack gravel, which prohibits the collection of surface soil samples. The previous UST studies completed at OU No. 16 are discussed in Section 1.4.

Investigative procedures and methodologies for the RI conducted at Sites 89 and 93 are provided in Section 6.0 of the Final Field Sampling and Analysis Plan (FSAP), for Operable Unit (OU) No. 16, (Baker, 1996, 1997). Locations of samples for each media are shown on Figures 2-1 and 2-2 for Sites 89 and 93, respectively. For clarity, individual sample designations are not depicted on this figure, but are presented on subsequent figures included herein.

2.1 Site Survey

The site survey task was performed during both phases of the RI at Sites 89 and 93. Surface features (i.e., buildings, structures, tree lines, drainage ways, utilities, roads, parking areas, fences, etc.) at both sites were surveyed during the Phase I investigation. This information was utilized for creation of base mapping that was used throughout the investigation. Following both phases, the location (i.e., longitude and latitude) and elevation (referenced to mean sea level [msl]) of each final sample point sampled during that phase was surveyed. For monitoring wells, the elevation of the surrounding ground surface (or top of well cover for flush mount monitoring wells), and top of polyvinyl chloride (PVC) casing were surveyed. Staff gauges which were installed during the Phase I investigation and then repaired and repositioned during Phase II were surveyed during both phases of the RI. Figure 2-1 presents the most recent positions of the staff gauges (i.e., Phase II locations). All surveying was referenced to the North Carolina State Plane Coordinates System, and was conducted by Lanier Surveying, Inc, a licensed professional surveyor in the State of North Carolina.

2.2 Subsurface Soil Investigation

Subsurface soil samples were collected to assess site contamination and to provide lithological information for the evaluation of geologic and hydrogeological conditions. Subsurface soil samples were collected from each monitoring well (permanent and temporary) that was advanced at Sites 89 and 93.

All subsurface soil samples were classified in the field by the Baker Field Geologist. Soils were classified using the Unified Soil Classification System (USCS) via visual-manual methods that are described in American Society for Testing and Materials (ASTM) D-2488. Lithologic descriptions were recorded in a field logbook and later entered into boring log records. Soil classification included characterization of soil type, grain size, color, moisture content, relative density, plasticity, and other pertinent information such as indications of contamination. Lithologic descriptions of the site soils are provided on the Test Boring and Well Construction Records which are presented in Appendix A. Information obtained from the soil borings were used to generate hydrogeologic cross-sections which describe the subsurface conditions of OU No. 16. These cross-sections and related discussions are presented in Section 3.0.

Soil borings were typically advanced in clusters (i.e., shallow, intermediate, and deep juxtaposed soil borings) or in pairs (i.e., shallow and intermediate juxtaposed soil borings or intermediate and deep juxtaposed wells). The depths, locations, and designations of soil borings are discussed in Section 2.3.1.1 and 2.3.1.2. The following text summarizes the number of soil borings that were advanced at each site.

Site 89

During the Phase I investigation, a total of 30 soil borings were advanced at Site 89 with temporary monitoring wells installed in each of the soil borings. During the Phase II investigation, a total of 21 soil borings were advanced at the site with temporary monitoring wells installed in seven of the soil borings, while permanent monitoring wells were installed in 14 soil borings.

Site 93

A total of 15 soil borings were advanced at Site 93 during the Phase I investigation. Temporary monitoring wells were installed in each of these soil borings. During the Phase II investigation, a total of 11 soil borings were advanced with permanent monitoring wells installed in each of the borings.

2.2.1 Drilling Procedures

All of the soil borings were advanced via hollow stem augering and split-spoon sampling methods in general accordance with procedures outlined in ASTM Standard Method for Penetration Test and Split-Barrel Sampling of Soils (Designation D 1586). Split-spoons of 24-inch (nominal) length were used throughout the investigation. Soil samples were collected continuously (at 2 foot intervals) from the ground surface down to groundwater from at least one soil boring in a cluster (i.e., shallow, intermediate, deep or intermediate, deep). Sample intervals for soil borings that were not sampled continuously were selected by the Baker Field Geologist. Sample intervals are shown on the Test Boring and Well Construction Records which are presented in Appendix A. For select sample intervals, relatively undisturbed Shelby tube samples were collected for analysis of geotechnical and hydrogeological parameters. These samples were collected in general accordance with ASTM Standard Practice for Thin-Walled Tube Sampling of Soils (Designation D 1587). All drilling and soil sampling activities were performed in Level D personal protective equipment. Soil cuttings and decontamination fluids generated during the investigation were managed in accordance with the procedures outlined in Section 2.7.

2.2.2 Laboratory Analysis of Subsurface Soil Samples

None of the subsurface soil samples collected at either site during the Phase I investigation were submitted for on-site fixed base laboratory analysis. Select subsurface soil samples collected during the Phase II investigation were submitted for one or more of the following laboratory analyses:

Parameter	Site 89	Site 93
Target Compound List (TCL) volatiles	26 samples	22 samples
TCL semivolatiles	26 samples	22 samples
TCL pesticides/polychlorinated biphenyls (PCBs)	5 samples	4 samples
Target Analyte List (TAL) metals	26 samples	22 samples
Engineering parameters including:		
▸ Total organic carbon (TOC)	1 sample	1 sample
▸ Grain size	3 samples	1 sample
▸ Bulk density	3 samples	1 sample
Vertical permeability	3 samples	0 samples

The TCL and TAL analyses were performed to characterize the nature and extent of contamination in subsurface soils which is discussed in Section 4.0. Total petroleum hydrocarbon (TPH) analyses were not necessary due to the initial characterization provided by the UST investigations which identified the contaminants of concern as chlorinated solvents. Geotechnical engineering parameters including, vertical permeability, TOC, grain size, and bulk density are used for the assessment and development of remedial alternatives. Vertical permeability and grain size are also used for evaluation of hydrogeologic conditions which are discussed in Section 3.0. Results for the analyses of vertical permeability and the other geotechnical engineering/hydrogeologic parameters are presented in Appendix B.

Subsurface soil samples were shipped to the laboratory overnight via Federal Express for analysis. Sample tracking forms were updated by Baker throughout the investigation. Chain-of-custody forms were included with each shipping cooler that was sent to the laboratory. Internal sample tracking forms and chain-of-custody forms are included in Appendix C, sample documentation.

Tables 2-1 and 2-2 present a summary of the subsurface soil sampling programs for Sites 89 and 93, respectively. The summaries include the following: sample identification; sample interval; analyzed parameters; duplicate samples; and matrix spike/matrix spike duplicate (MS/MSD) samples. Analytical results are discussed in Section 4.0. Field quality assurance/quality control (QA/QC) samples are discussed in Section 2.5.

2.2.2.1 Air Monitoring and Field Screening

During drilling, ambient air monitoring in the vicinity of the borehole was performed with a photo ionization detector (PID) to monitor for airborne contaminants. In addition, split-spoon soil samples were screened with a PID to measure for volatile organic vapor. Measurements obtained in the field were recorded in a field logbook and later transposed onto the Test Boring and Well Construction Records which are provided in Appendix A. Prior to daily monitoring, the field instruments were calibrated and documentation was recorded in a field logbook and on calibration forms.

2.3 Groundwater Investigation

A groundwater investigation was conducted at Sites 89 and 93 to define the nature and extent of contamination in the surficial aquifer and in the Castle Hayne aquifer which may have resulted from past site activities. The groundwater investigation included the following activities which are discussed in the proceeding sections:

- Temporary monitoring well installation
- Permanent monitoring well installation
- Monitoring well development
- Groundwater sample acquisition
- Groundwater level measurements
- On-site laboratory analysis
- Fixed-base laboratory analysis
- In situ hydraulic conductivity (slug) tests
- Monitoring well abandonment

2.3.1 Temporary Monitoring Well Installation

Temporary monitoring wells were situated spatially across the sites to provide acquisition stations for sampling potentially impacted groundwater, to partially characterize the nature and extent of possible contamination, and to provide information used for placement of permanent monitoring well locations. Placement of the temporary wells was based on review of aerial photographs, previous investigations, site conditions, locations of underground utilities, the location of existing monitoring wells, and the overall scope and objectives of the project. Locations of the temporary monitoring wells presented in the Final Project Plans provided initial guidance, however, results of on-site laboratory data were used on a daily basis for the subsequent selection of additional temporary well locations. Temporary monitoring well location selection was a cooperative effort involving the Baker Site Manager, the Baker Project manager, Naval Facilities Engineering Command, Atlantic Division (LANTDIV), and MCB, Camp Lejeune personnel.

All temporary monitoring wells were constructed of 1-inch diameter, schedule 40, flush-joint and threaded, polyvinyl chloride (PVC) casing. The wells utilized either a 5-foot (intermediate wells) or a 10-foot (shallow wells) screened interval of No. 10 (i.e., 0.0010 inch) slot screen sections. The screened sections of the wells were covered with a piece of cloth material known as a "well sock", which reduces the amount of fine grained material that moves through the screen and into the monitoring well. The temporary monitoring wells were left as "stick-up" for subsequent groundwater sampling. The identification of each temporary monitoring well was written on the outside of the PVC casing with a permanent marker. A typical temporary monitoring well construction detail is shown on Figure 2-3. Temporary monitoring locations for Sites 89 and 93 are shown on Figure 2-4. Monitoring well construction records are provided in Appendix A.

The temporary monitoring wells were installed after completing a soil boring to the appropriate depth as discussed in Section 2.2.1. In general, the shallow temporary monitoring wells were installed approximately 10 feet below the level at which the water table was encountered during drilling. The intermediate wells were installed to identify the absence or presence of the Castle Hayne Confining Unit and to characterized the groundwater at this depth.

The following sections discuss the installation of the temporary wells on a site by site basis, providing information concerning the number, depths and locations, of shallow and intermediate temporary monitoring wells.

2.3.1.1 Site 89

During the Phase I investigation a total of 30 temporary monitoring wells were installed at Site 89 between August 2, 1996, and August 19, 1996. During Phase I, a total of 14 temporary shallow monitoring wells were installed ranging in depths of 10 to 19 feet bgs. A total of 16 intermediate temporary monitoring wells were installed during the Phase I investigation ranging in depths from 35.0 to 47.0 feet below ground surface (bgs). During the Phase II investigation, seven temporary monitoring wells were installed between April 14, 1997 and April 29, 1997, at depths ranging from 10.5 to 41.0 feet bgs. Temporary monitoring well construction data for Site 89 including well identification, date installed, top of casing and ground surface elevations, boring and well depths, and screen intervals is presented on Table 2-3.

2.3.1.2 Site 93

Fourteen temporary monitoring wells were installed at Site 93 including seven shallow and seven intermediate wells. The temporary monitoring wells at Site 93 were installed during the Phase I investigation between July 29, 1996 and August 5, 1996. Shallow temporary monitoring wells at Site 93 ranged in depth from 14.5 to 24.5 feet bgs. The intermediate wells ranged in depth from 50 to 53.5 feet bgs. Temporary monitoring well construction data for Site 93 including well identification, date installed, top of casing and ground surface elevations, boring and well depths, and screen intervals is presented on Table 2-4.

2.3.2 Permanent Monitoring Well Installation

Permanent monitoring wells were installed spatially across the sites to facilitate groundwater sample collection from groundwater that has been impacted by past site activities and to characterize the nature and extent of groundwater contamination. The permanent monitoring wells provide secure, fixed groundwater sampling locations from which future samples may be acquired, and from which critical hydrogeologic data such as hydraulic conductivity, and groundwater depths, flow directions and gradients can be ascertained. The Final Project Plans provided initial guidance for permanent monitoring well locations. However, placement of the permanent monitoring wells was selected based on the mobile laboratory results of groundwater samples collected from temporary monitoring well groundwater samples (as discussed in Section 4.0). Permanent monitoring well location selection was a cooperative effort involving the Baker Site Manager, the Baker Project Manager, LANTDIV, and MCB, Camp Lejeune representatives.

Shallow, intermediate, and deep permanent monitoring wells were installed to monitor different intervals within the shallow groundwater regime at Sites 89 and 93. Figures 2-5 and 2-6 illustrate the locations of the permanent monitoring wells at Sites 89 and 93, respectively. The shallow permanent monitoring wells were positioned to facilitate monitoring of the upper zone of the surficial aquifer. The intermediate permanent monitoring wells were installed to monitor the zone just above the first semi-confining layer within the Castle Hayne aquifer. The deep permanent monitoring wells were installed to monitor the zone just above the second semi-confining layer within the Castle Hayne aquifer. The hydrogeologic conditions at MCB, Camp Lejeune, including aquifer and confining unit descriptions, are discussed in Section 3.0.

Permanent monitoring wells were constructed of 2-inch diameter, schedule 40, flush-joint and threaded PVC casing. Well screen intervals were comprised of 10 feet (shallow monitoring wells) or 5 feet (intermediate and deep monitoring wells) lengths of No. 10 slot well screen. A sand pack consisting of No. 1 sand was placed inside of the annulus between the screen/riser and the borehole wall from the bottom of the well to approximately 2 feet above the top of the screen. A bentonite seal of 1 foot thickness for shallow wells, and 2 foot minimum thickness for intermediate and deep monitoring wells was placed above the sand pack. Above the bentonite seal, the annular space was filled with cement-bentonite grout to the ground surface.

In developed areas, the PVC riser was terminated below the level of the surrounding ground surface and a "flush-mount"protective well cover was installed. A typical permanent monitoring well construction diagram for below ground surface completion is presented in Figure 2-7 In undeveloped (i.e., wooded) areas, the PVC riser was terminated above the level of the surrounding ground surface and an above ground "stick-up"steel protective well cover, with a concrete pad and bollards were installed. A typical permanent monitoring well construction diagram for above ground surface completion is presented in Figure 2-8. All permanent monitoring wells were installed using standard construction techniques as detailed in Section 6.0 of the Final FSAP. Monitoring well construction records are presented in Appendix A.

2.3.2.1 Site 89

A total of 14 permanent monitoring wells were installed at Site 89 during the Phase II investigation, between April 16, 1997, and May 19, 1997. There were no permanent monitoring wells installed at Site 89 during the Phase I investigation. Two shallow permanent monitoring wells were installed, each to a depth of 14.0 feet. A total of six intermediate permanent monitoring wells were installed at depths ranging from 37.0 to 41.5 feet bgs. Six deep permanent monitoring wells were installed at depths ranging from 70.0 to 90.0 feet bgs.

Groundwater samples were collected from three monitoring wells (IR89-MW01, IR89-MW02, and IR89-MW03) that were installed as part of a previous Underground Storage Tank (UST) investigation. The wells, which were originally identified as STC868-MW01, STC868-MW02, and STC868-MW03, were installed in June 1994. Groundwater samples were also collected from two monitoring wells which were installed as part of investigations for other Installation Restoration Program (IRP) sites. During the Phase I investigation, a sample was collected from existing monitoring well IR35-MW42B. During the Phase II investigation, a sample was collected from existing monitoring well IR36-GW05. These wells were installed during RIs conducted at other sites; however, due to their proximity to Site 89, they were sampled for additional data needs. Permanent monitoring well construction data for Site 89 is presented on Table 2-5. This table includes well identification, date installed, top of casing and ground surface elevations, boring and well depths, screen, sand pack, and bentonite seal intervals, and height of riser above/below ground surface.

2.3.2.2 Site 93

A total of 11 permanent monitoring wells were installed at Site 93 during the Phase II investigation, between April 20, 1997, and May 17, 1997. No permanent monitoring wells were installed at Site 93 during the Phase I investigation. Five shallow permanent monitoring wells were installed at depths ranging from 12.0 to 14.0 feet bgs. A total of five intermediate permanent monitoring wells were installed at depths ranging from 40.0 to 50.0 feet bgs. One deep permanent monitoring well was installed at a depth of 71.0 feet bgs. Permanent monitoring well construction data for Site 93 is presented on Table 2-6. This table includes well identification, date installed, top of casing and ground surface elevations, boring and well depths, screen, sand pack, and bentonite seal intervals, and height of riser above/below ground surface.

2.3.3 Monitoring Well Development

All permanent monitoring wells were developed prior to sampling using an inertial displacement (Waterra®) pump in accordance with the procedures outlined in Section 6.0 of the Final FSAP. During development operations, water quality readings and turbidity comments were recorded and are presented on the monitoring well development records which are provided in Appendix D.

2.3.4 Water Level Measurements

Two rounds of static water level measurements were recorded at Sites 89 and 93. Measurements were recorded from permanently marked reference points on the top of the PVC casing at each monitoring well. The surveyed reference points provide a fixed datum from which groundwater levels can consistently be measured. Groundwater measurements were recorded to the nearest 0.01 foot from the top-of-casing reference point using an electric water level meter. Groundwater level measurements were recorded for the shallow intermediate and deep monitoring wells on May 29, 1997 and June 3, 1997. During the Phase I investigation, water level measurements were recorded at each temporary monitoring well prior to groundwater sample acquisition. As the measurements were recorded on different dates, and a much larger data set of measurements exists (Phase II temporary and permanent monitoring wells), the Phase I measurements will not be discussed herein.

Three staff gauges were installed in Edwards Creek in order to evaluate groundwater-surface water interaction and to further define groundwater flow directions and gradients. The locations of these staff gauges are shown on Figure 2-1. Surface water elevation readings were recorded on May 29, 1997. Water level measurements are presented and interpreted in Section 3.0 of this report.

2.3.5 Groundwater Sample Acquisition

Groundwater samples were collected to assess whether contamination that may have resulted from previous activities at Sites 89 and 93 was present in the aquifer underlying the sites. Based upon previous investigative results and historical records, the contaminants of potential concern were primarily VOCs. Prior to groundwater purging, a water level measurement from each well was obtained. The total well depth was also recorded from each well to the nearest 0.1-foot prior to sampling (during Phase I), or prior to development (during Phase II). Water level and well depth measurements were used to calculate the volume of water in each well.

A minimum of three to five well volumes were purged from each well prior to sampling. Measurements of pH, specific conductance, temperature, turbidity, and dissolved oxygen (D.O.) were taken after each well volume was purged to ensure that the groundwater quality had stabilized before sampling. These measurements were recorded in a field logbook and are provided on a site and phase basis on Tables 2-7 (Site 89 Phase I sampling) and 2-8 (Site 93 Phase I sampling), 2-9 (Site 89 Phase II sampling), and 2-10 (Site 93 Phase II sampling). Purge water was managed as described in Section 2.7.

During the groundwater sampling events, a low flow well purging and sampling technique was employed. The sampling methodology was developed based on conversations with USEPA Region IV personnel in Athens, Georgia. A peristaltic pump (GeoPump®), with the intake set two to three feet into the static water column (during the Phase I investigation), was used to purge each of the wells. During the Phase II investigation, the pump intake was set approximately at the mid-screen level. For the deep permanent monitoring wells, a second pump was utilized to expedite the purging process, the tubing for the auxiliary pump was set approximately 10 feet into the static water column. While purging groundwater from each of the monitoring wells, a flow rate of less than 0.30 gallons per minute (gpm) was maintained. The average flow rate for monitoring well purging was approximately 0.2 gpm. The groundwater samples were collected directly from the pump discharge. Dedicated sections of polyethylene tubing and silicon pump-head tubing were used during purging and sampling activities at each well.

Groundwater sampling documentation included specific sample information such as well number, sample identification, time and date of sample collection, sampling team, and analytical parameters. These items were recorded in a field logbook and on the sample labels.

2.3.6 On-Site Laboratory Analysis

During both phases of the investigation, on-site laboratory analysis was performed on groundwater samples that were collected from each temporary monitoring well and from select permanent monitoring wells. These samples were analyzed for VOCs in accordance with EPA Method 8240 and were collected in order to define the extent of VOC groundwater contamination and to facilitate selection of permanent monitoring wells locations. During Phase I of the investigation, select groundwater samples that were subjected to on-site laboratory analysis were submitted for confirmatory fixed-base laboratory analysis.

During Phase I of the investigation, a total of 33 groundwater samples collected from Site 89 temporary monitoring wells were subjected to on-site laboratory analysis of VOCs. One additional sample (IR89-MW42B-02) was collected from an existing permanent monitoring well. During Phase II of the investigation, seven groundwater samples collected from Site 89 were subjected to on-site laboratory analysis of VOCs. A summary of the on-site groundwater analysis program for Site 89 is presented on Table 2-11.

At Site 93, a total of 15 groundwater samples collected during Phase I were subjected to on-site laboratory analysis of VOCs. No samples were collected for on-site laboratory analysis during Phase II of the investigation. A summary of the on-site groundwater analysis program for Site 93 is presented on Table 2-12.

The results of the laboratory analyses as well as the nature and extent of site contamination is discussed in Section 4.0.

2.3.7 Fixed-Base Laboratory Analysis

During Phase I of the investigation, four samples from Site 89 and three samples from Site 93 were submitted for fixed-base laboratory analysis of TCL VOCs. These samples, which were collected from temporary monitoring wells, were also subjected to on-site analysis of VOCs as discussed in Section 2.3.6, above. During Phase II of the investigation, groundwater samples which were collected from permanent monitoring wells were submitted for fixed-base laboratory analysis of one or more of the following laboratory analyses:

Parameter	**Site 89**	**Site 93**
TCL volatiles	19 samples	11 samples
TCL semivolatiles	15 samples	11 samples
TCL pesticides/PCBs	1 sample	2 samples
TAL metals	15 samples	11 samples

Parameter	**Site 89**	**Site 93**
Engineering parameters including:		
▸ total suspended solids (TSS)	1 sample	0 samples
▸ total dissolved solids (TDS)	1 sample	0 samples
▸ biochemical oxygen demand (BOD)	0 samples	4 samples
▸ chemical oxygen demand (COD)	0 samples	4 samples
▸ methane	0 samples	4 samples
Natural attenuation parameters including nitrate, nitrite, sulfate, chloride, Fe^{+2}, and sulfide	0 samples	5 samples

The TCL and TAL analyses were performed to characterize the nature and extent of contamination in groundwater which is discussed in Section 4.0. As noted on the table above, not all of the samples were analyzed for full TCL parameters due to previous studies which had identified VOCs as the primary contaminant of concern.

The engineering and natural attenuation parameters are used for the assessment and development of remedial alternatives. The natural attenuation and engineering parameter results for groundwater are presented in Appendix E.

During the Phase II investigation, 19 groundwater samples were collected from Site 89, and 11 groundwater samples were collected from Site 93. (These numbers do not include duplicate samples). Because of the proximity of monitoring well IR36-MW05 to Site 89, a sample was collected from this monitoring well to provide additional data. Groundwater samples were shipped to the laboratory overnight via Federal Express for analysis. Sample tracking forms were updated by Baker throughout the investigation. Chain-of-custody forms were included with each shipping cooler that was sent to the laboratory. Internal sample tracking forms and chain-of-custody forms are included in Appendix C.

Table 2-13 and Table 2-14 present summaries of the fixed-base laboratory sampling programs for Sites 89 and 93, respectively. The summaries include sample identification; analyzed parameters; duplicate samples; and MS/MSD samples. Analytical results are discussed in Section 4.0. Field QA/QC samples are discussed in Section 2.5.

2.3.8 In Situ Hydraulic Conductivity (Slug) Tests

The shallow aquifer and upper portion of the Castle Hayne aquifer were characterized by performing in situ rising and falling head slug tests in select shallow and intermediate permanent monitoring wells. The tests were performed between May 31, 1997 and June 2, 1997. An electronic data logger

(In Situ Hermit Model SE2000) and pressure transducer assembly were used to record the recovery of groundwater in the monitoring wells to static level. All data was recorded on logarithmic scale to more closely monitor the initial changes in groundwater elevation. The data resulting from the slug tests were converted into time (in minutes) and the corresponding change in water level displacement (in feet). Results from the rising head tests were analyzed using Geraghty & Miller's AQTESOLV computer program for performing quantitative groundwater assessments. Results from falling head tests were analyzed only for intermediate monitoring wells due to the fact that groundwater levels within these monitoring wells were at or above the top of the sand packs, making the falling head tests valid at these locations. Rising head tests were performed on shallow and intermediate monitoring wells.

Following is a tabulation of the monitoring wells for which slug tests were performed:

Site 89

- Monitoring well 89-MW03 (rising head)
- Monitoring well 89-MW04 (rising head)
- Monitoring well 89-MW05 (rising head)
- Monitoring well 89-MW03IW (rising and falling head)
- Monitoring well 89-MW04IW (rising and falling head)
- Monitoring well 89-MW05IW (rising and falling head)
- Monitoring well 89-MW06IW (rising and falling head)
- Monitoring well 89-MW07IW (rising and falling head)
- Monitoring well 89-MW08IW (rising and falling head)

Site 93

- Monitoring well 93-MW01 (rising head)
- Monitoring well 93-MW02 (rising head)
- Monitoring well 93-MW03 (rising head)
- Monitoring well 93-MW04 (rising head)
- Monitoring well 93-MW01IW (rising head and falling head)
- Monitoring well 93-MW02IW (rising head and falling head)
- Monitoring well 93-MW03IW (rising head and falling head)
- well 93-MW04IW (rising head and falling head)

The Bouwer and Rice solution for slug tests in unconfined aquifers was used to evaluate all test data. The results of the in situ slug tests and hydrogeologic conditions at Site 89 and 93 are discussed in Section 3.0.

2.3.9 Temporary Monitoring Well Abandonment

Temporary monitoring wells installed during the phase I investigation (with the exception of monitoring well IR89-TW23IW) were abandoned following sampling and surveying activities. Abandonment was accomplished by manually removing the PVC pipe from the bore hole using pipe wrenches for leverage. The bore holes were then filled with soil cuttings to the surface. Temporary monitoring wells installed during the phase II investigation were left in place (i.e., not abandoned) in order to facilitate additional sampling or water level readings, if required.

2.4 Surface Water and Sediment Investigation

Surface water and sediment samples at Site 89 were collected from various reaches of Edwards Creek, considering both the upstream and downstream effects of the site. Figure 2-1 shows the locations of the surface water and sediment sample locations within Edwards Creek. Sampling of surface water and sediment was completed at the downstream sample locations first and then proceeded upstream. Each of the sampling stations were demarcated along the shoreline with wooden stakes with the sample identification.

2.4.1 Surface Water Sample Acquisition and Analysis

At each surface water sampling station, samples were collected by dipping the laboratory prepared containers directly into the water. The portion of the sample to be analyzed for volatiles were obtained before the remaining analytical fractions. During sample collection, care was taken to avoid excessive agitation that may result in loss of the VOCs.

A total of 11 surface water samples were collected during the Phase I investigation. Each of these samples were subjected to on-site laboratory analysis for VOCs via EPA Method 8240. Five of these samples were shipped to the fixed based laboratory and analyzed for TCL VOAs, SVOAs, and TAL metals according to Contact Laboratory Program (CLP) protocol. One surface water sample was analyzed for pesticides/PCBs in addition to the aforementioned parameters. A summary of the surface water sampling program is presented on Table 2-15.

Five surface water samples were collected during the Phase II investigation and submitted for laboratory analysis of chlorides from the upper portions of Edwards Creek near the DRMO facility and at locations downstream where the stream approaches Northeast Creek.

During the Phase I investigation, water quality readings (i.e., pH, dissolved oxygen, salinity, specific conductance, and temperature) were recorded at the five sampling stations from which fixed-base laboratory samples were not collected. The results of these readings are provided on Table 2-16.

2.4.2 Sediment Sample Acquisition and Analysis

Ten sediment samples were collected subsequent to the surface water samples to minimize sediment suspension that might falsely contaminate the surface water samples. The sediment samples were collected from the five stations from which fixed-base laboratory surface water samples were collected. Two sediment samples were collected at each of these locations for a total of ten samples. The first sample was collected below the water surface from the surface of the stream bed to approximately six inches bgs, and the second sample was collected from the 6 to 12 inch bgs interval. The samples were collected by manually pushing a sediment corer, equipped with a disposable acetate sleeve into the stream bed. The sediment was extruded from the disposable sampling tube and placed into the appropriate sample containers. The sediment samples were analyzed for TCL VOAs, TCL SVOAs, and TAL metals according to CLP protocol. One of these sediment samples was analyzed for TCL pesticides and PCBs in addition to the aforementioned parameters. A summary of the sediment sampling program is presented on Table 2-17.

2.5 Field Quality Assurance Quality Control Samples

Field QA/QC samples were collected at Sites 89 and 93 during both phases of the investigation according to the procedures outlined in the USEPA Region IV standard operating procedures (SOPs). These samples were obtained to 1) ensure that decontamination procedures were effective (equipment rinsate samples); 2) evaluate field methodologies (duplicate samples); 3) establish field background conditions (field blanks); 4) evaluate whether cross-contamination occurred during sampling and shipping (trip blanks); and 5) evaluate laboratory analytical processes (MS/MSDs).

Data Quality Objectives (DQOs) for the QA/QC samples were implemented in accordance with DQO Level IV as defined in the Environmental Compliance Branch SOPs and Quality Assurance Manual, USEPA Region IV (USEPA, 1991). This DQO level is equivalent to the Naval Facilities Engineering Service Center (NFESC) DQO Level D, as specified in the "Sampling and Chemical Analysis Quality Assurance Requirements for the Navy Installation Restoration Programs" document (NEESA, 1988).

The definition of each type of QA/QC sample is provided in the Environmental Compliance Branch Standard Operating Procedures (SOPs) and Quality Assurance Manual, USEPA Region IV (USEPA, 1991). A brief summary of the QA/QC samples collected during this investigation is provided below.

- Duplicate Samples: Duplicates were collected at frequencies equal to or greater than ten percent of the total number of samples collected. The duplicate samples were collected at the same time, using the same techniques as the planned original environmental samples. Three duplicate samples were collected during the Phase I investigation. A total of 12 duplicate samples were collected during the Phase II investigation

- Equipment Rinsate Blanks: Equipment Rinsate blanks were prepared for sampling equipment utilized to collect environmental samples. Rinsate samples were analyzed for parameters associated with the sampling event. One rinsate blank sample was collected during the Phase I investigation. A total of 11 rinsate blank samples were collected during the Phase II investigation.

- Field Blanks: Field blanks were collected to provide analytical data on the water used in the field for decontamination purposes. One field blank sample was collected during the Phase I investigation. Three field blank samples were collected during the Phase II investigation.

- Trip Blanks: Trip blanks were prepared by the analytical laboratory prior to the sampling event, and stored with the investigative samples throughout the sampling event. Three trip blanks were analyzed during the Phase I investigation. A total of 10 trip blanks were analyzed during the Phase II investigation.

- Matrix Spike/Matrix Spike Duplicates: MS/MSDs were collected at a frequency equal to or greater than five percent of the total number of environmental samples collected during the study. Three MS/MSD samples were analyzed during the Phase I investigation. Six MS/MSD samples were collected during the Phase II investigation.

A summary of field QA/QC samples is included as Table 2-18. This table presents the sample identification and date, analytical parameters, and additional information pertinent to the field QA/QC samples. MS/MSD samples are indicated on the sample summary tables that are presented earlier in this section.

2.6 Decontamination Procedures

All sampling equipment that was used during the investigation was after each use to prevent cross-contamination of samples. Disposable sampling equipment was not decontaminated, but rather was discarded subsequent to its initial use. Disposable equipment included polyethylene and silicon tubing used for groundwater sampling. The drill rig and associated down-hole tools were steam cleaned prior to initiating drilling activities and also between borings. Meters and instruments used for measuring water quality parameters were thoroughly rinsed with distilled water after each use.

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

For heavy equipment, the following procedures were implemented:

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

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

- Clean with distilled water and laboratory detergent (Liquinox soap solution)
- Rinse thoroughly with distilled water
- Rinse with isopropyl alcohol
- Air dry
- Wrap in aluminum foil, if appropriate

Temporary decontamination pads, constructed of wood and plastic, were used to minimize spillage onto the ground surface. Decontamination fluids generated during the field program were containerized and handled according to the procedures outlined in Section 2.8.

2.7 Investigation Derived Waste Management

Field investigation activities associated with CTO-0356 resulted in the generation of various investigation derived waste (IDW). The IDW included soil cuttings, purge and development water, drilling fluids (mud) and solutions used to decontaminate non-disposable sampling equipment. The general management techniques utilized for the IDW were:

- Collection and containerization of IDW material
- Temporary storage of IDW while awaiting confirmatory analytical data
- Final disposal of aqueous and solid IDW material

The management of the IDW was performed in accordance with guidelines developed by the USEPA Office of Emergency and Remedial Response, Hazardous Site Control Division (USEPA, 1992). Both the IDW soils and water at Sites 89 and 93 were determined to be nonhazardous. All soils were transported to Lot 203 and disposed of in an area which contains other non-hazardous fill material. The liquid IDW was transported to the Groundwater Treatment Facility located at Lot 203 where proper treatment and disposal procedures were completed A complete summary of the IDW management is contained in Appendix F.

2.8 Data Management and Tracking

The management and tracking of data, from time of field collection to receipt of validation report, is of primary importance to the overall quality of laboratory analytical results. Sample identification of samples collected for on-site analysis were recorded in a field log book and on the sample container. These samples were immediately transported to the on-site laboratory and logged into a data base prior to analysis. Sample identification of those samples analyzed at the fixed based lab were recorded on chain-of-custody forms, provided in Appendix C. Chain-of-custody forms were reviewed by data management personnel to verify that appropriate laboratory analyses had been requested. Upon receipt of laboratory analytical results, a further comparison was performed to verify that each sample received by the laboratory was analyzed for the correct parameters.

The management and tracking of data from the time of sample collection until receipt of the analytical results was completed to determine the following items:

- Identify and correct chain-of-custody discrepancies prior to laboratory analysis
- Verify the receipt of all samples by the laboratory
- Confirm that requested sample analyses were performed
- Ensure the delivery of a complete data set

2.9 References

Baker Environmental, Inc. 1997. Remedial Investigation/Feasibility Study Project Plans, Operable Unit No. 16 (Sites 89 and 93) Marine Corps Base Camp Lejeune, North Carolina. February 1997.

Baker Environmental, Inc. 1996. Phase I Investigation Report Operable Unit No. 16 (Sites 89 and 93), Marine Corps Base Camp Lejeune, North Carolina.

USEPA 1992, Guide to Management of Investigation - Derived Wastes. Office of Emergency and Remedial Response Hazardous Site Control Division, Washington, D.C., 0S-220W. April 1992.

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

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

SECTION 2.0 TABLES

TABLE 2-1

SOIL SAMPLING SUMMARY - SITE 89
OPERABLE UNIT NO. 16 (SITES 89 AND 93)
REMEDIAL INVESTIGATION, CTO-0356
MCB CAMP LEJEUNE, NORTH CAROLINA

Sample Identification	Sample Interval (ft)	TCL Volatiles	TCL Semi-volatiles	TCL Pesticides/ PCBs	TAL Metals	Total Organic Carbon	Bulk Density	Grain Size	Vertical Permeability	Duplicate Sample	MS/MSD
Phase II Soil Samples (1)											
IR89-MW03IW-02	3.0-5.0	X	X	X	X					X	
IR89-MW03IW-05	9.0-11.0	X	X	X	X						X
IR89-MW03DW-02	3.0-5.0	X	X		X						
IR89-MW03DW-05	9.0-11.0	X	X		X						
IR89-MW04-03	5.0-7.0	X	X	X	X						
IR89-MW04-05	9.0-11.0	X	X	X	X						
IR89-MW04DW-02	3.0-5.0						X	X	X		
IR89-MW04DW-03	5.0-7.0	X	X		X						
IR89-MW04DW-05	9.0-11.0	X	X		X						
IR89-MW04DW-06	11.0-13.0						X	X	X		
IR89-MW04DW-22	43.0-45.0						X	X	X		
IR89-MW05-03	5.0-7.0	X	X		X					X	
IR89-MW05-06	11.0-13.0	X	X		X						
IR89-MW05IW-03	5.0-7.0	X	X	X	X						
IR89-MW05IW-06	11.0-13.0	X	X		X						
IR89-MW05DW-03	5.0-7.0	X	X		X						X
IR89-MW05DW-06	11.0-13.0	X	X		X						
IR89-MW06IW-01	1.0-3.0	X	X		X					X	
IR89-MW06IW-02	3.0-5.0	X	X		X						
IR89-MW06DW-01	1.0-3.0	X	X		X						
IR89-MW06DW-02	3.0-5.0	X	X		X						
IR89-MW07IW-04	7.0-9.0	X	X		X						X
IR89-MW07IW-06	11.0-13.0	X	X		X						
IR89-MW07DW-04	7.0-9.0	X	X		X						

TABLE 2-1 (Continued)

SOIL SAMPLING SUMMARY - SITE 89
OPERABLE UNIT NO. 16 (SITES 89 AND 93)
REMEDIAL INVESTIGATION, CTO-0356
MCB CAMP LEJEUNE, NORTH CAROLINA

Sample Identification	Sample Interval (ft)	TCL Volatiles	TCL Semi-volatiles	TCL Pesticides /PCBs	TAL Metals	Total Organic Carbon	Bulk Density	Grain Size	Vertical Permeability	Duplicate Sample	MS/MSD
IR89-MW07DW-06	11.0-13.0	X	X		X						
IR89-MW08IW-04	7.0-9.0	X	X		X						
IR89-MW08IW-06	11.0-13.0	X	X		X						
IR89-MW08IW-20	39.0-41.0					X					
IR89-MW08DW-04	7.0-9.0	X	X		X						
IR89-MW08DW-06	11.0-13.0	X	X		X						

Notes:

[1] - No soil samples were collected during the Phase I Investigation.
[2] - The contaminants of concern at OU No. 16 are VOCs; therefore, it was not necessary to perform a full organic analysis of all of the samples.

ft - Feet
TCL - Target Compound List
PCBs - Polychlorinated Biphenyls
TAL - Target Analyte List
MS/MSD - Matrix Spike/Matrix Spike Duplicate
X - Sample Analyzed for Indicated Parameter

TABLE 2-2

SOIL SAMPLING SUMMARY - SITE 93
OPERABLE UNIT NO. 16 (SITES 89 AND 93)
REMEDIAL INVESTIGATION, CTO-0356
MCB CAMP LEJEUNE, NORTH CAROLINA

Sample Identification	Sample Interval (ft)	TCL Volatiles	TCL Semi-volatiles	TCL Pesticides/ PCBs	TAL Metals	Total Organic Carbon	Bulk Density	Grain Size	Duplicate Sample	MS/MSD
Phase II Soil Samples (1)										
IR93-MW01-02	3.0-5.0	X	X	X	X					
IR93-MW01-04	7.0-9.0	X	X		X					
IR93-MW01IW-02	3.0-5.0	X	X		X					
IR93-MW01IW-04	7.0-9.0	X	X		X				X	
IR93-MW02-02	3.0-5.0	X	X		X					
IR93-MW02-04	7.0-9.0	X	X		X					
IR93-MW02IW-02	3.0-5.0	X	X		X					
IR93-MW02IW-04	7.0-9.0	X	X		X					
IR93-MW02DW-02	3.0-5.0	X	X	X	X					
IR93-MW02DW-04	7.0-9.0	X	X		X					X
IR93-MW03-02	3.0-5.0	X	X		X				X	
IR93-MW03-04	7.0-9.0	X	X		X					
IR93-MW03IW-02	3.0-5.0	X	X		X					
IR93-MW03IW-04	7.0-9.0	X	X		X					
IR93-MW04-02	3.0-5.0	X	X		X				X	
IR93-MW04-04	7.0-9.0	X	X		X					

TABLE 2-2 (Continued)

SOIL SAMPLING SUMMARY - SITE 89
OPERABLE UNIT NO. 16 (SITES 89 AND 93)
REMEDIAL INVESTIGATION, CTO-0356
MCB CAMP LEJEUNE, NORTH CAROLINA

Sample Identification	Sample Interval (ft)	TCL Volatiles	TCL Semi-volatiles	TCL Pesticides /PCBs	TAL Metals	Total Organic Carbon	Bulk Density	Grain Size	Duplicate Sample	MS/MSD
IR93-MW04IW-02	3.0-5.0	X	X		X					
IR93-MW04IW-04	7.0-9.0	X	X		X					
IR93-MW05-02	3.0-5.0	X	X	X	X				X	X
IR93-MW05-04	7.0-9.0	X	X	X	X					
IR93-MW05IW-02	3.0-5.0	X	X		X					
IR93-MW05IW-04	7.0-9.0	X	X		X					
IR93-MW05IW-07	13.0-15.0					X	X	X		

Notes:

(1) - No soil samples were collected during the Phase I Investigation.
(2) - The contaminants of concern at OU No. 16 are VOCs; therefore, it was not necessary to perform a full organic analysis of all of the samples.

ft - Feet
TCL - Target Compound List
PCBs - Polychlorinated Biphenyls
TAL - Target Analyte List
MS/MSD - Matrix Spike/Matrix Spike Duplicate
X - Sample Analyzed for Indicated Parameter

TABLE 2-3

SUMMARY OF TEMPORARY MONITORING WELL CONSTRUCTION DATA - SITE 89
OPERABLE UNIT NO. 16 (SITES 89 AND 93)
REMEDIAL INVESTIGATION, CTO-0356
MCB, CAMP LEJEUNE, NORTH CAROLINA

Well Identification	Date Installed	Top of Casing Elevation (ft above msl)	Ground Surface Elevation (ft above msl)	Boring Depth (ft bgs)	Well Depth (ft bgs)	Screen Interval Depth (ft bgs)
Phase I Temporary Monitoring Wells						
IR89-TW04	7/31/96	13.92	11.84	15.0	15.0	5.0-15.0
IR89-TW04IW	7/31/96	14.2	11.84	50.0	47.0	42.0-47.0
IR89-TW08	8/2/96	15.38	13.26	15.0	15.0	5.0-15.0
IR89-TW08IW	8/2/96	15.19	13.36	42.0	42.0	37.0-42.0
IR89-TW09	8/3/96	16.94	14.45	15.0	15.0	5.0-15.0
IR89-TW09IW	8/3/96	17.12	14.45	40.0	38.0	33.0-38.0
IR89-TW10	8/3/96	16.14	13.78	15.0	15.0	5.0-15.0
IR89-TW10IW	8/3/96	14.81	13.78	44.0	44.0	39.0-44.0
IR89-TW11	8/4/96	17.72	15.15	15.0	15.0	5.0-15.0
IR89-TW11IW	8/4/96	17.63	15.25	42.0	38.0	33.0-38.0
IR89-TW12	8/4/96	13.62	11.98	10.0	10.0	5.0-10.0
IR89-TW12IW	8/4/96	13.35	11.68	47.0	47.0	42.0-47.0
IR89-TW13	8/5/96	14.00	13.28	20.0	19.0	9.0-19.0
IR89-TW13IW	8/4/96	14.29	13.18	47.0	44.0	39.0-44.0
IR89-TW15	8/6/96	17.47	16.21	15.0	15.0	5.0-15.0
IR89-TW15IW	8/6/96	16.70	16.25	47.0	44.5	39.5-44.5
IR89-TW16	8/6/96	17.02	15.02	15.0	15.0	5.0-15.0
IR89-TW16IW	8/6/96	15.46	15.46	47.0	45.0	40.0-45.0
IR89-TW17IW	8/7/96	--	--	42.0	40.0	35.0-40.0
IR89-TW18	8/12/96	17.11	15.19	15.0	15.0	5.0-15.0
IR89-TW18IW	8/12/96	15.04	14.89	47.0	45.0	40.0-45.0
IR89-TW19	8/13/96	17.59	15.67	15.0	15.0	5.0-15.0
IR89-TW19IW	8/13/96	17.71	15.47	42.0	40.0	35.0-40.0
IR89-TW20	8/13/96	20.34	17.92	15.0	15.0	5.0-15.0
IR89-TW20IW	8/13/96	20.84	17.56	47.0	45.0	40.0-45.0
IR89-TW21	8/14/96	18.36	16.17	15.0	14.0	4.0-14.0
IR89-TW21IW	8/14/96	18.49	16.27	42.0	40.0	35.0-40.0
IR89-TW22	8/14/96	20.97	18.12	15.0	15.0	5.0-15.0
IR89-TW22IW	8/15/96	20.69	18.12	47.0	45.0	40.0-45.0
IR89-TW23IW	8/19/96	15.39	12.10	37.0	35.0	30.0-35.0

TABLE 2-3 (Continued)

SUMMARY OF TEMPORARY MONITORING WELL CONSTRUCTION DATA - SITE 89
OPERABLE UNIT NO. 16 (SITES 89 AND 93)
REMEDIAL INVESTIGATION, CTO-0356
MCB, CAMP LEJEUNE, NORTH CAROLINA

Well Identification	Date Installed	Top of Casing Elevation (ft above msl)	Ground Surface Elevation (ft above msl)	Boring Depth (ft bgs)	Well Depth (ft bgs)	Screen Interval Depth (ft bgs)
Phase II Temporary Monitoring Wells						
IR89-TW24IW	4/14/97	17.78	15.71	22.0	20.0	15.0 - 20.0
IR89-TW25IW	4/14/97	18.35	19.20	28.0	28.0	23.0 - 28.0
IR89-TW26IW	4/15/97	18.41	15.42	42.0	41.0	36.0 - 41.0
IR89-TW27IW	4/15/97	9.04	6.54	36.0	34.0	29.0 - 34.0
IR89-TW28IW	4/22/97	18.83	15.42	29.0	28.0	23.0 - 28.0
IR89-TW29IW	4/23/97	7.97	6.28	19.0	16.3	11.3 - 16.3
IR89-TW30IW	4/29/97	6.41	5.77	14.0	10.5	5.5 - 10.5

Notes:

msl - Mean sea level
bgs - Below ground surface
ft - Feet
-- - Information not available

TABLE 2-4

SUMMARY OF PHASE I TEMPORARY MONITORING WELL CONSTRUCTION DATA - SITE 93
OPERABLE UNIT NO. 16 (SITES 89 AND 93)
REMEDIAL INVESTIGATION, CTO-0356
MCB, CAMP LEJEUNE, NORTH CAROLINA

Well Identification	Date Installed	Top of Casing Elevation (ft above msl)	Ground Surface Elevation (ft above msl)	Boring Depth (ft bgs)	Well Depth (ft bgs)	Screen Interval Depth (ft bgs)
Phase I Temporary Monitoring Wells (1)						
IR93-TW01	7/29/96	16.48	14.44	15.0	15.0	5.0-15.0
IR93-TW01IW	7/29/96	16.70	14.54	54.0	53.5	48.5-53.5
IR93-TW02	7/30/96	18.74	16.59	15.0	15.0	5.0-15.0
IR93-TW02IW	7/30/96	18.72	16.69	52.0	50.0	45.0-50.0
IR93-TW03	7/30/96	15.93	13.08	15.0	14.5	4.5-14.5
IR93-TW03IW	7/30/96	14.74	12.98	54.0	50.0	45.0-50.0
IR93-TW05	7/31/96	19.72	16.58	15.0	15.0	5.0-15.0
IR93-TW05IW	7/31/96	18.88	16.68	52.0	50.0	45.0-50.0
IR93-TW06	8/1/96	19.45	17.72	15.0	14.5	4.5-14.5
IR93-TW06IW	8/1/96	19.08	17.72	52.0	50.0	45.0-50.0
IR93-TW07	8/2/96	20.08	17.82	15.0	15.0	5.0-15.0
IR93-TW07IW	8/2/96	19.87	17.52	52.0	50.0	45.0-50.0
IR93-TW14	8/5/96	17.69	15.58	25.0	24.5	14.5-24.5
IR93-TW14IW	8/5/96	17.73	15.58	50.0	50.0	45.0-50.0

Notes:

(1) - No temporary monitoring wells were installed during the Phase II investigation at Site 93.
ft - Feet
msl - Mean sea level
bgs - Below ground surface

TABLE 2-5

SUMMARY OF PERMANENT MONITORING WELL CONSTRUCTION DATA - SITE 89
OPERABLE UNIT NO. 16 (SITES 89 AND 93)
REMEDIAL INVESTIGATION, CTO-0356
MCB CAMP LEJEUNE, NORTH CAROLINA

Well Identification	Date Installed	Top of Casing Elevation (ft above msl)	Ground Surface Elevation (ft above msl)	Boring Depth (ft bgs)	Well Depth (ft bgs)	Screen Interval Depth (ft bgs)	Sand Pack Interval Depth (ft bgs)	Bentonite Interval Depth (ft bgs)	Stick Up[2] (ft)
Phase II Permanent Monitoring Wells[1]									
IR89-MW03IW	5/15/97	13.48	13.89	42.0	41.5	36.5 - 41.5	34.0 - 42.0	32.0 - 34.0	-0.41
IR89-MW03DW	5/19/97	13.47	13.90	72.0	70.0	65.0 - 70.0	63.0 - 72.0	61.0 - 63.0	-0.43
IR89-MW04	4/16/97	11.91	9.43	14.0	14.0	4.0 - 14.0	2.0 - 14.0	1.0 - 2.0	2.48
IR89-MW04IW	4/16/97	11.16	9.69	37.5	37.5	32.5 - 37.5	30.0 - 37.5	28.0 - 30.0	1.47
IR89-MW04DW	4/17/97	10.91	9.37	74.0	70.0	65.0 - 70.0	63.0 - 70.0	60.0 - 63.0	1.54
IR89-MW05	4/20/97	12.37	12.92	14.0	14.0	4.0 - 14.0	2.0 - 14.0	1.0 - 2.0	-0.55
IR89-MW05IW	4/18/97	12.41	13.07	46.0	40.0	35.0 - 40.0	33.0 - 40.0	28.0 - 33.0	-0.66
IR89-MW05DW	4/19/97	12.86	13.33	74.0	70.0	65.0 - 70.0	63.0 - 70.0	60.0 - 63.0	-0.47
IR89-MW06IW	5/2/97	11.71	9.88	40.0	37.0	32.0 - 37.0	30.0 - 37.0	28.0 - 30.0	1.83
IR89-MW06DW	5/3/97	11.44	9.50	74.0	70.0	65.0 - 70.0	63.0 - 70.0	60.0 - 63.0	1.94
IR89-MW07IW	5/4/97	19.30	17.44	42.0	40.0	35.0 - 40.0	33.0 - 40.0	31.0 - 33.0	1.86
IR89-MW07DW	5/5/97	18.99	17.19	84.0	80.0	75.0 - 80.0	73.0 - 84.0	70.0 - 73.0	1.80
IR89-MW08IW	5/13/97	13.26	11.31	40.0	37.0	32.0 - 37.0	30.0 - 37.0	28.0 - 30.0	1.95
IR89-MW08DW	5/14/97	13.38	11.43	92.0	90.0	85.0 - 90.0	83.0 - 90.0	80.0 - 83.0	1.95
IR89-MW01	6/22/94	13.32	13.7	13.7	13.3	3.3 - 13.7	2.0 - 13.3	1.0 - 2.0	-0.38
IR89-MW02	6/22/94	14.81	13.7	--	--	--	--	--	--
IR89-MW03	6/22/94	15.38	14.2	--	--	--	--	--	--

Notes:

(1) - No permanent monitoring wells were installed during the Phase I investigation.
(2) - Where stick up is negative, flush mount wells were installed.
msl - Mean sea level
bgs - Below ground surface
ft - Feet
-- - Information not available

TABLE 2-6

SUMMARY OF PERMANENT MONITORING WELL CONSTRUCTION DATA - SITE 93
OPERABLE UNIT NO. 16 (SITES 89 AND 93)
REMEDIAL INVESTIGATION, CTO-0356
MCB CAMP LEJEUNE, NORTH CAROLINA PHASE II

Well Identification	Date Installed	Top of Casing Elevation (ft above msl)	Ground Surface Elevation (ft above msl)	Boring Depth (ft bgs)	Well Depth (ft bgs)	Screen Interval Depth (ft bgs)	Sand Pack Interval Depth (ft bgs)	Bentonite Interval Depth (ft bgs)	Stick Up (ft)
Phase II Permanent Monitoring Wells[1]									
IR93-MW01	04/30/97	14.98	15.46	14.0	12.0	4.0 - 12.0	2.0 - 12.0	1.0 - 2.0	-0.48
IR93-MW01IW	04/30/97	15.18	15.50	50.0	50.0	45.0 - 50.0	43.0 - 50.0	41.0 - 43.0	-0.32
IR93-MW02	04/22/97	12.76	13.31	14.0	14.0	4.0 - 14.0	2.0 - 14.0	1.0 - 2.0	-0.55
IR93-MW02IW	04/21/97	12.71	13.44	50.0	46.0	41.0 - 46.0	39.0 - 46.0	37.0 - 39.0	-0.73
IR93-MW02DW	05/17/97	12.84	13.07	72.0	71.0	66.0 - 71.0	64.0 - 72.0	62.0 - 64.0	-0.23
IR93-MW03	04/30/97	17.05	17.49	22.0	14.0	4.0 - 14.0	2.0 - 15.0	1.0 - 2.0	-0.44
IR93-MW03IW	04/29/97	17.18	17.63	50.0	50.0	45.0 - 50.0	43.0 - 50.0	41.0 - 43.0	-0.45
IR93-MW04	05/06/97	15.42	15.72	15.0	14.0	4.0 - 14.0	2.0 - 15.0	1.0 - 2.0	-0.30
IR93-MW04IW	05/06/97	15.41	15.68	52.0	49.0	44.0 - 49.0	42.0 - 50.0	40.0 - 42.0	-0.27
IR93-MW05	04/20/97	13.64	11.02	14.0	14.0	4.0 - 14.0	2.0 - 14.0	1.0 - 2.0	2.62
IR93-MW05IW	04/20/97	13.29	10.82	46.0	40.0	35.0 - 40.0	33.0 - 40.0	31.0 - 33.0	2.47

Notes:

[1]	-	No permanent monitoring wells were installed during the Phase I investigation.
[2]	-	Where stick up is negative, flush mount walls were installed.
msl	-	Mean sea level
bgs	-	Below ground surface
ft	-	Feet

TABLE 2-7

SUMMARY OF PHASE I GROUNDWATER SAMPLING WATER QUALITY PARAMETERS - SITE 89
OPERABLE UNIT NO. 16 (SITES 89 AND 93)
REMEDIAL INVESTIGATION, CTO-0356
MCB CAMP LEJEUNE, NORTH CAROLINA

Well Identification Date Approximate Purge Rate	Time	Well Volume	Purge Volume (gals)	Water Quality Parameters				
				Specific Conductance at 25°C (µmhos/cm)	Temperature (°C)	pH (S.U.)	Turbidity (N.T.U.)	Dissolved Oxygen (mg/L)
IR89-TW18	1331	1.0	0.5	0.5	329	6.36	106	3.95
08/13/96	1400	2.0	1.0	1.0	313	6.19	34.5	3.6
0.02 gpm	1435	3.0	1.5	1.5	303	6.17	12.2	2.5
IR89-TW18IW	1215	1.0	3.0	404	19.0	7.64	>200	1.6
08/13/96	1235	2.0	6.0	425	19.0	7.63	28	1.2
0.13 gpm	1300	3.0	9.0	430	19.5	7.64	13	1.6
IR89-TW19	1720	1.0	0.7	660	22.2	6.70	77	NR
08/13/96	1725	2.0	1.4	NR	NR	NR	48	NR
0.21gpm	1730	3.0	2.8	650	22.2	6.70	40	NR
	1740	N/A	N/A	645	22.2	6.53	27.5	NR
	1745	N/A	N/A	NR	NR	NR	19.5	NR
	1750	N/A	N/A	655	22.4	6.81	21.5	NR
IR89-TW19IW(1) 08/13/96	1650	1.0	2.5	555	21.4	9.29	>200	5.2
IR89-TW20	0950	1.0	0.5	105	19.8	5.47	>200	3.0
08/14/96	1005	2.0	1.0	105	19.9	5.30	>200	3.0
0.04 gpm	1015	3.0	1.5	96	19.8	5.31	>200	3.2
	1025	4.0	2.0	93	19.9	5.30	>200	3.4
	1035	N/A	N/A	NR	NR	NR	170	NR
	1040	N/A	N/A	NR	NR	NR	>200	NR
	1050	N/A	N/A	NR	NR	NR	>200	NR
	1100	N/A	N/A	NR	NR	NR	170	NR
	1105	N/A	N/A	NR	NR	NR	79	NR
	1110	N/A	N/A	NR	NR	NR	76	NR
	1115	N/A	N/A	NR	NR	NR	48	NR
IR89-TW20IW	0840	1.0	0.2	583	19.4	7.36	47	2.6
08/14/96	0850	N/A	N/A	531	19.4	7.18	71	2.6
	0900	N/A	N/A	505	19.3	7.14	135	2.8
	0910	N/A	N/A	507	19.4	7.11	115	2.5
	0920	N/A	N/A	500	20.2	7.55	67	2.6
	0925	N/A	N/A	NR	NR	NR	100	NR

TABLE 2-7 (Continued)

SUMMARY OF PHASE I GROUNDWATER SAMPLING WATER QUALITY PARAMETERS - SITE 89
OPERABLE UNIT NO. 16 (SITES 89 AND 93)
PHASE II REMEDIAL INVESTIGATION, CTO-0356
MCB CAMP LEJEUNE, NORTH CAROLINA

Well Identification Date Approximate Purge Rate	Time	Well Volume	Purge Volume (gals)	Water Quality Parameters				
				Specific Conductance at 25°C (μmhos/cm)	Temperature (°C)	pH (S.U.)	Turbidity (N.T.U.)	Dissolved Oxygen (mg/L)
IR89-TW21	1015	1.0	0.7	79	20.7	5.73	34	3.0
08/15/96	1025	2.0	1.5	76	20.6	5.47	7.0	3.0
0.08 gpm	1037	3.0	2.5	72	20.4	5.36	4.0	3.0
IR89-TW21IW	0820	1.0	2.5	500	18.0	703	>200	2.0
08/15/96	0840	2.0	5.0	484	18.1	7.10	>200	1.8
0.13 gpm	0900	3.0	7.6	485	18.2	7.20	>200	2.0
	0907	4.0	9.0	482	18.3	7.18	133	1.8
	0920	5.0	11	494	18.2	7.24	135	2.0
	0938	6.0	13	NR	NR	NR	6.3	NR
IR89-TW22	0955	1.0	0.5	81	20.9	6.31	20	1.85
08/16/96	1004	2.0	1.0	80	20.9	6.11	9.5	5.0
0.04 gpm	1015	3.0	1.5	80	21.2	5.52	8.0	5.2
IR89-TW22IW	0820	2.0	2.5	462	18.2	7.36	>200	1.4
08/16/96	0847	2.0	5.0	448	18.4	7.43	50	1.6
0.09 gpm	0911	3.0	8.5	450	18.2	7.44	23	1.8
	0930	N/A	10	452	18.6	7.42	13	1.8
	0940	N/A	N/A	NR	NR	NR	10	NR
IR89-TW23IW	0900	1.0	2.5	350	18.2	6.83	>200	0.6
08/21/96	0913	2.0	0.5	334	18.0	7.14	93	1.0
0.21 gpm	0924	3.0	7.5	334	18.0	7.31	52	1.2
	0930	N/A	N/A	NR	NR	NR	35	NR
	0935	N/A	N/A	NR	NR	NR	53	NR
	0940	N/A	N/A	NR	NR	NR	83	NR
IR35-MW42B	1332	1.0	6.0	513	24.0	6.94	1.85	1.75
7/31/96	1359	2.0	12.0	575	24.3	7.63	2.05	1.30
0.17 gpm	1423	3.0	18.0	573	23.3	7.69	1.04	1.50

Notes:

gals - Gallons
°C - Degrees Centigrade
S.U. - Standard Units
μmhos/cm - Micro mhos per centimeter
N.T.U. - Neophelometric Turbidity Units
N/A - Not applicable
mg/L - milligrams per liter
NR - Not recorded
(1) - Insufficient volume of water for measurements.
gpm - Gallons per minute

TABLE 2-8

SUMMARY OF PHASE I GROUNDWATER SAMPLING WATER QUALITY PARAMETERS - SITE 93
OPERABLE UNIT NO. 16 (SITES 89 AND 93)
REMEDIAL INVESTIGATION, CTO-0356
MCB CAMP LEJEUNE, NORTH CAROLINA

Well Identification Date Approximate Purge Rate	Time	Well Volume	Purge Volume (gals)	Field Parameters				
				Specific Conductance at 25°C (μmhos/cm)	Temperature (°C)	pH (S.U.)	Turbidity (N.T.U.)	Dissolved Oxygen (mg/L)
IR93-TW01	0825	1.0	1.0	740.0	22.0	6.00	166.9	1.25
07/30/96	0835	2.0	2.0	556.0	22.1	6.15	50.9	1.25
0.13 gpm	0843	3.0	3.0	488.1	21.8	6.13	28.4	1.5
	0852	4.0	4.0	462.5	21.8	6.14	16.8	1.5
	0859	5.0	5.0	464.3	22.7	6.07	19.4	1.25
	0903	6.0	6.0	456.0	22.1	6.12	12.0	1.25
IR93-TW01IW	0829	1.0	4.0	446.1	21.3	6.81	168.0	1.0
07/30/96	0849	2.0	8.0	422.6	21.4	6.89	102.6	1.6
0.18 gpm	0915	3.0	12.0	415.0	22.3	7.15	64.0	1.0
	0933	4.0	16.0	417.0	22.0	7.46	43.7	1.2
	0955	5.0	20.0	416.3	22.0	7.55	39.5	1.0
	1016	6.0	24.0	416.5	22.5	7.61	14.4	1.0
IR93-TW02	1338	1.0	1.0	269.4	25.0	5.23	161.0	1.25
07/30/96	1343	2.0	2.0	265.8	24.8	5.05	26.4	1.20
0.20 gpm	1348	3.0	3.0	268.7	23.8	5.10	15.8	1.25
IR93-TW02IW(1) 07/30/96	1330	0.5	2.0	NR	NR	NR	NR	NR
IR93-TW03	0852	1.0	1.0	449.7	24.4	6.50	>200	3.5
07/31/96 0.06 gpm	0908	2.0	2.0	446.4	24.1	7.20	20.8	3.5
IR93-TW03IW	0902	1.0	4.0	482.3	21.8	7.31	>200	1.1
07/31/96	0920	2.0	8.0	438.3	21.7	7.40	173.8	1.2
0.23 gpm	0933	3.0	12.0	448.7	22.5	7.55	170.5	1.25
IR93-TW05	0812	1.0	1.0	719.0	25.8	6.24	99.1	1.3
08/01/96	0816	2.0	2.0	711.0	25.0	6.51	172.5	1.0
0.18 gpm	0822	3.0	3.0	720.0	24.7	6.81	39.8	NR
	0829	4.0	4.0	726.0	25.0	6.85	13.2	NR
IR93-TW05IW 08/01/96	0841	1.0	3.6	483.5	22.4	7.32	4.8	1.75
IR93-TW06	1707	1.0	0.75	144.3	24.8	5.62	98.0	1.25
08/01/96	1709	2.0	1.50	135.2	24.5	5.58	41.5	1.25
0.19 gpm	1715	3.0	2.25	NR	NR	5.89	25.7	1.25

TABLE 2-8 (Continued)

SUMMARY OF PHASE I GROUNDWATER SAMPLING WATER QUALITY PARAMETERS - SITE 93
OPERABLE UNIT NO. 16 (SITES 89 AND 93)
PHASE II REMEDIAL INVESTIGATION, CTO-0356
MCB CAMP LEJEUNE, NORTH CAROLINA

Well Identification Date Approximate Purge Rate	Time	Well Volume	Purge Volume (gals)	Field Parameters				
				Specific Conductance at 25°C (µmhos/cm)	Temperature (°C)	pH (S.U.)	Turbidity (N.T.U.)	Dissolved Oxygen (mg/L)
IR93-TW06IW	1712	1.0	3.5	425.0	23.2	6.56	170.2	1.0
08/01/96 0.25 gpm	1726	2.0	7.0	437.1	23.2	6.84	172.2	1.2
	1740	3.0	10.5	448.4	23.2	7.29	170.0	1.2
IR93-TW07	0823	1.0	1.0	132.6	23.9	5.60	165.4	1.2
08/03/96	0829	2.0	2.0	132.5	23.9	5.51	163.4	1.2
0.13 gpm	0840	3.0	3.0	124.1	23.8	6.07	40.5	1.2
	0847	4.0	4.0	124.0	23.9	5.70	9.7	1.5
IR93-TW07IW	0835	1.0	3.5	461.1	21.7	6.60	26.7	1.5
08/03/96	0857	2.0	7.0	445.7	21.5	6.67	18.8	1.5
0.14 gpm	0924	3.0	10.5	439.0	21.8	7.09	14.8	1.3
IR93-TW14	1538	1.0	1.2	519.0	36.7	7.39	172.2	1.25
08/05/96	1544	2.0	2.4	533.0	28.8	7.51	170.4	1.25
0.18 gpm	1552	3.0	3.6	525.0	27.5	7.50	169.8	1.30
	1558	4.0	4.8	NR	NR	NR	NR	NR
IR93-TW14IW	1548	1.0	3.6	479.6	22.2	7.68	25.5	1.75
08/05/96	1608	2.0	7.2	477.1	22.4	7.51	35.0	2.10
0.20 gpm	1624	3.0	10.8	490.1	21.9	7.70	39.3	1.25

Notes:

gals	-	Gallons
°C	-	Degrees Centigrade
S.U.	-	Standard Units
µmhos/cm	-	Micro mhos per centimeter
N.T.U.	-	Neophelometric Turbidity Units
N/A	-	Not applicable
mg/L	-	milligrams per liter
(1)	-	Insufficient volume of water for measurements.
NR	-	Not recorded
gpm	-	Gallons per minute

TABLE 2-9

SUMMARY OF PHASE II GROUNDWATER SAMPLING WATER QUALITY PARAMETERS - SITE 89
OPERABLE UNIT NO. 16 (SITES 89 AND 93)
REMEDIAL INVESTIGATION, CTO-0356
MCB CAMP LEJEUNE, NORTH CAROLINA

				Water Quality Parameters				
Sample Identification Date Approximate Purge Rate	Time	Well Volume	Purge Volume (gals)	Specific Conductance at 25°C (µmhos/cm)	Temperature (°C)	pH (S.U.)	Turbidity (N.T.U.)	Dissolved Oxygen (mg/L)
Permanent Monitoring Wells								
IR89-MW03-01 05/28/97 0.17 gpm	1032	0.0	0.0	199	19.2	4.72	32	2.6
	1035	0.5	0.5	180	18.9	4.84	33	1.9
	1038	1.0	1.0	172	18.4	4.87	24	2.0
	1041	1.5	1.5	173	18.4	4.85	14	1.7
	1044	2.0	2.0	174	18.3	4.82	12	2.3
	1047	2.5	2.5	179	18.6	4.83	6	2.3
	1050	3.0	3.0	182	18.6	4.89	5	2.0
IR89-MW03IW-01 05/28/97 0.27 gpm	0826	0.0	0.0	470	18.6	6.99	76	2.5
	0835	0.5	3.0	463	18.6	6.88	8	2.1
	0850	1.0	6.0	482	18.8	7.18	3	2.4
	0900	1.5	9.0	478	18.7	7.14	3	2.7
	0911	2.0	12.0	468	19.1	7.08	3	2.7
	0923	2.5	15.0	485	19.2	7.16	3	1.7
	0934	3.0	18.0	463	18.9	7.12	2	3.4
	0945	3.5	21.0	484	19.6	7.27	2	2.4
	0956	4.0	24.0	470	19.2	7.19	2	3.4
IR89-MW03DW-01 05/28/97 0.25 gpm	0819	0.0	0.0	727	19.1	6.64	10	2.7
	0839	0.5	5.0	745	19.3	7.32	3	1.1
	0859	1.0	10.0	758	18.8	7.35	5	2.6
	0919	1.5	15.0	739	18.9	7.39	7	2.6
	0939	2.0	20.0	740	19.4	7.48	11	2.0
	0959	2.5	25.0	364	19.6	7.50	3	1.5
	1019	3.0	30.0	755	19.5	7.54	3	3.0
	1039	3.5	35.0	463	19.5	7.35	3	2.4
	1059	4.0	40.0	743	19.8	7.29	2	2.1
IR89-MW04-01 05/29/97 0.2 gpm	1322	0.0	0.0	488	17.0	6.55	21	2.2
	1326	0.5	1.0	490	17.1	6.44	4	2.0
	1330	1.0	2.0	488	17.2	6.49	7	2.0
	1334	1.5	3.0	488	17.4	6.80	4	2.1
	1338	2.0	4.0	489	17.0	6.58	3	2.1
	1342	2.5	5.0	491	17.4	6.62	3	2.0
	1346	3.0	6.0	486	17.2	6.55	2	2.1

TABLE 2-9 (Continued)

SUMMARY OF PHASE II GROUNDWATER SAMPLING WATER QUALITY PARAMETERS - SITE 89
OPERABLE UNIT NO. 16 (SITES 89 AND 93)
REMEDIAL INVESTIGATION, CTO-0356
MCB CAMP LEJEUNE, NORTH CAROLINA

Sample Identification Date Approximate Purge Rate	Time	Well Volume	Purge Volume (gals)	Water Quality Parameters				
				Specific Conductance at 25°C (µmhos/cm)	Temperature (°C)	pH (S.U.)	Turbidity (N.T.U.)	Dissolved Oxygen (mg/L)
IR89-MW04IW-01 05/29/97 0.20 gpm	1317	0.0	0.0	417	18.1	7.08	200	2.1
	1331	0.5	3.0	429	18.6	6.81	27	1.9
	1347	1.0	6.0	436	18.4	6.81	8	2.0
	1402	1.5	9.0	450	18.6	7.12	8	1.5
	1417	2.0	12.0	438	18.5	7.15	>200	1.9
	1432	2.5	15.0	434	18.4	7.07	121	2.2
	1447	3.0	18.0	441	18.4	7.18	>200	2.1
	1502	3.5	21.0	435	18.7	7.11	28	2.8
	1517	4.0	24.0	437	18.5	7.01	6	2.7
	1532	4.5	27.0	437	18.5	7.10	9	2.0
	1547	5.0	30.0	439	18.3	7.21	8	2.0
IR89-MW04DW-01 05/29/97 0.23 gpm	1312	0.0	0.0	1110	18.7	7.68	23	3.7
	1334	0.5	5.0	1065	18.9	9.11	15	3.0
	1356	1.0	10.0	1091	18.9	8.27	4	2.4
	1418	1.5	15.0	1115	18.6	7.88	3	2.2
	1440	2.0	20.0	1117	18.7	7.65	1	2.0
	1502	2.5	25.0	1112	19.2	7.64	2	3.8
	1524	3.0	30.0	1120	18.8	7.46	1	4.0
	1546	3.5	35.0	1131	18.8	7.66	2	2.0
IR89-MW05-01 05/28/97 0.13 gpm	1345	0.0	0.0	719	19.6	6.20	5	2.0
	1349	0.3	0.5	348	18.8	6.14	6	2.4
	1353	0.7	1.0	337	19.4	6.20	4	2.0
	1357	1.0	1.5	712	19.1	6.23	3	2.0
	1401	1.3	2.0	324	19.2	6.17	3	2.2
	1405	1.7	2.5	694	19.2	6.18	2	2.0
	1409	2.0	3.0	654	19.4	6.25	2	18
	1413	2.3	3.5	637	19.4	6.22	2	2.1
	1417	2.7	4.0	628	19.0	6.29	2	1.9
	1421	3.0	4.5	615	19.1	6.29	2	1.8
	1425	3.3	5.0	578	19.1	6.28	2	2.0
	1429	3.7	5.5	565	19.0	6.28	2	2.1
	1433	4.0	6.0	545	19.1	6.35	2	2.0
	1437	4.3	6.5	536	19.0	6.38	2	2.1
	1441	4.7	7.0	550	19.3	6.36	2	2.3
	1445	5.0	7.5	519	19.3	6.43	2	2.0

TABLE 2-9 (Continued)

SUMMARY OF PHASE II GROUNDWATER SAMPLING WATER QUALITY PARAMETERS - SITE 89
OPERABLE UNIT NO. 16 (SITES 89 AND 93)
REMEDIAL INVESTIGATION, CTO-0356
MCB CAMP LEJEUNE, NORTH CAROLINA

Sample Identification Date Approximate Purge Rate	Time	Well Volume	Purge Volume (gals)	Water Quality Parameters				
				Specific Conductance at 25°C (μmhos/cm)	Temperature (°C)	pH (S.U.)	Turbidity (N.T.U.)	Dissolved Oxygen (mg/L)
IR89-MW05IW-01 05/28/97 0.21 gpm	1353	0.0	0.0	431	20.3	6.80	49	1.6
	1407	0.5	3.0	444	19.9	6.85	12	1.3
	1421	1.0	6.0	438	19.8	6.93	10	1.5
	1435	1.5	9.0	441	19.8	6.96	10	1.5
	1449	2.0	12.0	441	20.1	6.9	8	1.3
	1503	2.5	15.0	442	20.2	7.06	8	1.4
	1517	3.0	18.0	437	20.4	7.01	6	1.9
IR89-MW05DW-01 05/28/97 0.25 gpm	1337	0.0	0.0	912	20.5	6.96	23	4.4
	1357	0.3	5.0	826	19.7	7.21	8	1.7
	1417	0.7	10.0	822	20.0	7.15	3	1.6
	1437	1.0	15.0	820	19.9	7.28	3	1.4
	1457	1.3	20.0	824	20.0	7.28	3	1.8
	1517	1.7	25.0	814	20.0	7.40	2	1.4
	1537	2.0	30.0	830	20.2	7.53	3	1.6
	1557	3.0	35.0	828	19.8	7.24	3	2.2
IR89-MW06IW-01 05/19/97 0.23 gpm	1530	0.5	2.6	290	21	7.16	4.8	1.7
	1541	1.0	5.2	280	19	7.36	3.3	2.0
	1552	1.5	7.8	275	19	7.30	2.8	2.2
	1603	2.0	10.4	275	19	7.30	2.7	1.8
	1614	2.5	13.0	275	19	7.31	2.5	1.8
	1626	3.0	15.6	275	19	7.33	2.1	1.8
IR89-MW06DW-01 05/19/97 0.22 gpm	1533	0.5	5.5	600	20	7.27	1.65	1.7
	1559	1.0	11.0	590	19	7.31	1.19	1.7
	1625	1.5	16.5	600	19	7.33	0.99	1.8
	1653	2.0	22.0	590	19	7.35	1.21	1.8
	1717	2.5	27.5	600	19	7.38	0.80	1.8
	1740	3.0	33.0	600	19	7.35	0.80	1.8
IR89-MW07IW-02 05/20/97 0.20 gpm	0915	0.0	0.0	200	19	7.56	48	1.75
	0920	0.5	2.5	305	19	7.45	22.6	1.70
	0936	1.0	5.0	305	18.5	7.39	11.7	1.60
	0953	1.5	7.5	295	19	7.36	8.3	1.80
	1003	2.0	10.0	305	19	7.33	6.1	1.85
	1015	2.5	12.5	300	19	7.30	6.6	1.70
	1030	3.0	15.0	300	19	7.34	5.9	1.65

TABLE 2-9 (Continued)

SUMMARY OF PHASE II GROUNDWATER SAMPLING WATER QUALITY PARAMETERS - SITE 89
OPERABLE UNIT NO. 16 (SITES 89 AND 93)
REMEDIAL INVESTIGATION, CTO-0356
MCB CAMP LEJEUNE, NORTH CAROLINA

Sample Identification Date Approximate Purge Rate	Time	Well Volume	Purge Volume (gals)	Water Quality Parameters				
				Specific Conductance at 25°C (µmhos/cm)	Temperature (°C)	pH (S.U.)	Turbidity (N.T.U.)	Dissolved Oxygen (mg/L)
IR89-MW07DW-01 05/20/97 0.21 gpm	0855	0.0	0.0	500	19	7.56	18	1.8
	0915	0.5	5.5	500	19	7.58	108	1.5
	0935	1.0	11.0	505	19	7.42	17.1	1.5
	0957	1.5	10.0	505	19	7.41	10.5	2.0
	1020	2.0	15.5	500	19	7.33	7.3	1.5
	1041	2.5	21.0	500	20	7.30	7.0	1.5
	1100	3.0	26.5	500	20	7.38	6.7	1.6
IR89-MW08IW-01 05/19/97 0.21 gpm	1020	0.0	0.0	280	20.0	7.22	72	2.9
	1030	0.5	2.25	280	19.0	7.39	7	2.2
	1039	1.0	4.5	272	21.0	7.35	3.8	2.3
	1050	1.5	6.75	282	21.0	7.38	2.8	2.0
	1102	2.0	9.0	282	20.5	7.40	2.4	2.0
	1114	2.5	11.25	272	20.5	7.43	1.9	2.0
	1123	3.0	13.5	272	20.5	7.42	1.5	2.2
IR89-MW08DW-01 05/19/97 0.16 gpm	1008	0.0	0.0	800	20	6.79	7.4	--
	1050	0.5	6.5	780	20.5	7.23	2.2	3.4
	1133	1.0	13.0	750	20.5	7.21	2.5	3.5
	1215	1.5	19.5	725	22.5	7.23	3.1	3.75
	1250	2.0	26.0	700	22.5	7.22	2.7	2.5
	1326	2.5	32.5	700	21.5	7.26	2.6	2.75
	1405	3.0	39.0	700	22.0	7.23	2.6	2.25
IR36-GW05-02 05/18/97 0.23 gpm	1510	0.0	0.0	429	19.4	6.03	29.4	1.9
	1520	0.5	1.5	373	18.8	5.98	81.0	1.9
	1527	1.0	3.0	291	18.8	5.79	64.0	2.3
	1533	1.5	4.5	300	18.6	5.83	48.0	2.2
	1539	2.0	6.0	285	18.0	5.79	19.2	2.1
	1546	2.5	7.5	290	17.8	5.83	11.4	2.3
	1550	3.0	9.0	293	18.2	5.85	8.6	2.3
Temporary Monitoring Wells								
IR89-TW24IW-01 04/20/97 0.09 gpm	1012	1.0	2.0	91.7	17.6	5.35	52	6.0
	1040	2.0	4.0	76.5	17.6	5.35	1.5	6.0
	1055	3.0	6.0	72.6	18.0	5.33	0.65	6.2
IR89-TW25IW-01 04/20/97 0.04 gpm	1255	1.0	1.0	194	21.8	6.46	135	5.0
	1310	2.0	2.0	143	19.2	6.44	3.05	5.0
	1340	3.0	3.0	131	19.2	6.37	1.2	5.0

TABLE 2-9 (Continued)

SUMMARY OF PHASE II GROUNDWATER SAMPLING WATER QUALITY PARAMETERS - SITE 89
OPERABLE UNIT NO. 16 (SITES 89 AND 93)
MCB CAMP LEJEUNE, NORTH CAROLINA
REMEDIAL INVESTIGATION, CTO-0356

Sample Identification Date Approximate Purge Rate	Time	Well Volume	Purge Volume (gals)	Water Quality Parameters				
				Specific Conductance at 25°C (µmhos/cm)	Temperature (°C)	pH (S.U.)	Turbidity (N.T.U.)	Dissolved Oxygen (mg/L)
IR89-TW26IW-01 04/20/97 0.07 gpm	1425	1.0	2.0	425	19	7.06	32	1.2
	1505	2.0	4.0	174	20	7.20	122	2.0
	1522	3.0	6.0	332	19	7.28	2.1	2.0
	1532	4.0	7.0	327	19	7.33	1.1	1.8
IR89-TW27IW-01 04/20/97 0.05 gpm	1620	1.0	2.0	770	19.6	7.38	128	3.5
	1650	2.0	4.0	717	18.2	7.27	86	3.2
	1740	3.0	6.0	694	18.0	7.53	9.5	3.2
IR89-TW28IW-01 04/29/97 0.08 gpm	1635	1.0	1.5	190	17.2	6.71	72.6	2.5
	1655	2.0	3.0	165	16.9	6.45	7.8	2.0
	1711	3.0	4.5	192	16.8	6.59	5.5	2.5
IR89-TW29IW-01 04/29/97 0.03 gpm	1045	1.0	1.2	486	15.6	6.89	>200	4.5
	1115	2.0	2.4	416	15.7	7.00	19.8	4.5
	1153	3.0	3.6	370	15.5	7.00	13.8	5.2
	1200	3.2	3.8	364	15.5	7.02	7.38	4.0
	1208	3.4	4.0	361	15.8	6.89	4.82	4.5
IR89-TW30IW-01 04/29/97 0.08 gpm	1320	1.0	0.75	116	16.0	5.40	154	1.5
	1328	2.0	1.50	105	15.8	5.24	55	1.2
	1339	3.0	2.25	98	16.0	5.15	20	1.5

Notes:

gals - Gallons
°C - Degrees Centigrade
S.U. - Standard Units
µmhos/cm - Micromhos per centimeter
N.T.U. - Neophelometric Turbidity Units
NR - Not Recorded
mg/L - milligrams per liter
gpm - Gallons per minute

TABLE 2-10

SUMMARY OF PHASE II GROUNDWATER SAMPLING WATER QUALITY PARAMETERS - SITE 93
OPERABLE UNIT NO. 16 (SITES 89 AND 93)
REMEDIAL INVESTIGATION, CTO-0356
MCB CAMP LEJEUNE, NORTH CAROLINA

Sample Identification Date Approximate Purge Rate	Time	Well Volume	Purge Volume (gals)	Water Quality Parameters				
				Specific Conductance at 25°C (μmhos/cm)	Temperature (°C)	pH (S.U.)	Turbidity (N.T.U.)	Dissolved Oxygen (mg/L)
Permanent Monitoirng Wells (1)								
IR93-MW01-01 05/30/97 0.13 gpm	0751	0.0	0.0	227	18.5	5.17	3	2.9
	0755	0.5	0.5	277	19.2	5.11	8	3.8
	0759	1.0	1.0	278	19.3	5.09	3	2.4
	0803	1.5	1.5	239	19.1	5.11	2	3.5
	0807	2.0	2.0	217	19.1	5.09	2	2.3
	0811	2.5	2.5	215	19.0	5.09	1	3.0
	0815	3.0	3.0	209	18.9	5.12	1	3.2
IR93-MW01IW-01 05/30/97 0.18 gpm	0751	0.0	0.0	431	19.1	6.79	89	1.6
	0808	0.5	3.0	459	19.2	6.62	2	2.0
	0825	1.0	6.0	445	19.3	6.68	3	2.4
	0842	1.5	9.0	448	19.9	6.73	4	1.5
	0859	2.0	12.0	461	19.6	6.82	4	2.8
	0916	2.5	15.0	458	19.7	6.64	5	2.5
	0933	3.0	18.0	462	19.9	6.78	7	2.9
	0950	3.5	21.0	461	19.8	6.83	8	2.5
IR93-MW02-01 06/02/97 0.14 gpm	0847	0.0	0.0	451	19.4	6.88	22.0	1.4
	0856	0.5	1.0	451	19.2	6.93	6.2	1.6
	0902	1.0	2.0	456	19.2	6.92	5.1	1.4
	0909	1.5	3.0	448	19.3	6.93	3.2	1.4
	0916	2.0	4.0	448	19.3	6.89	2.6	1.5
	0922	2.5	5.0	446	19.4	6.95	2.6	1.1
	0931	3.0	6.0	445	19.5	6.90	2.2	1.4
IR93-MW02IW-01 06/02/97 0.26 gpm	0842	0.0	0.0	458	20.3	6.86	113	1.6
	0854	0.5	3.3	464	20.1	6.90	6.2	1.7
	0904	1.0	6.6	463	20.1	6.91	3.6	1.6
	0920	1.5	10.0	458	20.2	6.96	3.5	1.4
	0935	2.0	13.3	461	20.2	6.89	3.0	1.7
	0946	2.5	16.6	460	20.1	6.91	2.1	1.6
	0958	3.0	20.0	462	20.1	6.89	2.3	1.6

TABLE 2-10 (Continued)

SUMMARY OF PHASE II GROUNDWATER SAMPLING WATER QUALITY PARAMETERS - SITE 93
OPERABLE UNIT NO. 16 (SITES 89 AND 93)
REMEDIAL INVESTIGATION, CTO-0356
MCB CAMP LEJEUNE, NORTH CAROLINA

Sample Identification Date Approximate Purge Rate	Time	Well Volume	Purge Volume (gals)	Water Quality Parameters				
				Specific Conductance at 25°C (µmhos/cm)	Temperature (°C)	pH (S.U.)	Turbidity (N.T.U.)	Dissolved Oxygen (mg/L)
IR93-MW03-01 05/27/97 0.23 gpm	1355	0.0	0.0	118	20.8	5.40	12.0	1.5
	1359	0.5	1.0	113	20.1	5.33	95.0	1.4
	1405	1.0	2.0	110	20.4	5.41	47.0	1.5
	1408	1.5	3.0	112	20.3	5.38	15.6	1.4
	1413	2.0	4.0	110	20.6	5.33	9.0	1.6
	1416	2.5	5.0	108	20.5	5.37	4.3	1.7
	1421	3.0	6.0	108	20.7	5.36	4.0	1.7
IR93-MW03IW-01 05/20/97 0.30 gpm	1349	0.0	0.0	549	22.1	6.93	35.0	2.5
	1401	0.5	5.0	572	21.5	6.80	8.1	1.5
	1424	1.0	10.0	577	22.0	6.88	2.2	1.5
	1439	1.5	15.0	579	22.2	6.86	1.6	1.7
	1455	2.0	20.0	583	22.0	6.83	1.0	1.7
	1513	2.5	25.0	573	22.0	6.84	1.0	1.7
	1536	3.0	32.0	576	22.0	6.85	2.5	1.5
IR93-MW04-01 05/30/97 0.19 gpm	1106	0.0	0.0	193	21.3	5.37	19	2.3
	1110	0.5	0.75	189	21.1	5.25	14	1.7
	1114	1.0	1.5	186	21.0	5.25	17	2.1
	1118	1.5	2.25	186	21.0	5.25	9	2.1
	1122	2.0	3.0	188	21.1	5.21	5	2.1
	1126	2.5	3.75	184	21.3	5.31	5	2.2
	1130	3.0	4.5	185	21.0	5.29	4	2.0
	1134	3.5	5.25	186	20.9	5.28	4	1.9
	1138	4.0	6.0	186	21.0	5.30	4	2.4
	1142	4.5	6.75	187	21.3	5.32	5	2.0
IR93-MW04IW-01 05/30/97 0.15 gpm	1059	0.0	0.0	462	21.2	6.84	33	3.5
	1119	0.5	3.0	449	21.2	6.87	4	2.4
	1139	1.0	6.0	430	21.2	6.68	2	2.7
	1159	1.5	9.0	436	21.1	6.91	2	2.4
	1219	2.0	12.0	445	21.6	6.79	2	2.5
	1239	2.5	15.0	447	21.6	6.88	2	2.5
	1259	3.0	18.0	450	21.4	6.79	3	2.5
	1319	3.5	21.0	448	21.9	6.91	2	1.7

TABLE 2-10 (Continued)

SUMMARY OF PHASE II GROUNDWATER SAMPLING WATER QUALITY PARAMETERS - SITE 89
OPERABLE UNIT NO. 16 (SITES 89 AND 93)
MCB CAMP LEJEUNE, NORTH CAROLINA
REMEDIAL INVESTIGATION, CTO-0356

				Water Quality Parameters				
Sample Identification Date Approximate Purge Rate	Time	Well Volume	Purge Volume (gals)	Specific Conductance at 25°C (µmhos/cm)	Temperature (°C)	pH (S.U.)	Turbidity (N.T.U.)	Dissolved Oxygen (mg/L)
IR93-MW05-01 05/27/97 0.14 gpm	1602	0.0	0.0	138	20.6	5.09	3	3.0
	1609	0.5	1.0	147	19.2	5.12	2	2.3
	1616	1.0	2.0	180	18.6	5.14	8	2.6
	1623	1.5	3.0	190	18.6	5.33	3	1.8
	1630	2.0	4.0	187	18.4	5.27	2	2.6
	1637	2.5	5.0	192	18.3	5.37	1	1.0
	1644	3.0	6.0	193	18.3	5.34	1	2.1
IR93-MW05IW-01 05/27/97 0.27 gpm	1555	0.0	0.0	295	19.7	7.16	51	4.5
	1606	0.5	3.0	211	19.4	6.54	7	1.7
	1617	1.0	6.0	412	19.4	6.51	3	2.0
	1628	1.5	9.0	400	19.4	6.57	2	3.1
	1639	2.0	12.0	432	19.3	6.64	2	1.2
	1650	2.5	15.0	429	19.3	6.74	1	2.1
	1701	3.0	18.0	430	19.5	6.67	1	2.2
	1706	3.2	19.0	436	19.5	6.78	1	2.6

Notes:

gal - Gallons
°C - Degrees Centigrade
S.U. - Standard Units
µmhos/cm - Micromhos per centimeter
N.T.U. - Neophelometric Turbidity Units
NR - Not recorded
mg/L - Milligrams per liter
(1) - No temporary monitoring wells wereinstalled/sampled at Site 93 during the Phase II investigation.
gpm - Gallons per minute

TABLE 2-11

ON-SITE GROUNDWATER SAMPLING SUMMARY - SITE 89
OPERABLE UNIT NO. 16 (SITES 89 AND 93)
REMEDIAL INVESTIGATION, CTO-0356
MCB CAMP LEJEUNE, NORTH CAROLINA

Sample Identification	Analytical Parameters	
	On-Site Volatile Analysis (EPA 8240)	Fixed-Base CLP TCL Volatile Analysis
Phase I Samples		
IR89-MW01-01	X	
IR89-MW02-01	X	
IR89-MW03-01	X	
IR89-TW04-01	X	
IR89-TW04IW-01	X	X
IR89-TW08-01	X	
IR89-TW08IW-01	X	
IR89-TW09-01	X	X
IR89-TW09IW-01	X	X
IR89-TW10-01	X	
IR89-TW10IW-01	X	
IR89-TW11-01	X	
IR89-TW11IW-01	X	
IR89-TW12-01	X	
IR89-TW12IW-01	X	
IR89-TW13-01	X	
IR89-TW13IW-01	X	
IR89-TW15-01	X	
IR89-TW15IW-01	X	
IR89-TW16-01	X	
IR89-TW16IW-01	X	
IR89-TW17IW-01	X	X
IR89-TW18-01	X	
IR89-TW18IW-01	X	
IR89-TW19-01	X	
IR89-TW19IW-01	X	
IR89-TW20-01	X	
IR89-TW20IW-01	X	
IR89-TW21-01	X	
IR89-MW42B-02	X	

TABLE 2-11 (Continued)

ON-SITE GROUNDWATER SAMPLING SUMMARY - SITE 89
OPERABLE UNIT NO. 16 (SITES 89 AND 93)
REMEDIAL INVESTIGATION, CTO-0356
MCB CAMP LEJEUNE, NORTH CAROLINA

Sample Identification	Analytical Parameters	
	On-Site Volatile Analysis (EPA 8240)	Fixed-Base CLP TCL Volatile Analysis
Phase I Samples (Continued)		
IR89-TW21IW-01	X	
IR89-TW22-01	X	
IR89-TW22IW-01	X	
IR89-TW23IW-01	X	
TOTAL PHASE I	34	4
Phase II Samples		
IR89-TW24-01	X	
IR89-TW25-01	X	
IR89-TW26-01	X	
IR89-TW27-01	X	
IR89-TW28-01	X	
IR89-TW29-01	X	
IR89-TW30-01	X	
TOTAL PHASE II	7	0

Notes:

CLP - USEPA Contract Laboratory Program
TCL - Target Compound List
X - Sample analyzed for indicated parameter

TABLE 2-12

ON-SITE GROUNDWATER SAMPLING SUMMARY - SITE 93
OPERABLE UNIT NO. 16 (SITES 89 AND 93)
REMEDIAL INVESTIGATION, CTO-0356
MCB CAMP LEJEUNE, NORTH CAROLINA

Sample Identification	Analytical Parameters	
	On-Site Volatiles Analysis (EPA 8240)	Fixed-Base CLP TCL Volatile Analysis
Phase I Samples (1)		
IR93-MW05	X	
IR93-TW01	X	X
IR93-TW01IW	X	
IR93-TW02	X	
IR93-TW02IW	X	X
IR93-TW03	X	
IR93-TW03IW	X	
IR93-TW05	X	
IR93-TW05IW	X	
IR93-TW06	X	
IR93-TW06IW	X	
IR93-TW07	X	X
IR93-TW07IW	X	
IR93-TW14	X	
IR93-TW14IW	X	
TOTAL PHASE I	15	3

Notes:

(1)	-	No on-site analysis was performed on Site 93 samples during the Phase II investigation.
CLP	-	USEPA Contract Laboratory Program
TCL	-	Target Compound List
X	-	Sample analyzed for indicated parameter

TAB 2-13

PERMANENT MONITORING WELL GROUNDWATER SAMPLING SUMMARY - SITE 89
OPERABLE UNIT NO. 16 (SITES 89 AND 93)
REMEDIAL INVESTIGATION, CTO-0356
MCB CAMP LEJEUNE, NORTH CAROLINA

Sample Identification	Well Screen Interval (ft bgs)	TCL Volatiles	TCL Semi-volatiles	TCL Pesticides/ PCBs	TAL Metals	TSS/TDS	Duplicate Sample
Phase II Permanent Monitoring Groundwater Samples (1)							
IR89-MW03IW-01	36.5 - 41.5	X	X		X		
IR89-MW03DW-01	65.0 - 70.0	X	X		X	X	
IR89-MW04-01	4.0 - 14.0	X	X		X		X
IR89-MW04IW-01	32.7 - 37.5	X	X		X		
IR89-MW04DW-01	65.0 - 70.0	X	X		X		
IR89-MW05-01	4.0 - 14.0	X	X		X		
IR89-MW05IW-01	35.0 - 40.0	X	X	X	X		X
IR89-MW05DW-01	65.0 - 70.0	X	X		X		
IR89-MW06IW-01	32.0 - 37.0	X					
IR89-MW06IW-02	32.0 - 37.0	X	X		X		
IR89-MW06DW-01	65.0 - 70.0	X					
IR89-MW06DW-02	65.0 - 70.0	X	X		X		
IR89-MW07IW-01	35.0 - 40.0	X					
IR89-MW07DW-01	75.0 - 80.0	X					
IR89-MW07IW-02	35.0 - 40.0	X	X		X		
IR89-MW07DW-02	75.0 - 80.0	X	X		X		
IR89-MW08IW-01	32.0 - 37.0	X	X		X		
IR89-MW08DW-01	85.0 - 90.0	X	X		X		
IR36-MW05-02	10.0 - 25.0 (2)	X	X		X		
TOTAL PHASE II		19	15	1	15	1	2

Notes:

ft	-	Feet
bgs	-	Below ground surface
TCL	-	Target Compound List
PCB	-	Polychlorinated Biphenyl
TAL	-	Target Analyte List
MS/MSD	-	Matrix Spike/Matrix Spike Duplicate
X	-	Sample Analyzed for Indicated Parameter
(1)	-	No Permanent monitoring wells were installed or sampled during the Phase I investigation.
(2)	-	Screen interval estimated for IR36-MW05.
(3)	-	The contaminants of concern at OU No. 16 are VOCs; therefore, it was not necessary to perform a full organic analysis of all of the samples.

TABLE 2-14

PERMANENT MONITORING WELL GROUNDWATER SAMPLING SUMMARY - SITE 93
OPERABLE UNIT NO. 16 (SITES 89 AND 93)
REMEDIAL INVESTIGATION, CTO-0356
MCB CAMP LEJEUNE, NORTH CAROLINA

Sample Identification	Well Screen Interval (ft bgs)	TCL Volatiles	TCL Semi-volatiles	TCL Pesticides/ PCBs	TAL Metals	Natural (2) Attenuation Parameters	BOD/COD	Methane	Duplicate Sample	MS/MSD
Phase II Permanent Monitoring Well Groundwater Samples (1)										
IR93-MW01-01	4.0 - 12.0	X	X		X	X	X	X		
IR93-MW01IW-01	45.0 - 50.0	X	X		X	X	X	X		
IR93-MW02-01	4.0 - 14.0	X	X	X	X				X	
IR93-MW02IW-01	42.0 - 46.0	X	X		X					
IR93-MW02DW-01	66.0 - 71.0	X	X		X					
IR93-MW03-01	4.0 - 14.0	X	X		X	X		X		
IR93-MW03IW-01	45.0 - 50.0	X	X	X	X					
IR93-MW04-01	4.0 - 14.0	X	X		X	X	X	X	X	
IR93-MW04IW-01	44.0 - 49.0	X	X		X	X	X	X		
IR93-MW05-01	4.0 - 14.0	X	X		X					
IR93-MW05IW-01	35.0 - 40.0	X	X		X					X
TOTAL PHASE II		11	11	2	11	5	4	5	2	1

Notes:

ft - Feet
bgs - Below ground surface
TCL - Target Compound List
PCB - Polychlorinated Biphenyl
TAL - Target Analyte List
BOD - Biochemical Oxygen Demand
COD - Chemical Oxygen Demand
X - Sample Analyzed for Indicated Parameter
MS/MSD - Matrix Spike/Matrix Spike Duplicate
(1) - No permanent monitoring wells were installed or sampled during the Phase I investigation.
(2) - Natural Attenuation Parameters include nitrate, nitrite, sulfate, chloride, Fe^{+2} and sulfide.
(3) - The contaminants of concern at OU No. 16 are VOCs; therefore, it was not necessary to perform a full organic analysis of all of the samples.

TABLE 2-15

SURFACE WATER SAMPLING SUMMARY
OPERABLE UNIT NO. 16 (SITES 89 AND 93)
REMEDIAL INVESTIGATION, CTO-0356
MCB CAMP LEJEUNE, NORTH CAROLINA

Sample Identification	Analytical Parameters							
	TCL Volatiles	TCL Semivolatiles	TCL Pesticides/PCB	TAL Metals	On-Site Volatiles Analysis (EPA 8240)	Chloride	Duplicate	MS/MSD
Phase I Surface Water Samples								
IR89-EC-SW01-01	X	X		X	X			
IR89-EC-SW02-01	X	X		X	X			
IR89-EC-SW03-01	X	X		X	X			
IR89-EC-SW04-01	X	X		X	X			
IR89-EC-SW05-01	X	X	X	X	X		X	X
IR89-EC-SW06-01					X			
IR89-EC-SW07-01					X			
IR89-EC-SW08-01					X			
IR89-EC-SW09-01					X			
IR89-EC-SW10-01					X			
IR89-EC-SW11-01					X			
TOTAL PHASE I	5	5	1	5	11	0	1	1
Phase II Surface Water Samples								
IR89-EC-SW01-02						X		
IR89-EC-SW02-02						X		
IR89-EC-SW03-02						X		
IR89-EC-SW04-02						X		
IR89-EC-SW05-02						X		
TOTAL PHASE II	0	0	0	0	0	5	0	0

TABLE 2-15 (Continued)

SURFACE WATER SAMPLING SUMMARY
OPERABLE UNIT NO. 16 (SITES 89 AND 93)
PHASE II REMEDIAL INVESTIGATION, CTO-0356
MCB, CAMP LEJEUNE, NORTH CAROLINA

Notes:

TCL - Target Compound List
TAL - Target Analyte List
PCB - Polychlorinated biphenyl
MS/MSD - Matrix Spike/Matrix Spike Duplicate
X - Sample analyzed for indicated parameter

(1) - The contaminants of concern at OU No. 16 are VOCs; therefore, it was not necessary to perform a full organic analysis of all of the samples.

TABLE 2-16

SUMMARY OF
SURFACE WATER SAMPLING WATER QUALITY PARAMETERS - SITE 89
OPERABLE UNIT NO. 16 (SITES 89 AND 93)
REMEDIAL INVESTIGATION, CTO-0356
MCB CAMP LEJEUNE, NORTH CAROLINA

Sample Identification (Date)	Water Quality Parameters				
	Specific Conductance at 25°C (μmhos/cm)	Temperature (°C)	pH (S.U.)	Salinity (ppt)	Dissolved Oxygen (mg/L)
Phase I Water Quality Parameters (1)					
IR89-EC-SW01-01	440	28.1	6.70	0.2	3.3
IR89-EC-SW02-01	327	25.2	6.86	0.2	4.5
IR89-EC-SW03-01	243	25.4	6.78	0.2	5.2
IR89-EC-SW04-01	229	29.0	6.03	0.10	5.0
IR89-EC-SW05-01	291	26.8	7.13	0.10	4.2

Notes:

μmhos/cm - micromhos per centimeter
°C - Degrees Centigrade
S.U. - Standard Units
ppt - parts per thousand
mg/L - milligrams per liter
(1) - Water Quality Parameters were not recorded during the Phase II sampling.

TABLE 2-17

SEDIMENT SAMPLING SUMMARY - SITE 89
OPERABLE UNIT NO. 16 (SITES 89 AND 93)
REMEDIAL INVESTIGATION, CTO-0356
MCB CAMP LEJEUNE, NORTH CAROLINA

Sample Identification	Analytical Parameters						
	Depth (ft)	TCL Volatiles	TCL Semivolatiles	TCL Pesticides/PCBs	TAL Metals	Duplicate	MS/MSD
Phase I Sediment Samples [1]							
IR89-EC-SD01-06	0.0 - 0.5	X	X		X		
IR89-EC-SD01-612	0.5 - 1.0	X	X		X		
IR89-EC-SD02-06	0.0 - 0.5	X	X		X		
IR89-EC-SD02-612	0.5 - 1.0	X	X		X		
IR89-EC-SD03-06	0.0 - 0.5	X	X		X		
IR89-EC-SD03-612	0.5 - 1.0	X	X		X		
IR89-EC-SD04-06	0.0 - 0.5	X	X		X		
IR89-EC-SD04-612	0.5 - 1.0	X	X		X		
IR89-EC-SD05-06	0.0 - 0.5	X	X	X	X	X	X
IR89-EC-SD05-612	0.5 - 1.0	X	X	X	X	X	X
TOTAL SAMPLES		10	10	2	10	2	2

Notes:

ft - Feet
TCL - Target Compound List
PCB - Polychlorinated Biphenyls
TAL - Target Analyte List
MS/MSD - Matrix Spike/Matrix Spike Duplicate
X - Sample analyzed for indicated parameter
[1] - No Sediment samples were collected during the Phase II investigation.
[2] - The contaminants of concern at OU No. 16 are VOCs; therefore, it was not necessary to perform a full organic analysis of all of the samples.

TABLE 2-18

SUMMARY OF FIELD QUALITY ASSURANCE/QUALITY CONTROL SAMPLING PROGRAM - SITES 89 AND 93 MCB CAMP LEJEUNE, NORTH CAROLINA REMEDIAL INVESTIGATION, CTO-0356

Sample Identification	Sample Date	Analytical Parameters	Comments
Phase I QA/QC Samples			
TRIP BLANKS			
89-TB01	07/26/96	TCL volatiles	Shipped with Site 89 surface water and sediment samples
89-TB02	07/27/97	TCL volatiles	Shipped with Site 89 surface water and sediment samples
TB-03	08/06/96	TCL volatiles	Shipped with Site 89 and 93 groundwater samples
FIELD BLANKS			
IR89-WBLANK-01	08/04/96		
EQUIPMENT RINSATE BLANKS			
IR89-EC-RS01	07/27/96	TCL volatiles, TCL semivolatiles, TAL metals	Rinsate of sediment and sampling equipment
FIELD DUPLICATES			
IR89-EC-SW05-01D	07/26/96	TCL organics, TAL metals	Surface water duplicate sample
IR89-EC-SD05-06	07/26/96	TCL organics, TAL metals, TOC	Sediment duplicate sample
IR89-EC-SD05-61	07/26/96	TCL organics, TAL metals, TOC	Sediment duplicate sample
Phase II QA/QC Samples			
TRIP BLANKS			
TB02	04/21/97	TCL volatiles	Shipped with Site 89 soil samples
TB03	04/23/97	TCL volatiles	Shipped with Site 93 soil samples
TB05	05/02/97	TCL volatiles	Shipped with Site 89 soil samples
TB06	05/05/97	TCL volatiles	Shipped with Site 89 soil samples
TB09	05/13/97	TCL volatiles	Shipped with Site 89 soil samples
TB10	05/14/97	TCL volatiles	Shipped with Site 89 soil samples
TB14	05/20/97	TCL volatiles	Shipped with Site 93 groundwater samples
TB15	05/28/97	TCL volatiles	Shipped with Site 89 groundwater samples
TB16	05/30/97	TCL volatiles	Shipped with Site 93 groundwater samples
TB17	06/02/97	TCL volatiles	Shipped with Site 93 groundwater samples
FIELD BLANKS			
IR89/93-FB01	05/13/97	TCL organics, TAL metals	Sample of potable water source used during drilling
IR89/93-FB02	05/13/97	TCL organics, TAL metals	Sample of lab grade DI water
IR89/93-FB03	05/13/97	TCL organics, TAL metals	Sample of distilled water

TABLE 2-18 (Continued)

SUMMARY OF FIELD QUALITY ASSURANCE/QUALITY CONTROL
SAMPLING PROGRAM - SITES 89 AND 93
MCB CAMP LEJEUNE, NORTH CAROLINA
REMEDIAL INVESTIGATION, CTO-0356

Sample Identification	Sample Date	Analytical Parameters	Comments
EQUIPMENT RINSATE BLANKS			
IR89-RBSB01	04/18/97	TCL organics, TAL metals	Rinsate of soil sampling equipment
IR89-RBSB02	04/20/97	TCL organics, TAL metals	Rinsate of soil sampling equipment
IR89-RBSB03	04/20/97	TCL organics, TAL metals	Rinsate of soil sampling equipment
IR89-RBSB04	04/20/97	TCL organics, TAL metals	Rinsate of soil sampling equipment
IR89-RBSB08	04/30/97	TCL organics, TAL metals	Rinsate of soil sampling equipment
IR93-RBSB09	04/30/97	TCL organics, TAL metals	Rinsate of soil sampling equipment
IR89-RBSB10	05/04/97	TCL organics, TAL metals	Rinsate of soil sampling equipment
IR93-RBSB11	05/06/97	TCL organics, TAL metals	Rinsate of soil sampling equipment
IR89-RBSB14	05/13/97	TCL organics, TAL metals	Rinsate of soil sampling equipment
IR93-RBSB16	05/16/97	TCL organics, TAL metals	Rinsate of soil sampling equipment
IR89/93-RBGW20	05/29/97	TCL organics, TAL metals	Rinsate of groundwater sampling equipment
FIELD DUPLICATES			
IR89-MW03IW-02D	05/15/97	TCL organics, TAL metals	Subsurface soil duplicate sample
IR89-MW05-03D	04/20/97	TCL volatiles, TCL semivolatiles, TAL metals	Subsurface soil duplicate sample
IR89-MW06IW-01D	05/02/97	TCL volatiles, TCL semivolatiles, TAL metals	Subsurface soil duplicate sample
IR93-MW01IW-04D	04/30/97	TCL volatiles, TCL semivolatiles, TAL metals	Subsurface soil duplicate sample
IR93-MW03-02D	04/30/97	TCL volatiles, TCL semivolatiles, TAL metals	Subsurface soil duplicate sample
IR93-MW04-02D	05/06/97	TCL volatiles, TCL semivolatiles, TAL metals	Subsurface soil duplicate sample
IR93-MW05-02D	04/21/97	TCL organics, TAL metals	Subsurface soil duplicate sample
IR89-MW04-01D	05/29/07	TCL volatiles, TCL semivolatiles, TAL metals	Groundwater duplicate sample
IR89-MW05IW-01D	05/28/97	TCL organics, TAL metals	Groundwater duplicate sample
IR93-MW02-01D	06/02/97	TCL organics, TAL metals	Groundwater duplicate sample
IR93-MW04-01D	05/30/97	TCL organics, TAL metals, BOD, COD, methane, and natural attenuation parameters	Groundwater duplicate sample

Notes:

QA/QC - Quality Assurance/Quality Control
TCL - Target Compound List
TAL - Target Analyte List
TOC - Total Organic Carbon
BOD - Biological Oxygen Demand
COD - Chemical Oxygen Demand

SECTION 2.0 FIGURES

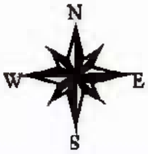
02020N 27Y

LEGEND

- 🚩 Staff Gauge
- ● Permanent Monitoring Well
- ☒ Surface Water Sample
- ⊠ Surface Water/Sediment Sample
- ◎ Temporary Monitoring Well
- — DRMO Fence Line
- → Edwards Creek with Flow Direction

Scale

400 0 400 800 Feet



MARINE CORPS BASE, CAMP LEJEUNE
NORTH CAROLINA

SAMPLE LOCATIONS
OPERABLE UNIT NO. 16 (SITE 89)
REMEDIAL INVESTIGATION
CTO 0356

Baker

FIGURE 2-1

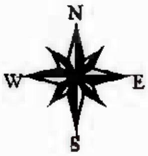
02020N28Y

LEGEND

- ⊕ Permanent Monitoring Well Location
- ⊙ Temporary Monitoring Well Location
- Swale
- Edwards Creek with Flow Direction
- Wooded Area

Scale

200 0 200 400 Feet



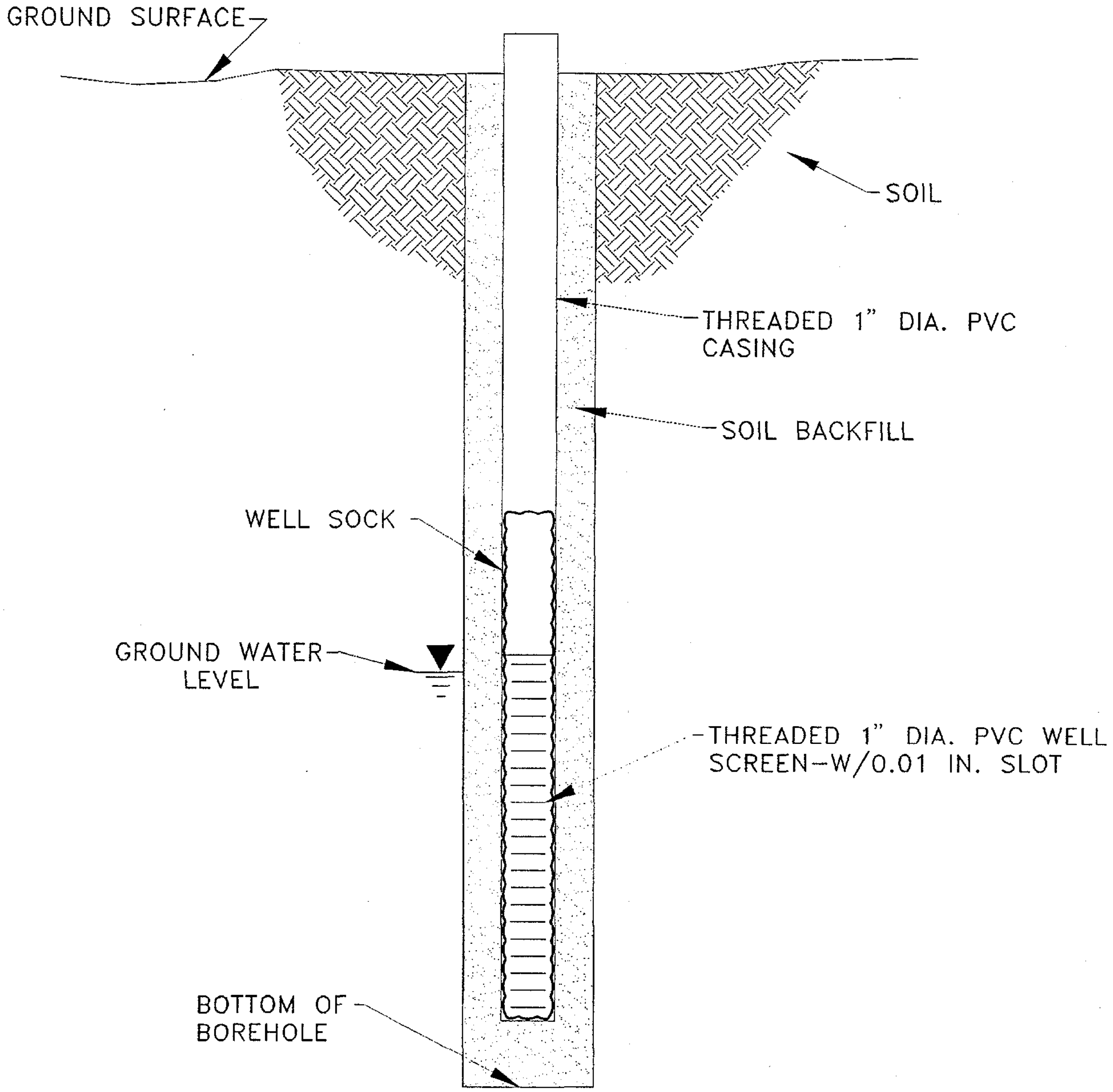
MARINE CORPS BASE, CAMP LEJEUNE
NORTH CAROLINA

SAMPLE LOCATIONS
OPERABLE UNIT NO. 16 (SITE 93)
REMEDIAL INVESTIGATION
CTO 0356

Baker

FIGURE 2-2

356602SI



N.T.S.

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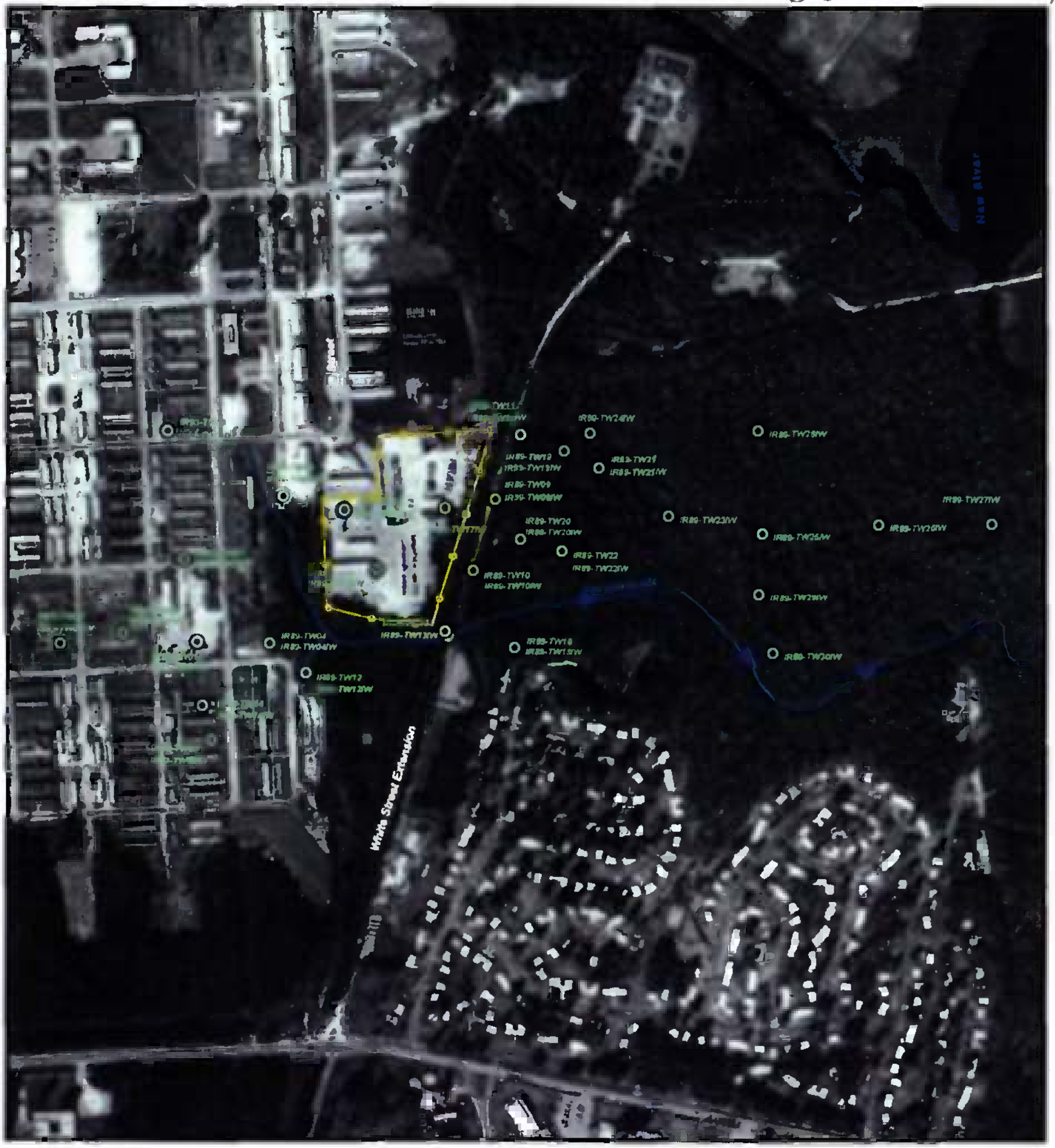
FIGURE 2–3
TYPICAL TEMPORARY MONITORING WELL CONSTRUCTION DIAGRAM
OPERABLE UNIT NO. 16 (SITES 89 AND 93)
REMEDIAL INVESTIGATION
CTO – 0356

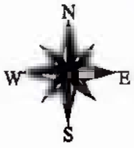
MARINE CORPS BASE, CAMP LEJEUNE
NORTH CAROLINA

02020N29Y



LEGEND

⁄\/	DRMO Fence Line
⁄\/	Edwards Creek with Flow Direction
TW04 ◉	Temporary Monitoring Well Location with Location ID



MARINE CORPS BASE, CAMP LEJEUNE NORTH CAROLINA

TEMPORARY MONITORING
WELL LOCATIONS
OPERABLE UNIT NO. 16 (SITES 89 & 93)
REMEDIAL INVESTIGATION
CTO 0356

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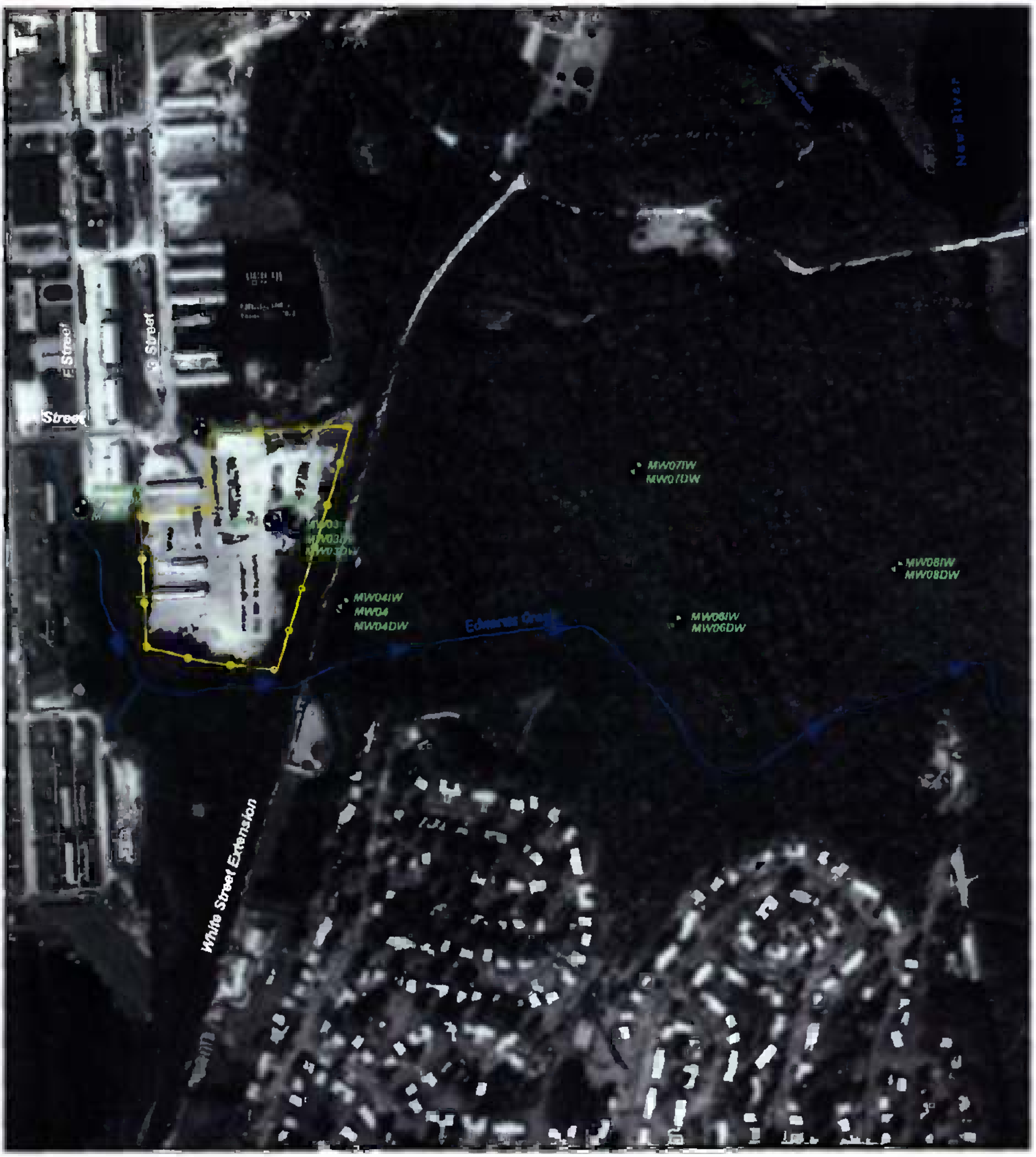
FIGURE 2 - 4

02020N 30Y



LEGEND

	DRMO Fence Line
	Edwards Creek with Flow Direction
MW04IW ●	Permanent Monitoring Well Location with Location ID

Scale

300 0 300 600 Feet

N
W E
S

MARINE CORPS BASE, CAMP LEJEUNE
NORTH CAROLINA

PERMANENT MONITORING
WELL LOCATIONS
OPERABLE UNIT NO. 16 (SITE 89)
REMEDIAL INVESTIGATION
CTO 0356

Baker

FIGURE 2 - 5

02020N31Y

LEGEND

MW04IW ●	Permanent Monitoring Well Location with Location ID
⁄\/	Swale
◀\/	Edwards Creek with Flow Direction
⌒⌒⌒	Wooded Area

Scale

200 0 200 400 Feet

MARINE CORPS BASE, CAMP LEJEUNE
NORTH CAROLINA

PERMANENT MONITORING
WELL LOCATIONS
OPERABLE UNIT NO. 16 (SITE 93)
REMEDIAL INVESTIGATION
CTO 0356

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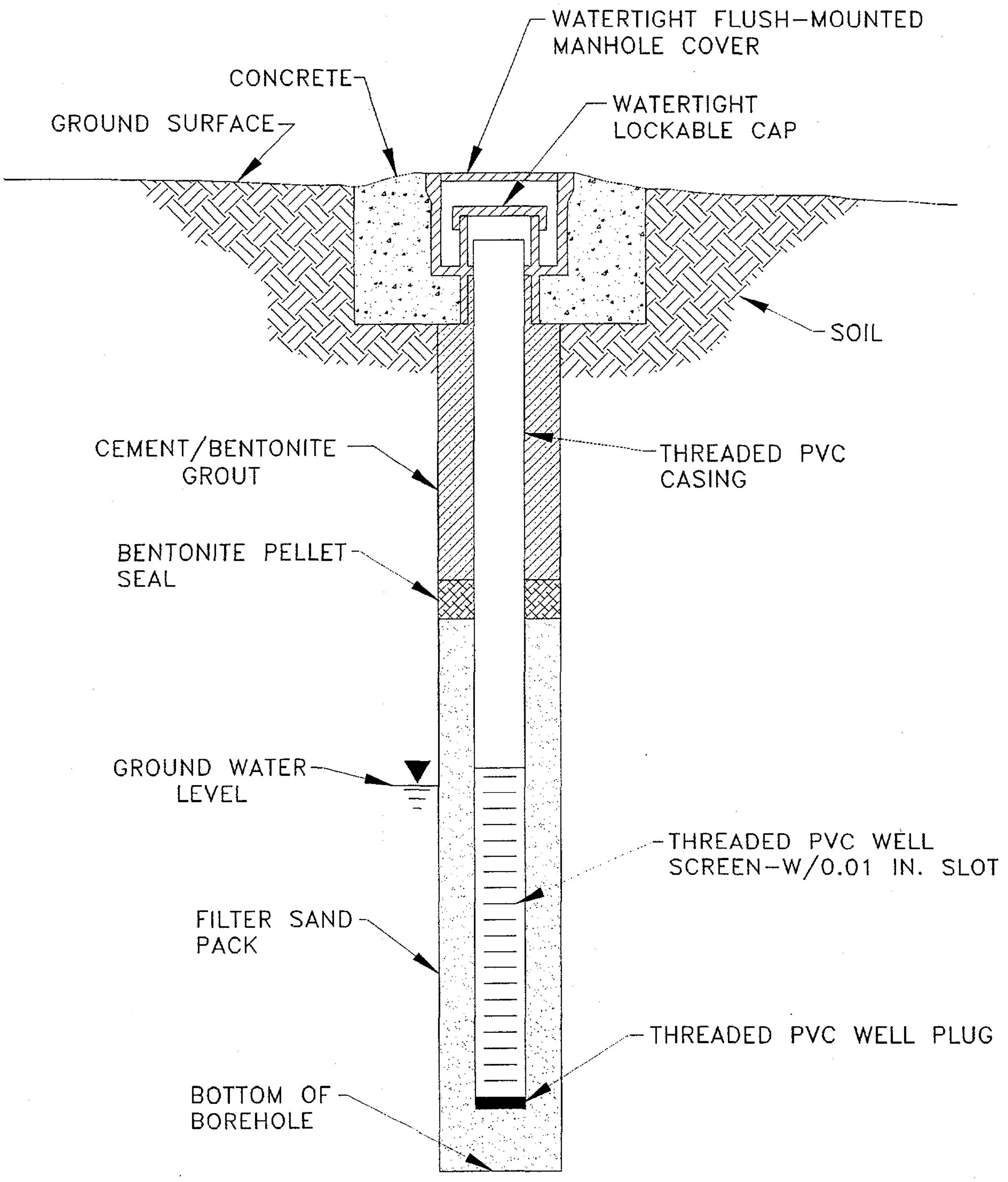
FIGURE 2-6



N.T.S.

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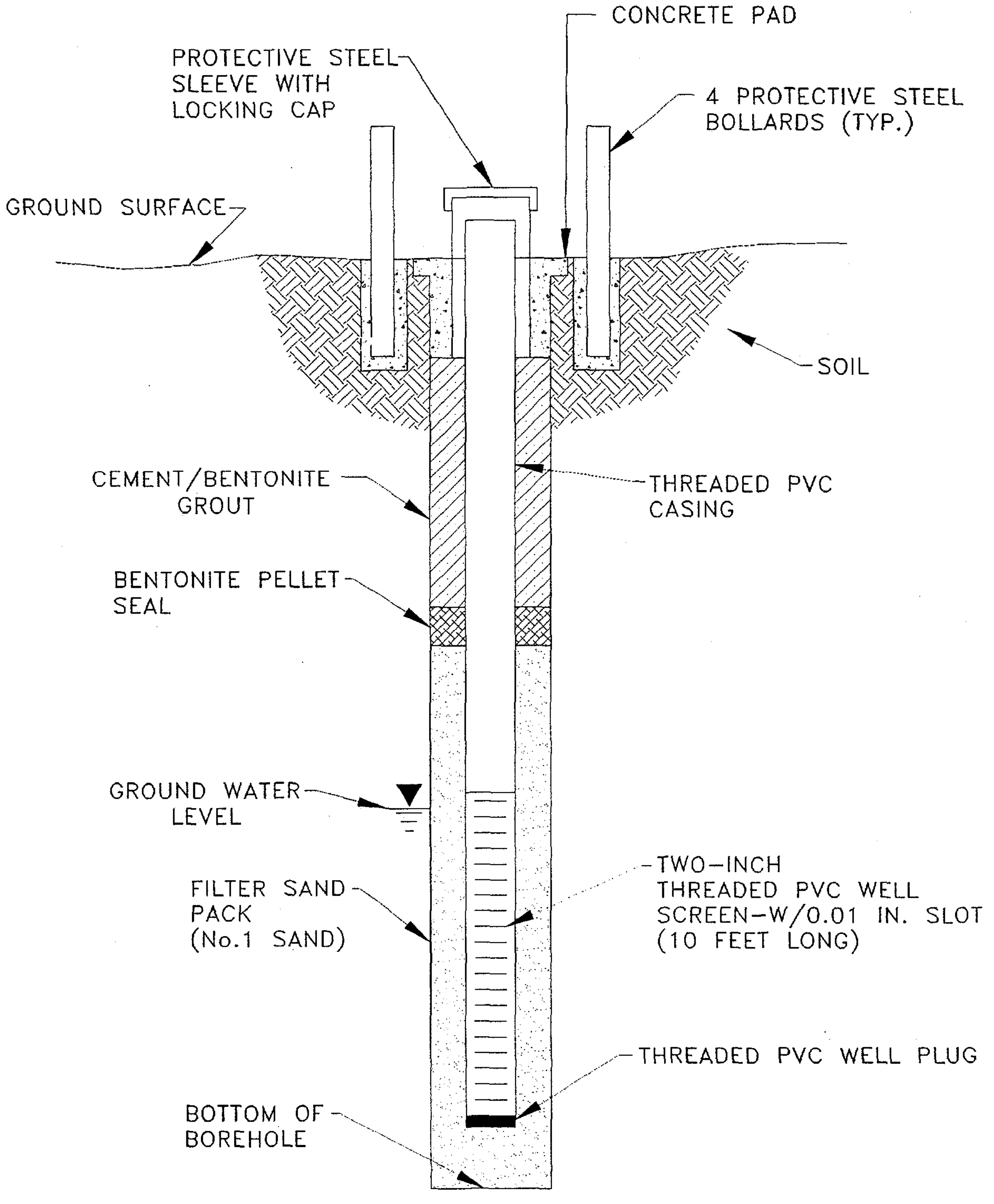
FIGURE 2-7
TYPICAL SHALLOW BELOW GRADE TYPE II GROUNDWATER
MONITORING WELL CONSTRUCTION DIAGRAM
OPERABLE UNIT NO. 16 (SITES 89 AND 93)
REMEDIAL INVESTIGATION CTO - 0356
MARINE CORPS BASE, CAMP LEJEUNE
NORTH CAROLINA



N.T.S.

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FIGURE 2-8
TYPICAL SHALLOW ABOVE GRADE TYPE II GROUNDWATER
MONITORING WELL CONSTRUCTION DIAGRAM
REMEDIAL INVESTIGATION CTO - 0356
OPERABLE UNIT NO. 16 (SITES 89 AND 93)
MARINE CORPS BASE, CAMP LEJEUNE
NORTH CAROLINA

3.0 REGIONAL AND SITE CHARACTERISTICS

This section describes the regional and site-specific environmental settings. A discussion of topography, surface hydrology and drainage, geology, hydrogeology, ecology, land use and demographics, climate/meteorology, and water supplies is presented for Marine Corps Base (MCB), Camp Lejeune and Operable Unit (OU) No. 16 (Sites 89 and 93). The tables and figures for Section 3.0 are presented at the end of the section.

3.1 Topography and Surface Features

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

Sites 89 and 93 are located within the Camp Geiger area of MCB, Camp Lejeune. Site 89 is located near the intersection of "G" and Eighth Streets within the Defense Reauthorization and Marketing Office (DRMO) while Site 93 is located near the intersection of "E" and Ninth Streets. Site 93 and the western portion of Site 89 are located within the developed portion of Camp Geiger. These areas are relatively flat and covered by buildings, streets, parking areas, and some grass. The eastern portion of Site 89 is wooded and slopes gently toward Edwards Creek. Ground surface elevations are approximately 5 to 20 feet above msl in the vicinity of OU 16. In general, the ground surface is higher in the northern and western portions of the site and gently slopes to the south and the east. Figure 3-1, provides an illustration of the area with topographic contour lines depicting the approximate elevation of the land surface. As shown on the figure, the area within the sites is relatively flat with topography in the central portion of the OU influenced by Edwards Creek.

3.2 Surface Hydrology

The following subsections present discussions of the regional and site-specific surface hydrology.

3.2.1 Regional

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

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

Water quality criteria for surface waters in North Carolina have been published under Title 15A of the North Carolina Administrative Code. At MCB, Camp Lejeune, the New River falls into two classifications: SC (aquatic life propagation and survival, fishing, wildlife, and secondary recreation) and SA (shell fishing for market purposes and any other usage specified by the "SB"and "SC"classification). The northern area of the New River near Montford Point at MCB, Camp Lejeune falls into the SA classification.

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

The U.S. Corps of Engineers has mapped the limits of the 100-year floodplain at Camp Lejeune at 7 feet above msl in the upper reaches of the New River.

3.2.2 Site-Specific

Surface water drainage features at the Sites 89 and 93 consist of a series of drainage swales and Edwards Creek which is located in the central and southern portions of OU No. 16. The majority of the drainage swales within Camp Geiger parallel the streets and capture storm water runoff from the sites. These swales direct surface runoff towards Edwards Creek and only flow during storm events. During heavy storm events, water ponds in some low lying areas at the sites. As shown on Figure 3-1, topography at the site directs the majority of surface drainage towards Edwards Creek. Edwards Creek is classified as SC (aquatic life propagation and survival, fishing, wildlife, and secondary recreation), HQW (high quality water), and NSW (nutrient sensitive water).

3.3 Geology

The following subsections present discussions of the regional and site-specific geology.

3.3.1 Regional

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

United States Geological Survey (USGS) studies (Harned, et al., 1989 and Cardinell, et al., 1993) conducted at MCB, Camp Lejeune indicate that the base is underlain by seven sand and limestone aquifers separated by confining/semiconfining units which are comprised primarily of silt and clay. These include the water table (i.e., surficial, water-bearing layer), Castle Hayne, Beaufort, Peedee, Black Creek, and the upper and lower Cape Fear aquifers. The combined thickness of these sediments is approximately 1500 feet. Less permeable clay and silt beds function as confining units or semiconfining units which separate the aquifers and impede the flow of groundwater between aquifers. For further information regarding the regional hydrogeologic conditions the reader is referred to the original USGS reports which are referenced above. These documents contain a series of hydrogeologic cross-sections illustrating the relationship between the aquifers and confining units in the vicinity of MCB, Camp Lejeune. The regional hydrogeology is discussed further in Section 3.4.1.

3.3.2 Site-Specific

The sections which follow describe the site specific geology based on the Phase I and Phase II Investigations. The site geology is also placed in context of the regional geology, as described in the "Hydrogeologic Framework of U.S. Marine Corps Base at Camp Lejeune, North Carolina", (Cardinell, et al., 1993). The geology at Sites 89 and 93 is described together because of the close proximity of the sites.

A fairly consistent depositional sequence was observed in the borings throughout Sites 89 and 93. This observed sequence is similar to the generalized North Carolina coastal plain sequence shown in Table 3-1. Table 3-1 shows that the Yorktown, Eastover, and Pungo River Formations lie between the Undifferentiated and Belgrade Formations. The Yorktown, Eastover, and Pungo River Formations, however, have not been identified at Camp Lejeune.

During this study, the Undifferentiated and River Bend Formations were encountered. The Belgrade Formation did not appear to be consistent at OU No. 16, however, a description of this unit has been included in this report. Based upon the regional geology and the soil borings completed at Sites 89 and 93, it appears that the shallow temporary wells installed during this investigation are screened in the Undifferentiated Formation (surficial aquifer) and the intermediate wells are screen in the upper portions of the River Bend Formation (Castle Hayne aquifer). The sections below provide a description of each of these units.

The Undifferentiated Formation is comprised of loose to medium dense sands and soft to medium stiff clay. This formation is comprised of several units of Holocene and Pleistocene ages and can consist of a fine to coarse sand, with lesser amounts of silt and clay. At Sites 89 and 93, this formation typically extends to a depth between 20 and 30 feet below ground surface (bgs). The silt and clay lenses present within this formation may be correlated to the regional geology as the Belgrade Formation, or Castle Hayne confining unit. This unit, however, did not appear consistent at Sites 89 and 93.

The Belgrade Formation is comprised of fine sand with some shell fragments, silt, and clay of the Miocene age. Identifying this formation at OU No. 16 was difficult due to its inconsistency. Overall, the Undifferentiated Formation (surficial aquifer) appears to lie immediately above the River Bend Formation (upper portion of the Castle Hayne aquifer), with little to no presence of the Belgrade Formation (Castle Hayne confining unit). The inconsistent nature of the Belgrade Formation suggests that a significant hydraulic connection exists between the Undifferentiated Formation (surficial aquifer) and the upper portions of the River Bend Formation (Castle Hayne aquifer). At best, the Belgrade Formation at OU No. 16 can be classified as a semi-confining unit or a "retarding layer", as it is laterally discontinuous and does not exhibit completely confining conditions on the River Bend Formation below (Castle Hayne aquifer).

Beneath the Undifferentiated Formation and the limited Belgrade Formation lies the River Bend Formation (upper potion of the Castle Hayne aquifer). This unit, which is predominantly composed of dense to very dense shell and fossil fragments interbedded with calcareous sands is present at OU No. 16 approximately 25 to 50 feet bgs.

Figure 3-2 provides the locations of four geologic cross-sections that have been prepared to illustrate the subsurface conditions at Sites 89 and 93. In general, cross-sections C-C' and D-D' traverse the sites from north to south and cross-sections A-A' and B-B' traverse east to west. The following paragraphs summarize the information displayed by each of the cross-sections.

Figure 3-3 displays the subsurface conditions at OU No. 16 along section A-A' which traverses the site from east to west. The cross-section begins at monitoring well location IR-93MW03 and extends west, to temporary monitoring well location IR89-TW27IW. The cross-section displays the subsurface conditions to approximately -70 feet msl, or 90 feet bgs.

The subsurface soil is comprised of several distinct layers. The near surface soils to approximately 15 to 25 feet below ground surface are comprised of mostly fine to medium sand with some silt and clay. This material is considered to be part of the surficial aquifer. The surficial aquifer can consist of varying amounts of sands, silts, and clays with trace shells. The shallow monitoring wells are screened in the surficial aquifer.

At approximately 20 feet bgs there appears to be a significant increase in the amount of shells present. The layer of shells is mixed with sands and silt with an occasional trace clay. At particular boring locations, the layer is also identified, or marked, by a partially cemented sand. The shell layer and occasional cemented sands at this depth appears consistent with other documents that describe the top of the Castle Hayne Aquifer. An estimate of the top of the Castle Hayne Aquifer has been indicated on the cross-section with a bold line. Beyond this depth, the shell content appears to decrease to a point approximately 40 to 45 feet bgs where a fine sand with some silt, clay and trace shells becomes apparent. In most borings this layer is identified by a significant decrease in moisture content and a color change to greenish, gray to olive color. In some areas of the site, this layer appears to act as a retarding layer, which can limit the amount of contaminant migration. The intermediate monitoring wells are screened above this layer.

As depth increases to approximately 50 feet bgs, the moisture content increases again as another layer becomes apparent which contains mostly fine to medium sand with trace to some shells, and trace to some silt. This layer appears as gray to greenish gray in color and continues to approximately 70 feet bgs. At this depth, another layer is encountered which exhibits a slight decrease in moisture content. The formation appears as a fine sand and silt with little to some clay and is olive to greenish gray in color. The screens of the deep monitoring wells are located on top of this layer.

Figure 3-4 displays the subsurface conditions along section B-B' which traverses the site from east to west. The cross-section begins at monitoring well location IR-93TW03 and extends west, to permanent monitoring well location IR89-MW08. The cross-section displays the subsurface conditions to approximately -70 feet msl, or 90 feet bgs.

The near surface soils are comprised mostly of fine sand with little to some silt, and trace clay and contain the surficial aquifer. As shown on the cross-section, this aquifer extends to approximately 15 to 25 feet bgs and consists of varying amounts of sands, silts, and clays with trace to little shells.

At approximately 20 to 25 feet bgs there is an increase in the amount of shells present. The layer of shells is interbedded with sand layers, trace to some silt, trace to little clay, and is gray to light greenish gray in color. Some boring locations, contain partially cemented sands at this depth which are indicative of the Castle Hayne Aquifer. At approximately 40 to 45 feet bgs there is a layer which demonstrates a significant decease in moisture content and a color change to olive greenish gray. This retarding layer is apparent on Figure 3-4, traversing the entire length of the cross-section. It ranges from about 4.5 feet in thickness to more than 10 feet near monitoring will location IR89-MW07 As mentioned above, where present, this layer appears to act as a retarding layer, limiting vertical contaminant migration. Below this layer, moisture content and shell content increases significantly to approximately 70 feet bgs. At approximately 70 to 80 feet bgs, the formation changes to a fine sand and silt with trace to little clay and is olive to greenish gray in color. Again, moisture content decreases from damp to moist with the presence of this material. The screens of the deep monitoring wells are located on top of this layer, ranging from approximately 70 to 80 feet bgs.

Figure 3-5 displays the subsurface conditions along the western portion of Site 93, parallel to E Street. Cross-section C-C' traverses the site from north to south beginning at temporary monitoring well location IR-93TW03 and extends south, to temporary monitoring well location IR93-TW05. The cross-section displays the subsurface conditions to approximately -40 feet msl, or 45 feet bgs. However, monitoring well IR93-MW02DW extends to approximately 70 feet bgs (-58.9 msl).

The subsurface soil conditions along this cross-section are comprised of several distinct layers. The surficial soils to approximately 15 to 20 feet bgs are comprised of mostly fine to medium sand with trace to little silt and trace to little clay. This material is considered to be the surficial aquifer consisting of varying amounts of sands, silts, and clays with trace shells. As shown on Figure 3-5, the shallow monitoring wells are screened in the surficial aquifer.

At approximately 20 feet bgs the top of the Castle Hayne Aquifer is encountered with an increase in shell content. The layer of shells is interbedded with limestone fragments, trace to some silt, and trace to little clay. This layer is gray to greenish gray in color and also contains a partially cemented sand. Again, the shell layer and occasional cemented sands at this depth appears consistent with other documents that define the Castle Hayne Aquifer. Below this depth, the shell content appears to decrease at approximately 40 to 45 feet bgs where a fine to medium sand with trace to little silt, shells becomes apparent.

Figure 3-6 displays the subsurface conditions at OU No. 16 along section D-D' which traverses the site in a general direction from northwest to southeast. The cross-section runs from temporary monitoring well location IR89-TW11 and extends to temporary monitoring well location IR89-TW30IW. The cross-section displays the subsurface conditions to approximately 40 feet bgs, although the soil boring for permanent monitoring well IR89-MW06DW extends to approximately 75 feet bgs, or -64.5 feet msl.

Cross-section D-D' shows the same general subsurface conditions as discussed above. An important point on this section, is the fact that the top of the Castle Hayne Aquifer is not at a consistent depth, but exhibits a slightly undulating characteristic. Again the surficial aquifer is generally comprised of varying amounts of sands, silts, and clays. However, the overall clay content in this area of the site appears to be somewhat higher.

The top of the Castle Hayne Aquifer is present at varying depths ranging from approximately 15 feet bgs at boring location IR89-TW30IW to nearly 33 feet at temporary monitoring well IR89-TW23IW. At this depth the formation contains mostly shells with trace silt and clay present. The presence of partially cemented sands are occasional and infrequent throughout this cross-section. Below approximately 40 feet, the shell content decreases and is replaced by a fine sand with some silt, clay and trace shells.

At approximately 60 feet bgs, material is a fine to medium sand with trace to some shells, and trace to some silt. This layer appears as gray to greenish gray in color and continues to approximately 70 feet bgs. Deep monitoring well IR89-MW06DW is screened at this depth.

In summary, the subsurface conditions at OU No. 16 (Sites 89 and 93) consist of several distinct layers. The near surface soils from zero to approximately 15 to 25 feet bgs are comprised of mostly fine to medium sand with some silt and clay, which is considered to be the surficial aquifer. The shallow monitoring wells are screened at this depth in the surficial aquifer.

At depths ranging from approximately 20 to 25 feet bgs there appears to be a significant increase in the amount of shells present underlying the site. The shell layer is mixed with sands and silt with an occasional trace clay. At some boring locations, this layer is also marked by a partially cemented sand. The shell layer and occasional cemented sands at this depth are consistent with documents that describe the top of the Castle Hayne Aquifer. The shell layer varies in thickness from several feet to more than 10 feet thick to a point approximately 40 to 45 feet bgs where a fine sand with some silt, clay and trace shells becomes apparent. In most borings this layer is usually identified by a decrease in moisture content and a marked color change from gray to greenish, gray to olive color. This layer of decreasing moisture content at approximately 40 to 45 feet bgs appears to act as a retarding layer. The intermediate monitoring wells are screened above this layer.

As depth increases to approximately 50 feet bgs, the moisture content increases again as another layer becomes apparent which contains mostly fine to medium sand with trace to some shells, and trace to some silt. This layer appears as gray to greenish gray in color and continues to approximately 70 feet bgs. At this depth, a second retarding layer is observed which exhibits a slight decrease in moisture content. The formation appears as a fine sand and silt with little to some clay and is olive to greenish gray in color. The screens of the deep monitoring wells are located on top of this layer.

3.4 Hydrogeology

The following subsections present discussions of the regional and site-specific surface hydrogeology.

3.4.1 Regional

The following summary of regional hydrogeology was originally presented in Harned, et al. (1989) and re-evaluated by Cardinell, et al. (1993).

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

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

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

Onslow County and MCB, Camp Lejeune lie in an area where the Castle Hayne Aquifer contains freshwater, although the presence of saltwater in deeper layers just below the aquifer and in the New River estuary is of concern in managing water withdrawals. Overpumping of the deeper parts of the aquifer could cause encroachment of saltwater. The aquifer contains water having less than 250 milligrams per liter (mg/L) chloride (State criteria for saltwater classification) in the vicinity of MCB, Camp Lejeune.

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

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

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

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

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

3.4.2 Site-Specific

As shown on Table 3-1, the surficial aquifer resides within the Undifferentiated Formation, the Castle Hayne confining unit resides within the Belgrade Formation, and the Castle Hayne aquifer resides within the River Bend Formation. The 1993 above-referenced USGS document reports the thickness of the surficial aquifer to be 18 to 23 feet and the thickness of the Castle Hayne confining layer as 4 to 7 feet in the vicinity of OU No. 16 (based on supply well boring logs). This places the elevation of the Castle Hayne confining unit from 0 to 8 feet above msl, although a definite confining layer which separates the surficial aquifer from the Castle Hayne aquifer is not present at

OU No. 16. General descriptions of the 1993 USGS document and site-specific geologic conditions place the top of the Castle Hayne aquifer at approximately -10 feet msl.

Groundwater levels within monitoring wells ranged from 2.15 feet below msl to 13.52 feet above msl. Groundwater level measurements for Sites 89 and 93 are presented on Tables 3-2 (Shallow Monitoring Wells and Staff Gauges), 3-3 (Intermediate Monitoring Wells) and 3-4 (Deep Monitoring Wells). Three groundwater elevation maps are included herein for the shallow monitoring wells (Figure 3-7), intermediate monitoring wells (Figure 3-8), and the deep monitoring wells (Figure 3-9). Groundwater elevations in the temporary monitoring wells were not included on these figures due to the fact that measurements were recorded on different days.

The groundwater elevation data suggest that the flow patterns observed for the surficial and upper portions of the Castle Hayne aquifers display similar trends. Overall, elevations are higher in the northern portion of the OU, with decreasing elevations in the direction of Edwards Creek and in the wooded area to the east. Groundwater flow in the surficial aquifer shows a pronounced localized flow to the south as Edwards Creek serves as a groundwater discharge boundary (Figure 3-7, shallow wells). Edwards Creek effects flow within the surficial aquifer and upper portions of the Castle Hayne aquifer more than in the deeper portion of the aquifer. Groundwater flow in the upper portions of the Castle Hayne (Figure 3-8, intermediate wells) is affected somewhat by the local discharge area of Edwards Creek, but there is also a trend eastward demonstrating the effects of the surface water bodies associated with the New River. The New River, located east of the OU, apparently influences the groundwater flow of the deeper portions of the Castle Hayne aquifer, causing groundwater at depth to move east, toward the river (Figure 3-9, deep wells).

Groundwater head differentials between the shallow and intermediate wells were evaluated to determine if a vertical component of flow underlies the OU. In general, elevations in shallow temporary wells are greater than the associated elevation in the intermediate temporary wells in those wells located north of Edwards Creek. This data demonstrate a downward component of groundwater movement from the surficial aquifer to the Castle Hayne aquifer north of Edwards Creek. This information supports the assumption that confining conditions of the Castle Hayne aquifer in this area are not likely. The geologic and hydrogeologic information collected thus far further suggest that there is a definite, and in some places a significant, hydraulic connection between the surficial aquifer and the underlying Castle Hayne aquifer. Accordingly, this system produces suitable conditions for the vertical migration of contaminants.

The surficial aquifer was characterized by performing in situ rising and falling head slug tests in select shallow and intermediate monitoring wells. The tests were performed between May 31, 1997 and June 2, 1997. An electronic data logger (In Situ Hermit Model SE2000) and pressure transducer assembly were used to record the recovery of groundwater in the monitoring wells. The Bouwer and Rice solution for slug tests in unconfined aquifers was used to evaluate all test data. The input parameters and plots generated from the slug tests are contained in Appendix G.

Tables 3-5 and 3-6 lists the hydraulic conductivity values (K values) obtained from the data analysis, at Sites 89 and 93, respectively. The average estimated K value from the shallow wells at Site 89 was 8.4 feet/day, which is within the typical range for silty sands (Freeze/Cherry, 1979). The average hydraulic conductivity in the intermediate well was 64.6 feet/day, one order of magnitude greater than the values measured in the shallow wells. This increase in average K values corresponds to the geologic framework. The shell layer present at the depth of the intermediate wells is expected to provide a more conductive media for the movement of groundwater. The estimated K values at Site 93 in the shallow and intermediate wells show similar results.

The hydraulic gradient at Site 89 was estimated from groundwater measurements in intermediate wells IR89-MW03IW and IR89-MW04IW on May 29, 1997 to be 0.005 ft/ft. Published effective porosity values indicate a range of 25 to 50 percent for sands and silts (Freeze/Cherry, 1979). Using the average K value from the intermediate wells, the estimated average linear groundwater velocity was calculated by using the following formula:

$V=Ki/n$

Where: V = groundwater velocity
K = hydraulic conductivity
I = hydraulic gradient
n = effective porosity

Using these variables, the groundwater velocity (V) in a northwest to southeast direction is estimated to be 0.64 to 1.29 ft/day (233 to 470 ft/year). This is a conservative estimate because of the nature of the silty sand and the variability in the estimated K values from the slug tests. An approximate transmissivity value (T) can be obtained from multiplying the hydraulic conductivity (K) by the saturated thickness (b) of the aquifer. Using a saturated thickness of approximately 45 feet, which corresponds to the depth of the first semi-confining layer at Sites 89 and 93, and an average K value taken from the intermediate wells, the approximate T value for the aquifer in this direction is 2,907 ft^2/day.

3.5 Ecological Features

The following subsections present discussions of the regional and site-specific surface hydrology.

3.5.1 Regional

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

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

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

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

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

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

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

3.5.2 Site-Specific

Four habitat types are present at Sites 89 and 93. These four include an open area, deciduous forest, pine forest, and ecotones between the open areas and the forests. Much of the area within the Camp Geiger portion of the OU has no vegetation at all growing on it. Scattered pines were identified within the deciduous forest. Numerous birds and mammals were identified in the area. No protected species were observed at Sites 89 or 93. The Sites are not within or in close proximity (i.e., one-half mile) to either a natural area or protected area. Protected areas have only been established for the red-cockaded woodpecker.

3.6 Land Use Demographics

The following subsections present discussions of the regional and site-specific surface hydrology.

3.6.1 Base-Wide

MCB, Camp Lejeune presently covers approximately 236 square miles. Present military population of MCB, Camp Lejeune is approximately 40,928 active duty personnel. The military dependent community is in excess of 32,081. About 36,086 of these personnel and dependents reside in Base housing units. The remaining personnel and dependents live off base and have dramatic effects on the surrounding area. An additional 4,412 civilian employees perform facilities management and support functions. The population of Onslow County has grown from 17,739 in 1940, prior to the formation of the base, to its present population of 121,350 (Master Plan, Camp Lejeune Complex, North Carolina, 1988). During World War II, MCB, Camp Lejeune was used as a training area to prepare Marines for combat. This has been a continuing function of the facility during the Korean and Vietnam conflicts, and the recent Gulf War (i.e., Desert Storm). Toward the end of World War II, the camp was designated as a home base for the Second Marine Division. Since that time, Fleet Marine Force (FMF) units also have been stationed here as tenant commands. The existing land use pattern for the various developed geographic areas within the MCB are listed, per geographic area, on Table 3-7. In addition, the number of acres comprising each land use category has been estimated and provided on the table.

3.6.2 Site-Specific

Operable Unit No. 16 is located within the Camp Geiger area which comprises a total of 216 acres. The majority of this area is taken up by troop housing, supply, storage and administrative buildings. Other land utilization areas consist of operations, training, maintenance and utility. Classroom training facilities and instruction areas are scattered throughout the Camp Geiger area, making up approximately 7 percent (i.e., 15 acres of the developed area).

Site 93 is located in the developed portion of Camp Geiger while Site 89 consists of the Defense Reauthorization and Marketing Office (DRMO) area and portions of the wooded area east of White Street Extension.

3.7 Climate and Meteorology

MCB, Camp Lejeune experiences mild winters, and hot and humid summers. The average yearly rainfall is greater than 50 inches, and the potential evapotranspiration in the region varies from 34 to 36 inches of rainfall equivalent per year. The winter and summer seasons usually receive the most precipitation. Temperature ranges are reported to be 33 to 53 degrees Fahrenheit (°F) in the winter (i.e., January) and 71 to 88 °F in the summer (i.e., July). Winds are generally south-southwesterly in the summer, and north-northwesterly in the winter (Water and Air Research, 1983). Table 3-8 presents a summary of climatic data readings from the Marine Corps Air Station (MCAS) at New River. These measurements were collected between January 1955 and December 1990.

3.8 Water Supply

MCB, Camp Lejeune water is supplied entirely from groundwater. Groundwater is obtained from approximately 90 water supply wells, and treated. There are eight water treatment plants with a total capacity of 15.821 million gallons per day (mgd). Groundwater usage is estimated at over 7 mgd (Harned, et al., 1989).

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

Water supply wells within a one-mile radius of the sites were identified by reviewing base information. A total of 13 supply wells were identified to be within a one-mile radius of Sites 89 and 93. The location of the wells relative to the sites are shown on Figure 3-10 . Table 3-9 provides detailed information concerning each of these wells including total depth, well screen interval, and whether the well is active or inactive. The supply wells near OU No. 16 range in depths from 70 feet bgs to 250 feet bgs. One of the supply wells, PSWTC-1256 falls just beyond the boundary of the 1-mile radius shown on Figure 3-10. This well is included on the figure and on Table 3-9 as additional information.

3.9 References

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SECTION 3.0 TABLES

TABLE 3-1

GEOLOGIC AND HYDROGEOLOGIC UNITS OF NORTH CAROLINA'S COASTAL PLAIN
OPERABLE UNIT 16 (SITES 89 AND 93)
REMEDIAL INVESTIGATION STUDY, CTO-0356
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) Eastover Formation(1)	Yorktown confining unit
	Miocene		Yorktown Aquifer
		Pungo River Formation(1)	Pungo River confining unit
			Pungo River Aquifer
		Belgrade Formation(2)	Castle Hayne confining unit
	Oligocene	River Bend Formation	Castle Hayne Aquifer
	Eocene	Castle Hayne Formation	Beaufort confining unit(3)
	Paleocene	Beaufort Formation	Beaufort Aquifer
Cretaceous	Upper Cretaceous	Peedee Formation	Peedee confining unit
			Peedee Aquifer
		Black Creek and Middendorf Formations	Black Creek confining unit
			Black Creek Aquifer
		Cape Fear Formation	Upper Cape Fear confining unit
			Upper Cape Fear Aquifer
			Lower Cape Fear confining unit
			Lower Cape Fear Aquifer
	Lower Cretaceous(1)	Unnamed deposits(1)	Lower Cretaceous confining unit
			Lower Cretaceous Aquifer(1)
Pre-Cretaceous basement rocks		--	--

Notes:

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

Source: Harned et al., 1989.

TABLE 3-2

WATER LEVEL MEASUREMENTS, SHALLOW MONITORING WELLS AND STAFF GAUGES
OPERABLE UNIT NO. 16 (SITES 89 AND 93)
PHASE II REMEDIAL INVESTIGATION, CTO-0356
MCB CAMP LEJEUNE, NORTH CAROLINA

Well/Staff Gauge I.D.	Reference Point Elevation [1] (ft above msl)	Water Level Measurements			
		May 29, 1997		June 3, 1997	
		Water Level Reading (ft)	Water Elevation[2] (ft above msl)	Water Level Reading (ft)	Water Elevation[2] (ft above msl)
Site 89 Shallow Monitoring Wells					
IR89-MW03	15.38	6.62	8.76	6.48	8.90
IR89-MW04	11.10	4.35	6.75	4.17	6.93
IR89-MW05	12.37	4.48	7.89	4.32	8.05
Site 93 Shallow Monitoring Wells					
IR93-MW01	14.98	5.24	9.74	4.80	10.18
IR93-MW02	12.76	2.77	9.99	2.70	10.06
IR93-MW03	17.05	3.53	13.52	3.53	13.52
IR93-MW04	15.42	5.15	10.27	5.00	10.42
IR93-MW05	13.64	5.10	8.54	4.85	8.79
IR36-GW05	16.50	4.48	12.02	NR	NR
Staff Gauges					
IR89/93-SG01	6.77	2.18	5.61	NR	NR
IR89/93-SG02	4.02	0.98	1.66	NR	NR
IR89/93-SG03	2.27	2.96	1.89	NR	NR

Notes:

(1) For monitoring wells, the reference point is the top of casing. For staff gauges, the reference point is the top of staff gauge.

(2) For monitoring wells, the water elevation is determined by subtracting the depth to water from the top of casing elevation. For staff gauges, the water elevation is determined by subtracting 3.34 feet from the reference point elevation and adding the water level reading.

NR - Not Recorded
ft - Feet
msl - Mean Sea Level

TABLE 3-3

WATER LEVEL MEASUREMENTS - INTERMEDIATE MONITORING WELLS
OPERABLE UNIT NO. 16 (SITES 89 AND 93)
PHASE II REMEDIAL INVESTIGATION, CTO-0356
MCB CAMP LEJEUNE, NORTH CAROLINA

Well Identification	Reference Point Elevation [1] (ft above msl)	Water Level Measurements			
		May 29, 1997		June 3, 1997	
		Water Level Reading (ft)	Water Elevation[2] (ft above msl)	Water Level Reading (ft)	Water Elevation[2] (ft above msl)
Site 89 Intermediate Monitoring Wells					
IR89-MW03IW	13.48	4.76	8.72	4.64	8.84
IR89-MW04IW	11.16	4.22	6.94	4.08	7.08
IR89-MW05IW	12.41	3.53	8.88	3.42	8.99
IR89-MW06IW	11.71	7.86	3.85	7.69	4.02
IR89-MW07IW	19.30	13.63	5.67	13.64	5.66
IR89-MW08IW	13.26	12.32	0.94	12.14	1.12
IR89-TW23IW	15.39	9.48	5.91	9.39	6.00
IR89-TW24IW	15.71	9.64	6.07	9.66	6.05
IR89-TW25IW	19.25	13.75	5.50	13.78	5.47
IR89-TW26IW	15.42	16.67	-1.25	16.64	-1.22
IR89-TW27IW	6.54	8.69	-2.15	8.46	-1.92
IR89-TW28IW	15.42	14.40	1.02	NR	NR
IR89-TW29IW	6.28	4.65	1.63	4.20	2.08
IR89-TW30IW	5.77	3.58	2.19	3.06	2.71
Site 93 Intermediate Monitoring Wells					
IR93-MW01IW	15.18	5.50	9.68	5.33	9.85
IR93-MW02IW	12.71	2.31	10.40	2.17	10.54
IR93-MW03IW	17.18	4.86	12.32	4.80	12.38
IR93-MW04IW	15.41	5.18	10.23	5.40	10.01
IR93-MW05IW	13.29	4.02	9.27	3.86	9.43
IR35-MW42B	15.12	6.15	8.97	6.08	9.04

Notes:

(1) For monitoring wells, the reference point is the top of casing. For staff gauges, the reference point is the top of staff gauge.

(2) For monitoring wells, the water elevation is determined by subtracting the depth to water from the top of casing elevation. For staff gauges, the water elevation is determined by subtracting 3.34 feet from the reference point elevation and adding the water level reading.

NR - Not Recorded
ft - Feet
msl - Mean Sea Level

TABLE 3-4

WATER LEVEL MEASUREMENTS, DEEP MONITORING WELLS
OPERABLE UNIT NO. 16 (SITES 89 AND 93)
PHASE II REMEDIAL INVESTIGATION, CTO-0356
MCB CAMP LEJEUNE, NORTH CAROLINA

Well Identification	Reference Point Elevation [1] (ft above msl)	Water Level Measurements			
		May 29, 1997		June 3, 1997	
		Water Level Reading (ft)	Water Elevation[2] (ft above msl)	Water Level Reading (ft)	Water Elevation [2] (ft above msl)
Site 89 Deep Monitoring Wells					
IR89-MW03DW	13.47	5.02	8.45	4.90	8.57
IR89-MW04DW	10.91	3.96	6.95	3.82	7.09
IR89-MW05DW	12.86	3.02	9.84	2.90	9.96
IR89-MW06DW	11.44	7.39	4.05	7.24	4.20
IR89-MW07DW	18.99	14.14	4.85	14.05	4.94
IR89-MW08DW	13.38	11.70	1.68	11.52	1.86
Site 93 Deep Monitoring Wells					
IR93-MW02DW	12.84	2.53	10.31	2.40	10.44

Notes:

(1) For monitoring wells, the reference point is the top of casing. For staff gauges, the reference point is the top of staff gauge.

(2) For monitoring wells, the water elevation is determined by subtracting the depth to water from the top of casing elevation. For staff gauges, the water elevation is determined by subtracting 3.34 feet from the reference point elevation and adding the water level reading.

NR - Not Recorded
ft - Feet
msl - Mean Sea Level

TABLE 3-5

SUMMARY OF HYDRAULIC CONDUCTIVITY ESTIMATES
OPERABLE UNIT NO. 16 (SITE 89)
PHASE II REMEDIAL INVESTIGATION, CTO-0356
MCB, CAMP LEJEUNE, NORTH CAROLINA

Well Identification	Hydraulic Conductivity (ft/day)		Average
	Falling Head	Rising Head	
89-MW03	--	8.5	--
89-MW04	--	5.8	--
89-MW05	--	10.8	--
Max	--	10.8	--
Min	--	5.8	--
Avg	--	8.4	--
89-MW03IW	152.4	128.4	140.4
89-MW04IW	125.5	78.1	101.8
89-MW05IW	134.5	154.0	144.3
89-MW06IW	256.6	438.6	347.6
89-MW07IW	151.2	157.2	154.2
89-MW08IW	104.2	64.6	84.4
Max	256.6	438.6	347.6
Min	104.2	64.6	84.4
Avg	154.1	170.2	162.1

Notes:

ft/day - Feet per Day
-- - Test Not Performed

TABLE 3-6

SUMMARY OF HYDRAULIC CONDUCTIVITY ESTIMATES
OPERABLE UNIT NO. 16 (SITE 93)
PHASE II REMEDIAL INVESTIGATION, CTO-0356
MCB, CAMP LEJEUNE, NORTH CAROLINA

Well Identification	Hydraulic Conductivity (ft/day)		Average
	Falling Head	Rising Head	
93-MW01	--	59.9	--
93-MW02	--	12.5	--
93-MW03	--	22.8	--
93-MW04	--	12.5	--
Max	--	59.9	--
Min	--	12.5	--
Avg	--	26.9	--
93-MW01IW	247.8	220.5	234.2
93-MW02IW	197.0	139.2	168.1
93-MW03IW	42.5	1.1	21.8
93-MW04IW	199.0	218.1	208.6
Max	247.8	220.5	234.2
Min	42.5	1.1	21.8
Avg	171.6	144.7	158.2

Notes:

ft/day - Feet per Day
-- - Test Not Performed

TABLE 3-7

LAND UTILIZATION: DEVELOPED AREAS ACRES/LAND USE (PERCENT)
REMEDIAL INVESTIGATION, CTO-0356
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)**

Source: DON, 1988

TABLE 3-8

CLIMATIC DATA SUMMARY FOR MCAS NEW RIVER
REMEDIAL INVESTIGATION, CTO-0356
MCB CAMP LEJEUNE, NORTH CAROLINA

	Temperature (Celsius)			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	4.2	76	54	34	44	11	2	0	1	14
February	7.0	1.5	3.8	74	57	36	46	9	3	0	1	11
March	8.0	0.8	3.5	78	64	42	53	10	2	0	5	7
April	6.5	0.5	3.0	79	73	51	62	8	2	--	14	--
May	8.4	1.7	4.3	86	80	60	70	10	3	2	25	0
June	11.8	2.4	5.8	85	85	67	76	11	4	6	19	0
July	14.3	4.5	8.0	85	88	72	80	14	5	12	31	0
August	12.6	1.7	6.1	87	87	71	80	12	4	11	31	0
September	12.2	1.4	4.7	87	83	66	75	9	3	3	27	0
October	6.5	0.7	2.8	82	74	54	64	7	2	--	16	--
November	5.7	0.6	2.6	80	66	44	55	7	1	0	6	4
December	6.1	0.4	4.0	77	58	37	48	9	2	0	2	11
Annual	14.3	0.4	52.8	81	72	53	63	117	33	34	188	47

-- Less than 0.5 days

Source: Naval Oceanography Command Detachment, Asheville, North Carolina. Measurements obtained from January 1955 to December 1982.

TABLE 3-9

WATER SUPPLY WELL INFORMATION
OPERABLE UNIT 16 (SITES 89 AND 93)
REMEDIAL INVESTIGATION, CTO-0356
MCB, CAMP LEJEUNE, NORTH CAROLINA

Well Number	Well Diameter (inches)	Casing Material	Date Installed (year)	Status (on/off/closed)	Date Closed	Depth (bgs)	Screen Top Depth	Screen Bottom Depth	Pump Depth	Airline Depth	Approx. Direction and Distance
PSWAS-106	--	--	1946 (Est)	On	NA	179	--	--	50	50	S 2,300 ft
PSWAS-131	--	--	--	On	NA	200	--	--	50	50	SE 3,960 ft
PSWAS-203	--	--	--	On	NA	173	--	--	77	60	SE 3,168 ft
PSWAS-190	--	--	--	On	NA	180	--	--	60	123	SW 5,000 ft
PSWAS-191	--	--	--	On	NA	180	--	--	60	117	SSW 4,752 ft
PSWAS-4140	--	--	--	On	NA	193	--	--	--	110	S 5,170ft
PSWTC-502	10	Steel	1941	On	NA	184	110	184	50	50	NNW 3,500 ft
PSWTC-600	8	Steel	1941	On		70	48	70	50	50	NNW 3,250 ft
PSWTC-700	18	Steel	1941	On	NA	76	27.5	76	50	50	NNW 2,920 ft
PSWTC-1251	--	Steel	1975	On	NA	155	95	140	70	80	
							160	170(1)			
PSWTC-1253	--	Steel	1975	On	NA	250	120	140	82	81	WSW 3,100 ft
							160	170			
PSWTC-1254	--	Steel	1975	Off	--	195	118	122	70	77	SE 4,500 ft
PSWTC-1255	--	Steel	1975	Off	--	250	124	132	70	100	SE 5,200 ft
PSWTC-1256	--	Steel	--	On	NA	204	124	134	70	80	WSW 6,200 ft
							154	164			
							182	192			

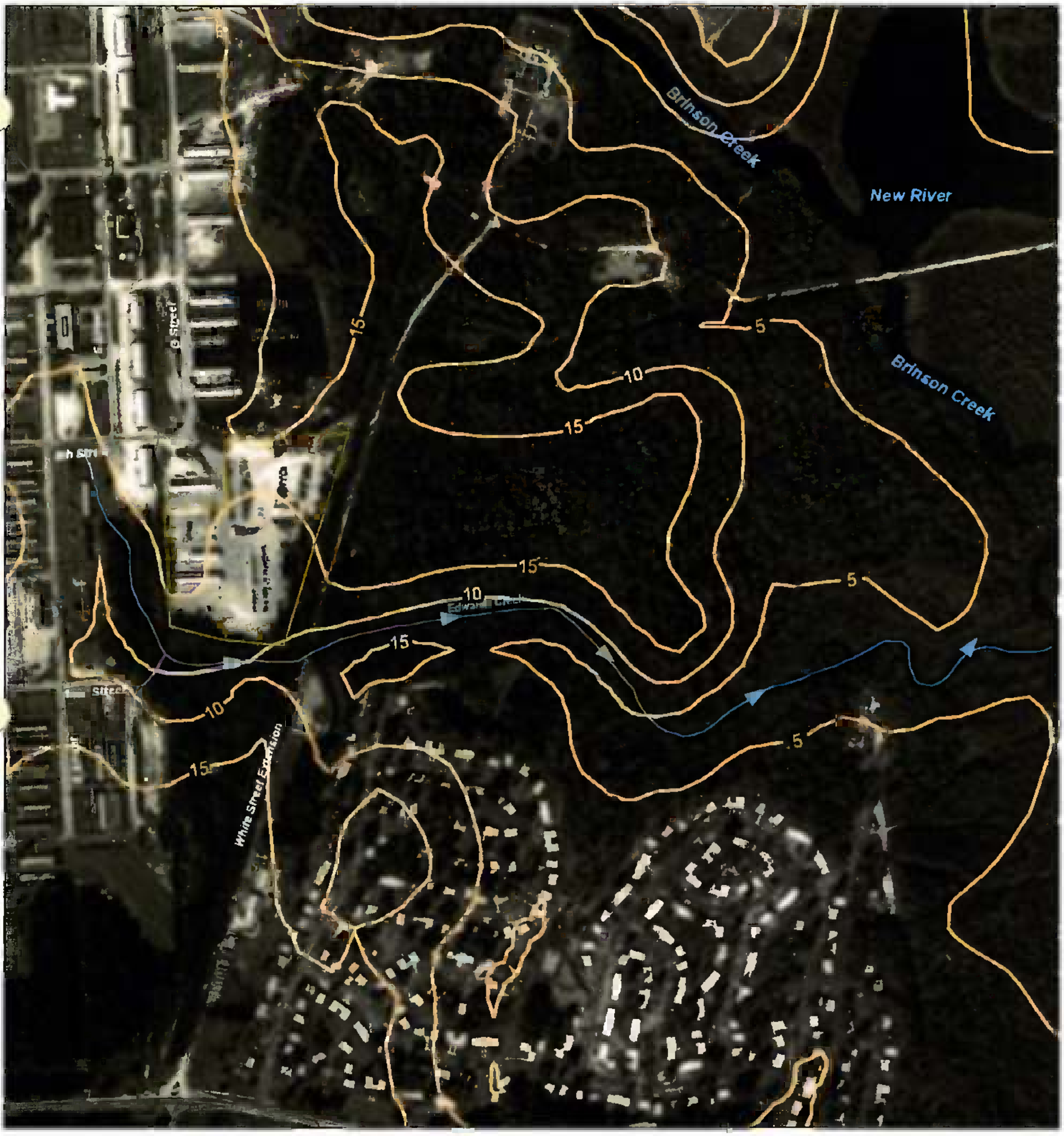
Notes:

(1) Discrepancy between total depth and screen interval

NA - Not applicable
-- - Data unavailable
EST - Estimate

SECTION 3.0 FIGURES

02020N32Y



LEGEND

— Contour Line

— DRMO Fence Line

➤ Edwards Creek with Flow Direction

Scale

400 0 400 800 Feet

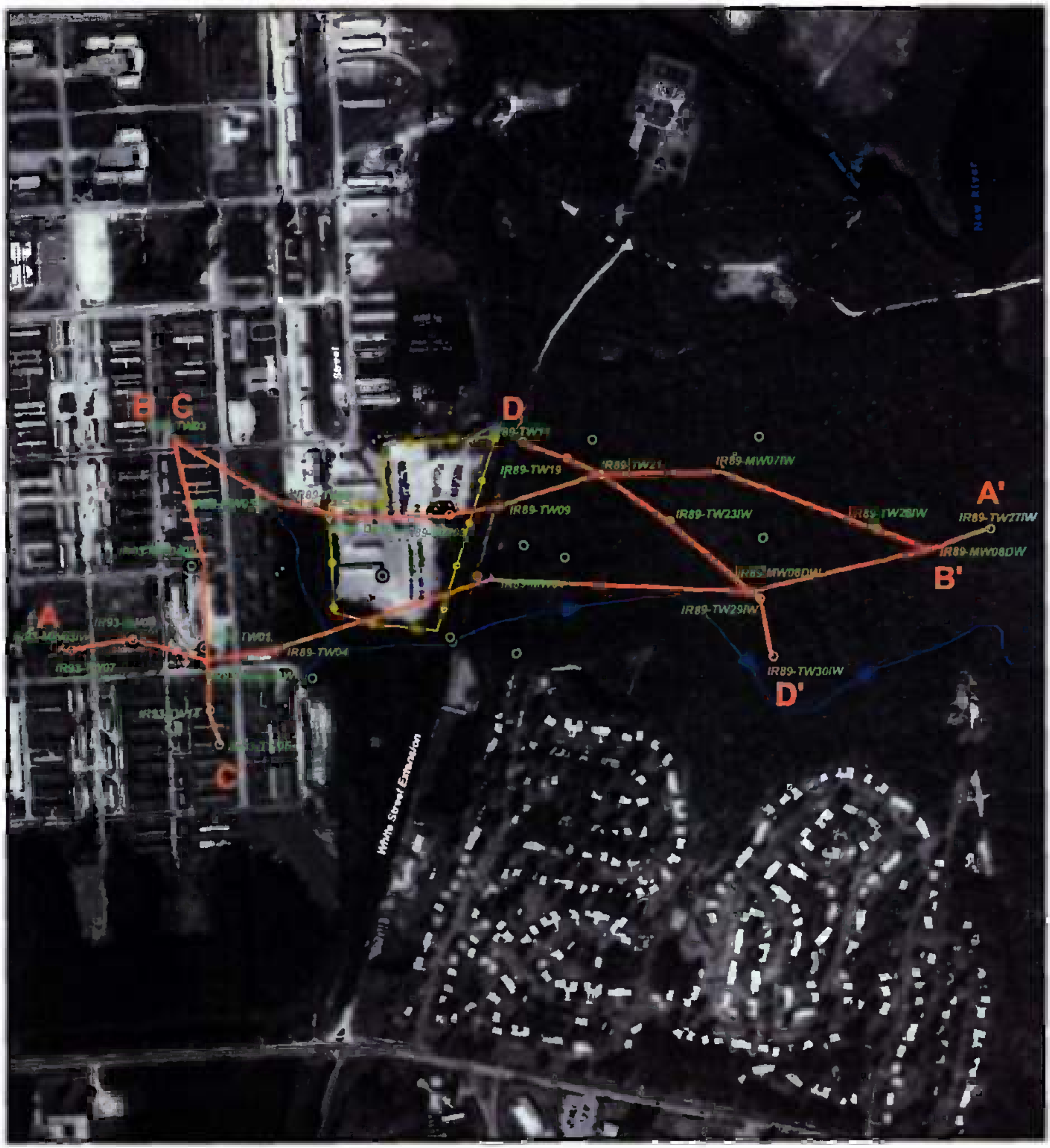
MARINE CORPS BASE, CAMP LEJEUNE
NORTH CAROLINA

SURFACE TOPOGRAPHY
OPERABLE UNIT NO. 16 (SITES 89 & 93)
REMEDIAL INVESTIGATION
CTO 0356

Baker

FIGURE 3-1

02020 N 33Y



LEGEND

DRMO Fence Line

Edwards Creek with Flow Direction

Cross-Section Traverse

Scale

600 0 600 1200 Feet

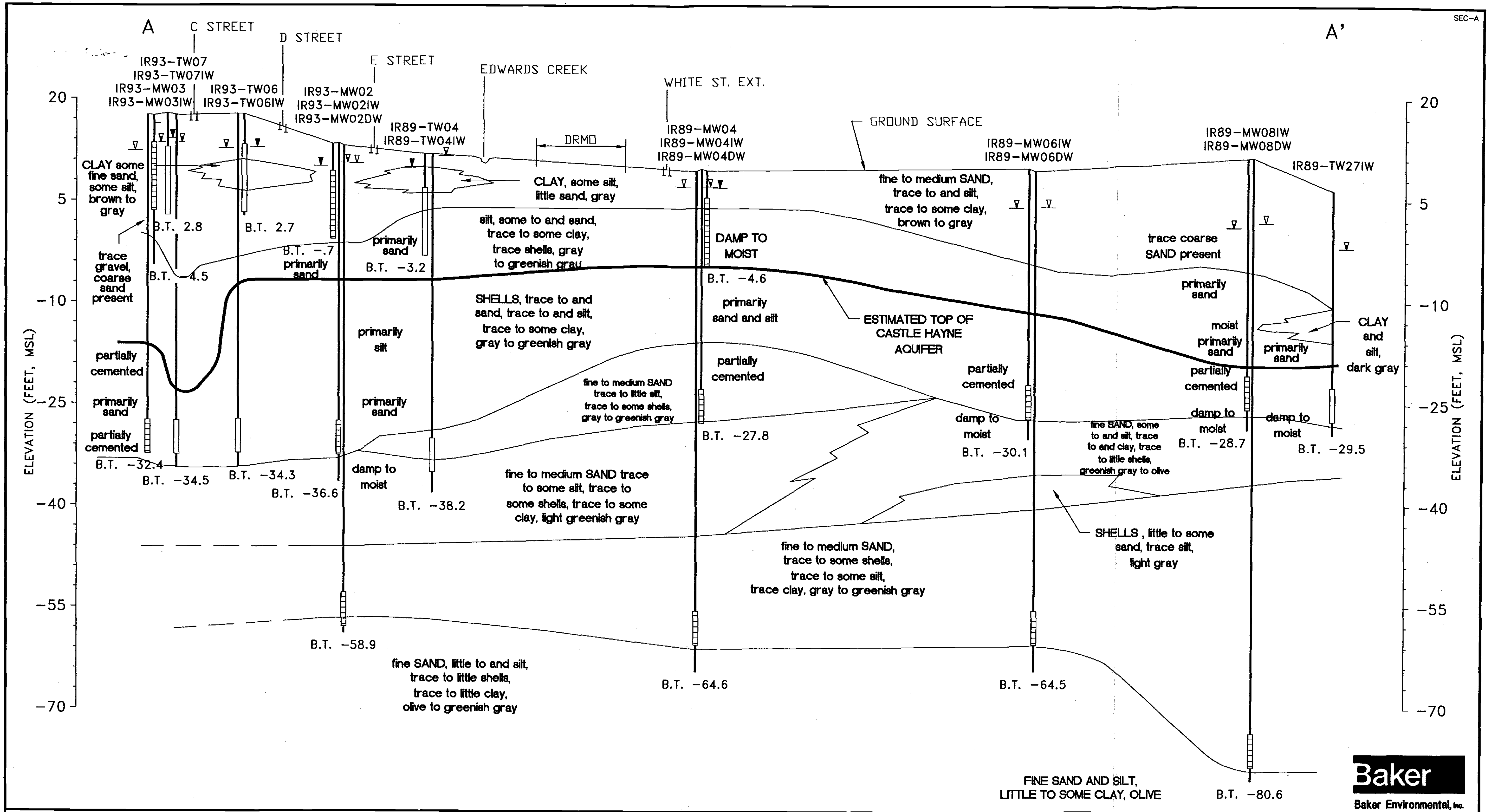
N
W E
S

MARINE CORPS BASE, CAMP LEJEUNE
NORTH CAROLINA

CROSS-SECTION LOCATION MAP
OPERABLE UNIT NO. 16 (SITES 89 & 93)
REMEDIAL INVESTIGATION
CTO 0356

Baker

FIGURE 3 - 2



LEGEND

▼	GROUNDWATER ELEVATION IN SHALLOW MONITORING WELL
▽	GROUNDWATER ELEVATION IN INTERMEDIATE MONITORING WELL
▽	GROUNDWATER ELEVATION IN DEEP MONITORING WELL
B.T. -32.4	BORING TERMINATED, ELEVATION (FEET MSL)
▯	PERMANENT MONITORING WELL SCREEN INTERVAL
▯	TEMPORARY MONITORING WELL SCREEN INTERVAL
——	ESTIMATED
-----	PROJECTED

400 0 200 400 800

Horizontal Scale: 1 inch = 400 ft.

15 0 7.5 15 30

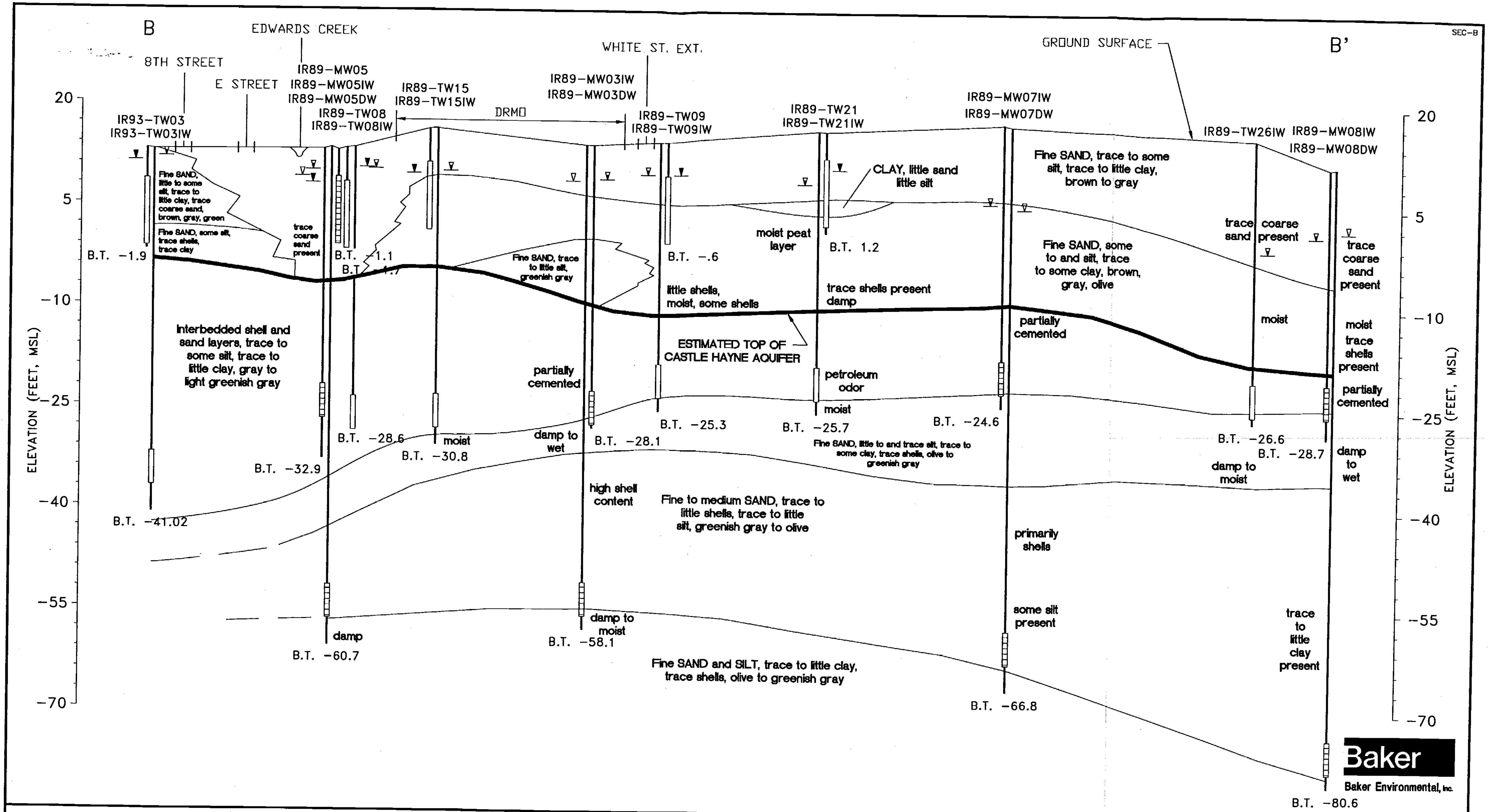
Vertical Scale: 1 inch = 15 ft.

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 3-3
HYDROGEOLOGIC CROSS-SECTION A-A'
OPERABLE UNIT NO.16 (SITES 89 AND 93)
REMEDIAL INVESTIGATION, CTO - 0356

MARINE CORPS BASE, CAMP LEJEUNE
NORTH CAROLINA

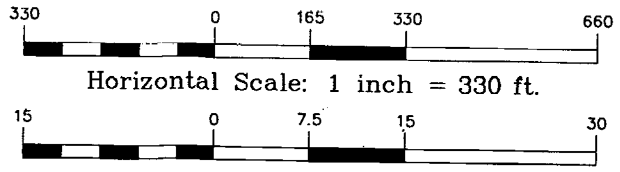
02020N342



Baker
Baker Environmental, Inc.

LEGEND

▼ GROUNDWATER ELEVATION IN SHALLOW MONITORING WELL
∇ GROUNDWATER ELEVATION IN INTERMEDIATE MONITORING WELL
∇ GROUNDWATER ELEVATION IN DEEP MONITORING WELL
B.T. -41.02 BORING TERMINATED, ELEVATION (FEET MSL)
▤ PERMANENT MONITORING WELL SCREEN INTERVAL
▯ TEMPORARY MONITORING WELL SCREEN INTERVAL
——— ESTIMATED
— — — PROJECTED



Horizontal Scale: 1 inch = 330 ft.

Vertical Scale: 1 inch = 15 ft.

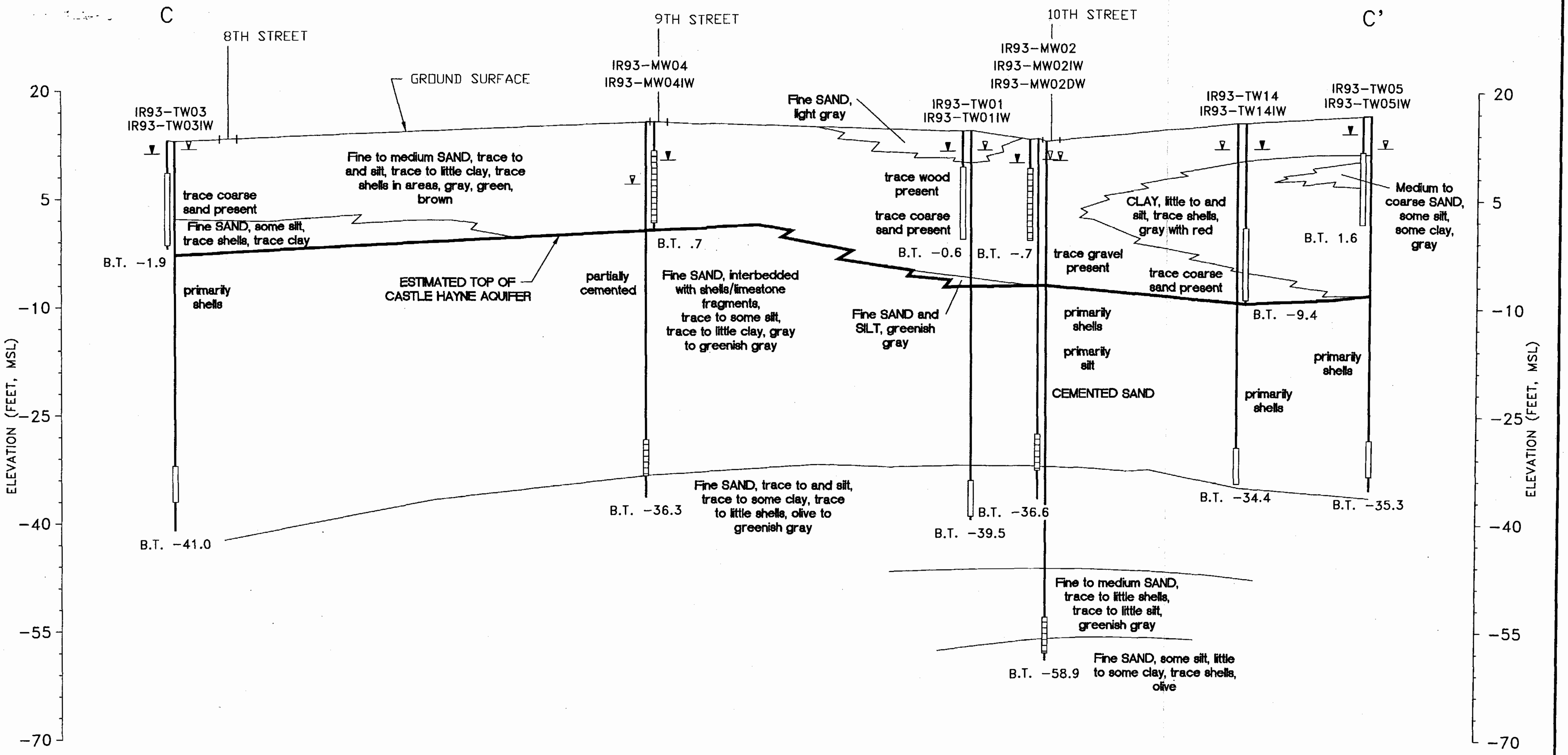
THE SOIL BORING INFORMATION IS CONSIDERED TO BE REPRESENTATIVE OF SUBSURFACE CONDITIONS AT THE RESPECTIVE BORING LOCATIONS. SUBSURFACE CONDITIONS INTERPOLATED BETWEEN BORINGS ARE ESTIMATED BASED ON ACCEPTED SOIL ENGINEERING PRINCIPLES AND GEOLOGIC JUDGEMENT.

FIGURE 3-4
HYDROGEOLOGIC CROSS-SECTION B-B'
OPERABLE UNIT NO.16 (SITES 89 AND 93)
REMEDIAL INVESTIGATION, CTO - 0356

MARINE CORPS BASE, CAMP LEJEUNE
NORTH CAROLINA

02020N352

SEC-C



Baker Environmental, Inc.

LEGEND

▼	GROUNDWATER ELEVATION IN SHALLOW MONITORING WELL
▽	GROUNDWATER ELEVATION IN INTERMEDIATE MONITORING WELL
▽	GROUNDWATER ELEVATION IN DEEP MONITORING WELL
B.T. -41.0	BORING TERMINATED, ELEVATION (FEET MSL)
▯	PERMANENT MONITORING WELL SCREEN INTERVAL
▯	TEMPORARY MONITORING WELL SCREEN INTERVAL
———	ESTIMATED
— — —	PROJECTED

140 0 70 140 280

Horizontal Scale: 1 inch = 140 ft.

15 0 7.5 15 30

Vertical Scale: 1 inch = 15 ft.

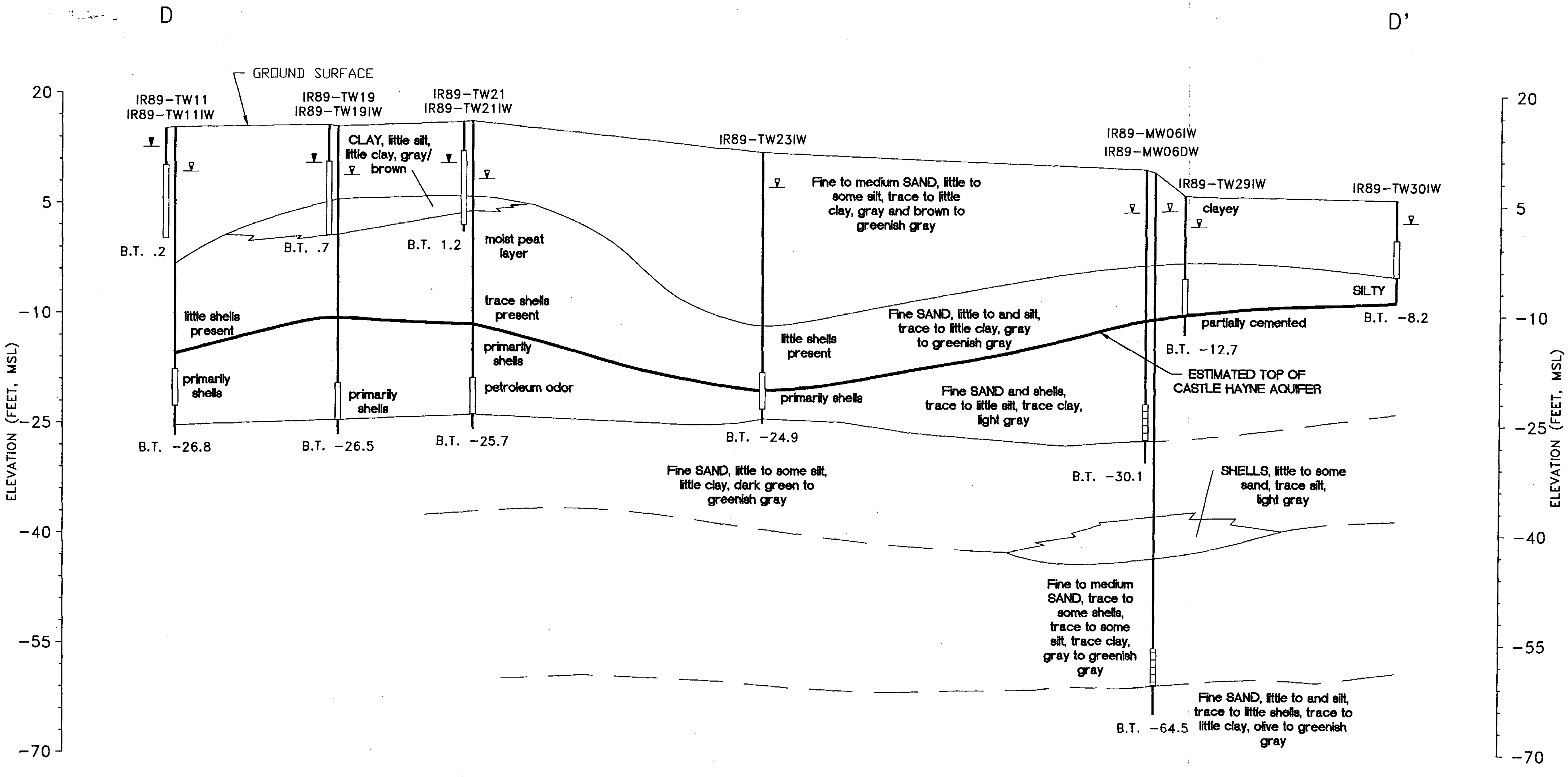
THE SOIL BORING INFORMATION IS CONSIDERED TO BE REPRESENTATIVE OF SUBSURFACE CONDITIONS AT THE RESPECTIVE BORING LOCATIONS. SUBSURFACE CONDITIONS INTERPOLATED BETWEEN BORINGS ARE ESTIMATED BASED ON ACCEPTED SOIL ENGINEERING PRINCIPLES AND GEOLOGIC JUDGEMENT.

FIGURE 3-5
HYDROGEOLOGIC CROSS-SECTION C-C'
OPERABLE UNIT NO.16 (SITES 89 AND 93)
REMEDIAL INVESTIGATION, CTO - 0356

MARINE CORPS BASE, CAMP LEJEUNE
NORTH CAROLINA

02020N362

SEC-D



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LEGEND

▼	GROUNDWATER ELEVATION IN SHALLOW MONITORING WELL
▽	GROUNDWATER ELEVATION IN INTERMEDIATE MONITORING WELL
▽	GROUNDWATER ELEVATION IN DEEP MONITORING WELL
B.T. -26.8	BORING TERMINATED, ELEVATION (FEET MSL)
▯	PERMANENT MONITORING WELL SCREEN INTERVAL
▯	TEMPORARY MONITORING WELL SCREEN INTERVAL
———	ESTIMATED
— — —	PROJECTED

150 0 75 150 300

Horizontal Scale: 1 inch = 150 ft.

15 0 7.5 15 30

Vertical Scale: 1 inch = 15 ft.

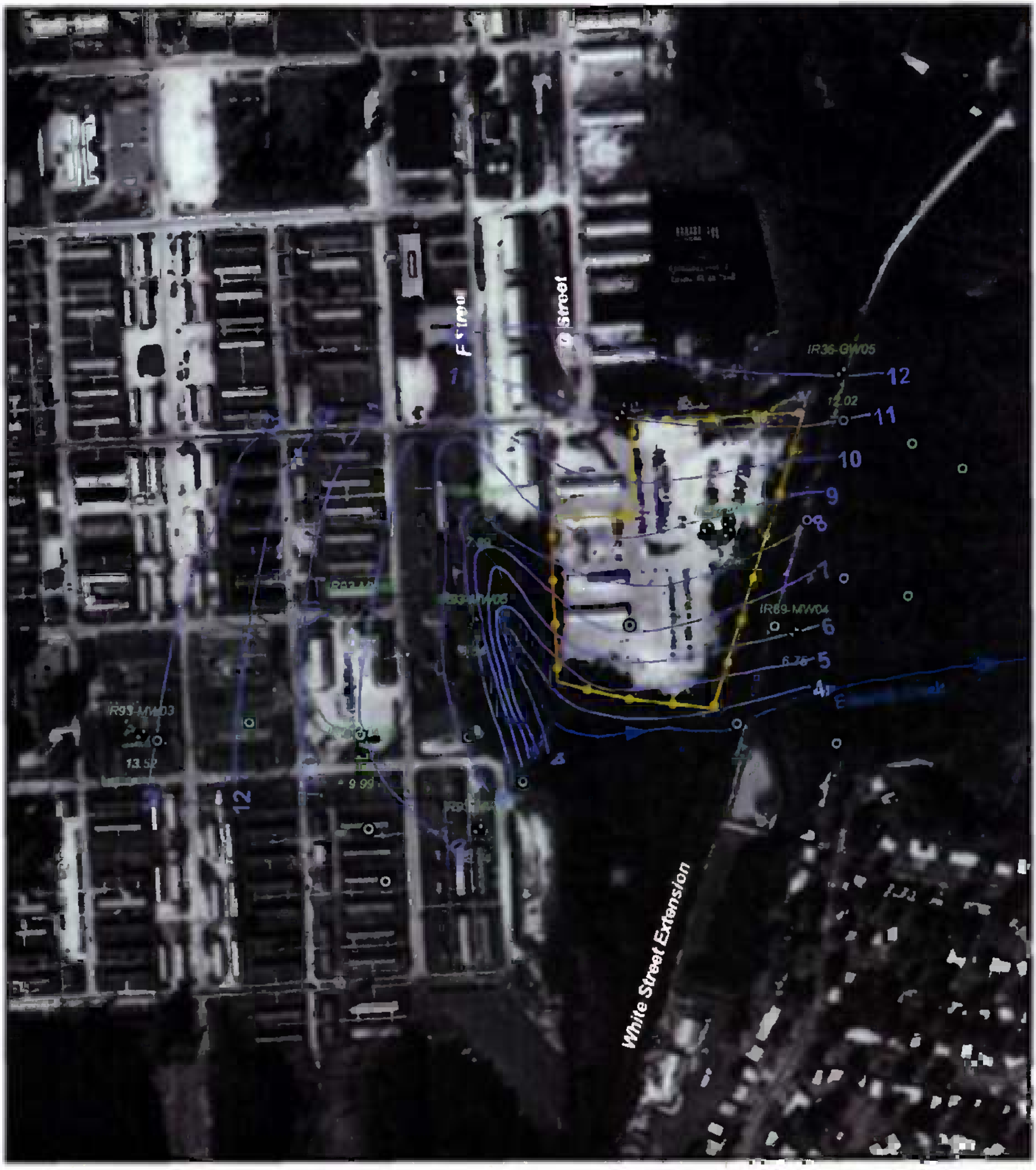
THE SOIL BORING INFORMATION IS CONSIDERED TO BE REPRESENTATIVE OF SUBSURFACE CONDITIONS AT THE RESPECTIVE BORING LOCATIONS. SUBSURFACE CONDITIONS INTERPOLATED BETWEEN BORINGS ARE ESTIMATED BASED ON ACCEPTED SOIL ENGINEERING PRINCIPLES AND GEOLOGIC JUDGEMENT.

FIGURE 3-6
HYDROGEOLOGIC CROSS-SECTION D-D'
OPERABLE UNIT NO.16 (SITES 89 AND 93)
REMEDIAL INVESTIGATION, CTO - 0356

MARINE CORPS BASE, CAMP LEJEUNE
NORTH CAROLINA

02020N37Z

02020N381



LEGEND

IR89-MW01 ● 10.47	Monitoring Well Location with Ground Water Elevation
╱╲╱	Contour Line

Scale

300 0 300 600 Feet

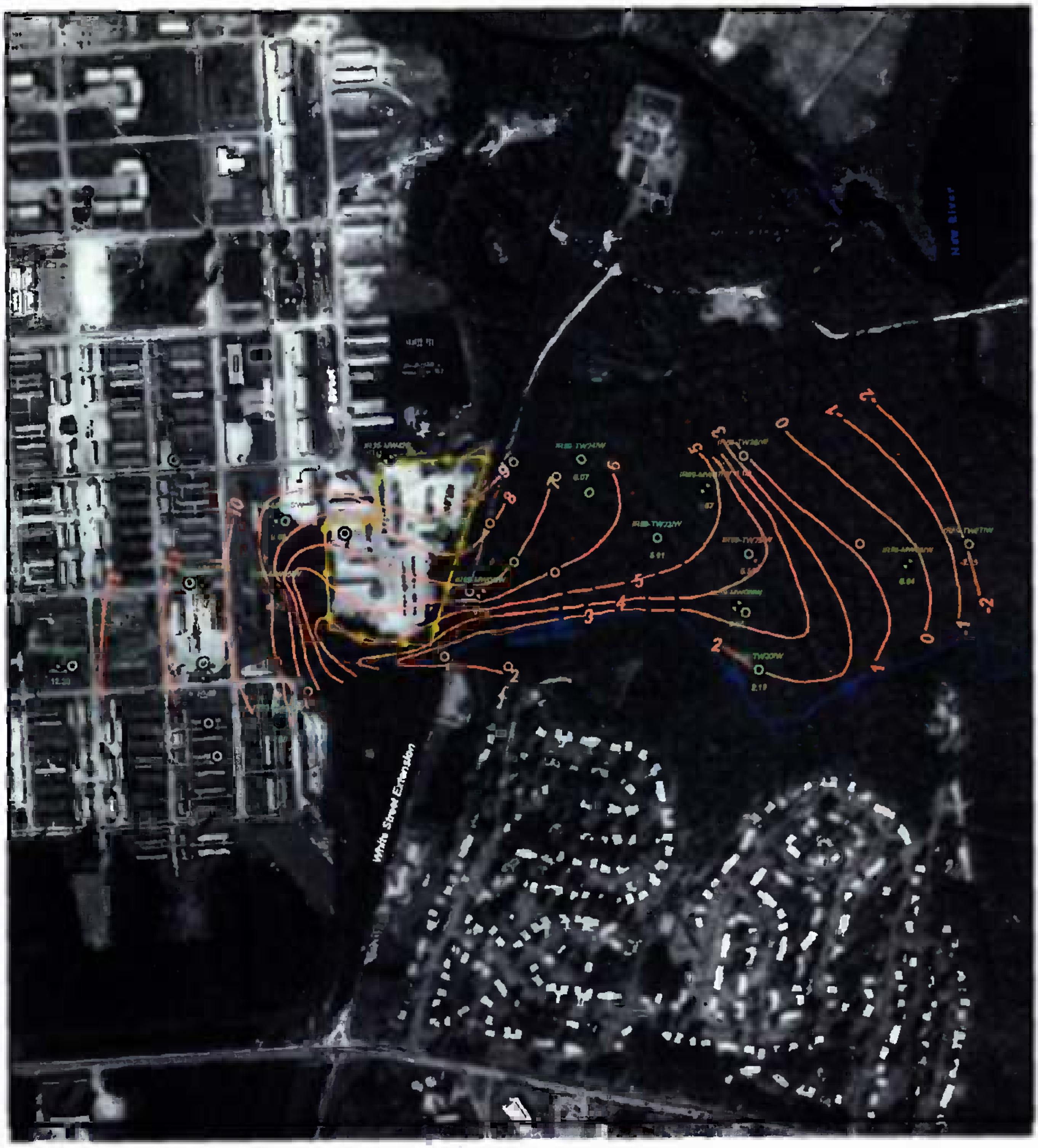
MARINE CORPS BASE, CAMP LEJEUNE
NORTH CAROLINA

POTENTIOMETRIC SURFACE
(SHALLOW WELLS)
OPERABLE UNIT NO. 16 (SITES 89 & 93)
REMEDIAL INVESTIGATION
CTO 0356

Baker

FIGURE 3 - 7

02020N394



LEGEND

Monitoring Well Location with Ground Water Elevation

Contour Line

Scale
600 0 600 1200 Feet

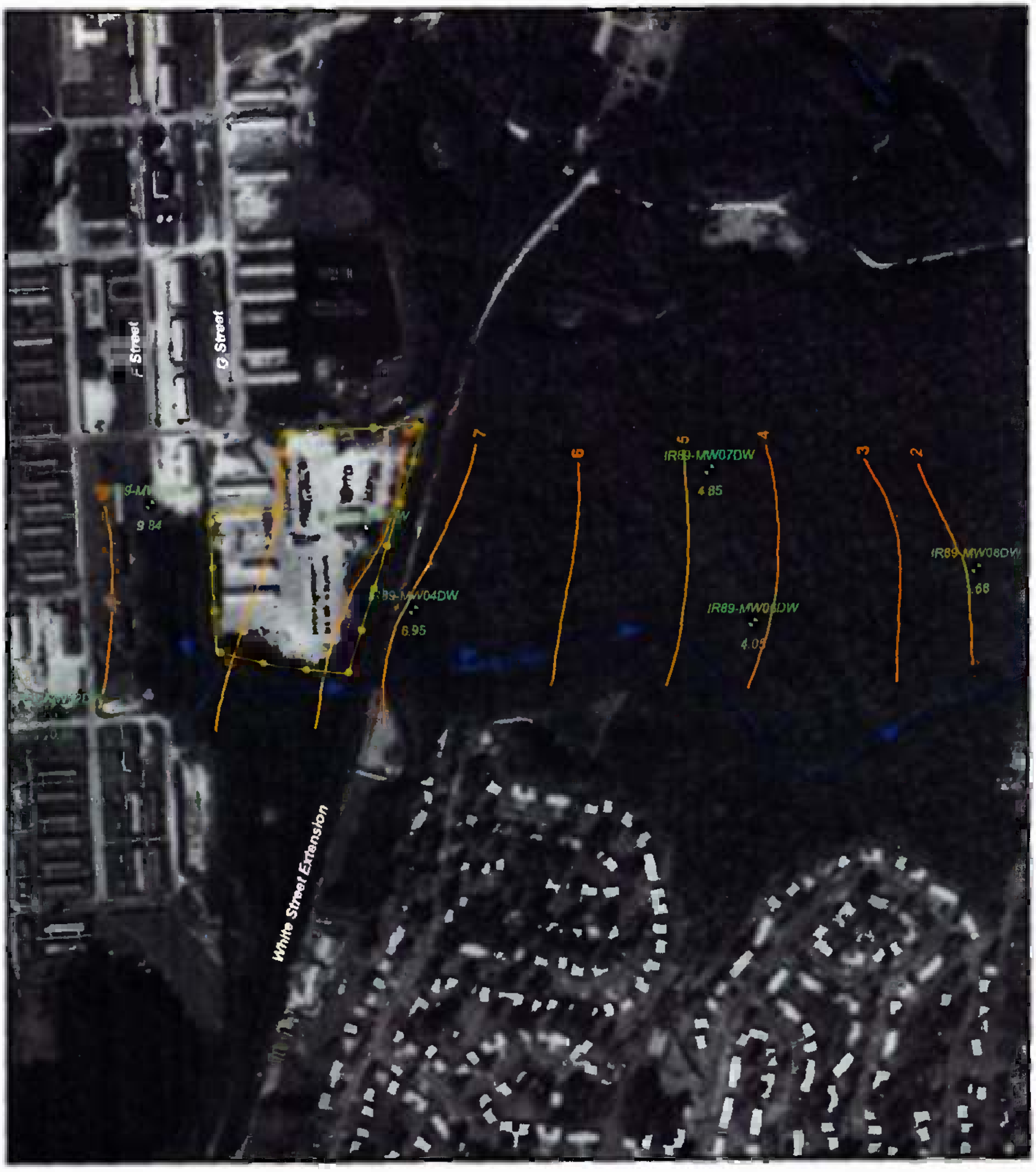
N
W E
S

MARINE CORPS BASE, CAMP LEJEUNE
NORTH CAROLINA

POTENTIOMETRIC SURFACE
(INTERMEDIATE WELLS)
OPERABLE UNIT NO. 16 (SITES 89 & 93)
REMEDIAL INVESTIGATION
CTO 0356

Baker

FIGURE 3 - 8



LEGEND

IR89-MWD01 ● 10.47 Monitoring Well Location with Ground Water Elevation

Contour Line

Scale

400 0 400 800 Feet

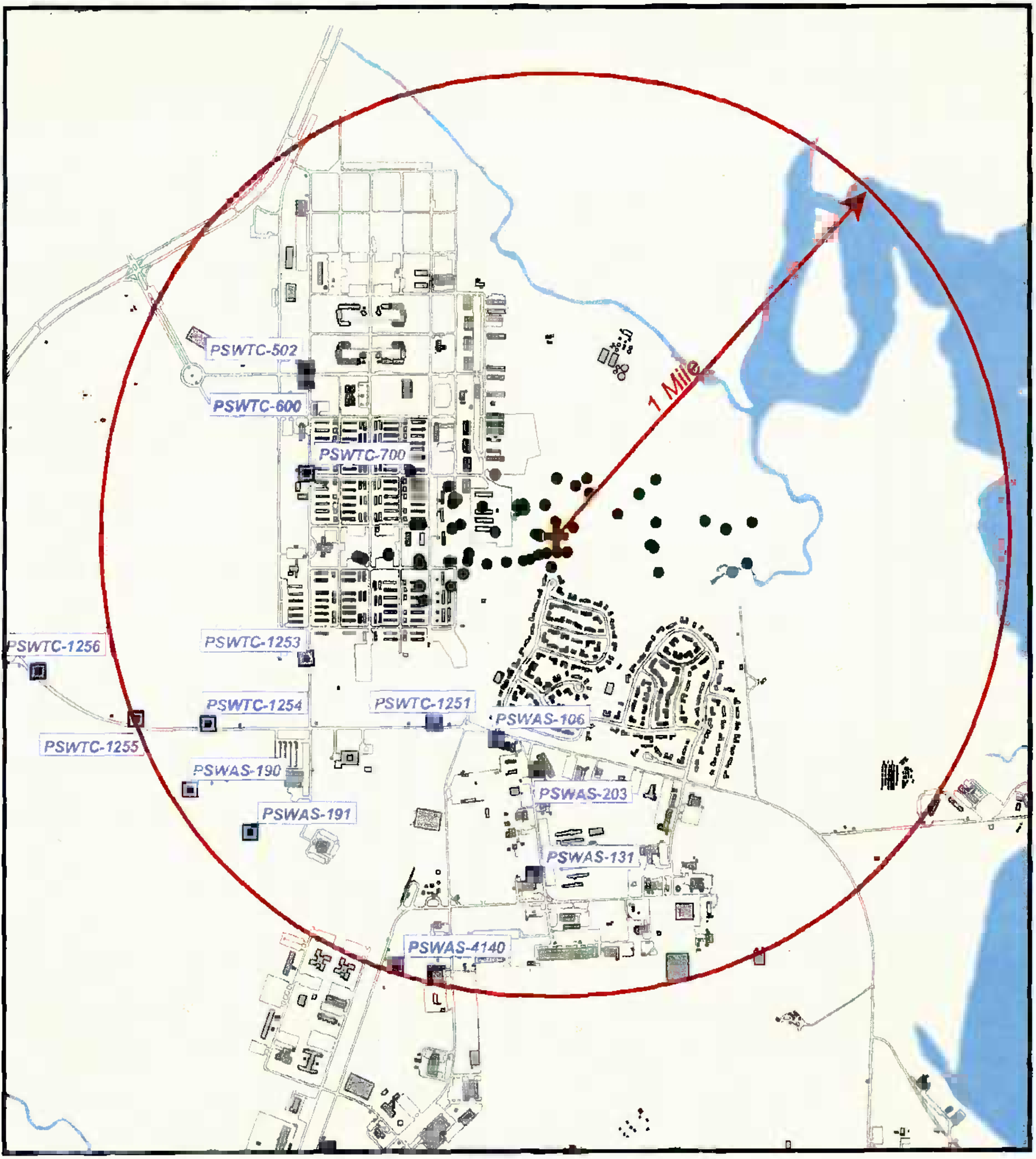
MARINE CORPS BASE, CAMP LEJEUNE
NORTH CAROLINA

POTENTIOMETRIC SURFACE
(DEEP WELLS)
OPERABLE UNIT NO. 16 (SITE 89 & 93)
REMEDIAL INVESTIGATION
CTO 0356

Baker

FIGURE 3 - 9

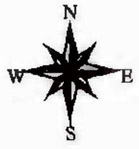
02020N41Y



LEGEND

● Monitoring Well Related to RI

PSWTC-1253
■ Potable Supply Well (Typical)



MARINE CORPS BASE, CAMP LEJEUNE
NORTH CAROLINA

POTABLE SUPPLY WELLS
WITHIN 1 MILE RADIUS
OPERABLE UNIT NO. 16 (SITES 89 & 93)
REMEDIAL INVESTIGATION
CTO 0356

Baker

FIGURE 3 - 10

4.0 NATURE AND EXTENT OF CONTAMINATION

This section presents the results of the Remedial Investigation (RI) performed at Operable Unit (OU) No. 16 (Sites 89 and 93). The objectives of the section are to characterize the nature and extent of contamination at Sites 89 and 93. This characterization was accomplished by specific laboratory analysis of environmental samples including soil, groundwater, surface water, and sediments. The positive detection summary tables and detection figures referenced in the text are presented at the end of Section 4.0. Results for Sites 89 and 93 are each presented separately in Sections 4.4.1 and 4.4.2. A complete summary of the analytical data is included in Appendix H.

Presentation of the analytical data includes a comparison of site data to established standards and/or criteria. The standards and criteria chosen for evaluation are media specific and help to provide a reasonable assessment of site conditions. An explanation of each of the standards and criteria are presented in Section 4.4.

The analytical results for Quality Assurance/Quality Control (QA/QC) samples are presented in Section 4.3. The QA/QC results include duplicate samples in Appendix I and blank samples included in Appendix J.

4.1 Data Quality

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

Additional data qualifiers were employed during the validation of data. For example, compounds which were not detected were assigned the "U"qualifier and those non-detected compounds which had inaccurate or imprecise quantitation limits were assigned the "UJ"qualifier.

4.2 Data Management and Tracking

The management and tracking of environmental samples from the time of field collection to the receipt of the validated electronic analytical results is of primary importance and reflects the overall quality of the laboratory results. Field samples and their corresponding analytical tests were recorded on the chain-of-custody sheets, which are included in Appendix C. The chain-of-custody records were compared to the sampling plan 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 sampling 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.

4.3 Non-Site Related Analytical Results

Many of organic and inorganic constituents detected in soil, groundwater, surface water, and sediments at Sites 89 and/or 93 can be attributed 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 Sites 89 and/or 93 is provided in the following subsections. This includes laboratory contaminants, non-site related contaminants, and naturally occurring inorganic elements.

4.3.1 Laboratory and Non-Site Related Contaminants

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

The QA/QC samples collected from the investigation included trip blanks, rinsate blanks, and field blanks. Trip blanks accompanied environmental samples to the fixed based laboratory to ensure sample integrity during collection and shipment. Rinsate blanks were collected from the sampling equipment to ensure that decontamination procedures were effective in cleaning the field equipment. Field blanks were collected from the potable water source used during drilling and from the laboratory grade water used for decontamination purposes.

The analytical results obtained from the QA/QC samples demonstrate that the data is reliable and useful for assessing the conditions at OU No. 16 (Sites 89 and 93). However, the field blank samples collected from the potable water source used during drilling detected low concentrations of chloroform. Detections of chloroform from a potable water source are not uncommon as the compound can be introduced to the water supply as part of the chlorination process for treating potable water. Consistent detections of chloroform also were noted in the groundwater samples collected from the intermediate temporary monitoring wells in which the potable water source was used while drilling. The potable water was used to prevent loose sands from flowing into the hollow stem augers during drilling. As the chloroform was present in the potable water source used for drilling, its detection in the environmental samples was not considered to be site related.

The presence of trace amounts of chloroform (which indicates potable water) may bias the analytical results low compared to actual conditions. However, VOC concentrations were typically high enough, such that the temporary monitoring wells provided sufficient information for screening purposes. It is important to note that the screening results were only intended to give preliminary estimates of the plume geometry. The permanent monitoring wells were installed at the site for full characterization. The permanent wells provide accurate groundwater data, and provide fixed points from which future samples can be obtained.

Other common laboratory contaminants (i.e., acetone, 2-butanone, methylene chloride, toluene, and phthalate esters) were considered as positive results only when observed concentrations exceeded ten times the maximum concentration detected in any blank. If the concentration of a common laboratory contaminant was less than ten times the maximum blank concentration, then it was concluded that the chemical was not detected in that particular sample (USEPA, 1989). The maximum concentrations of detected common laboratory contaminants in blanks for OU No. 16 (Sites 89 and 93) were as follows:

Aqueous Samples

• Bromodichloromethane	18 µg/L
• Bromoform	9J µg/L
• Dibromochloromethane	24 µg/L
• Bis (2-ethylhexyl) phthalate	120 µg/L

Solid Samples

• Acetone	70 µg/L
• Bromodichloromethane	18 µg/L
• Bromoform	9J µg/L
• Dibromochlormethane	24 µg/L
• Bis (2-ethylhexyl) phthalate	120 µg/L

Organic constituents contained in blanks that are not considered common laboratory contaminants [i.e., all other target compound list (TCL) compounds] were considered as positive results only when observed concentrations exceeded five times the maximum concentration detected in any blank (USEPA, 1989a). All TCL compounds of less than five times the maximum level of contamination noted in any blank were considered to be not detected in that sample. The maximum concentrations of all other detected blank contaminants for OU No. 16 (Sites 89 and 93) were as follows:

• Tetrachloroethene	3J µg/L
• Chloroform	12 µg/L

4.3.2 Naturally-Occurring Inorganic Elements

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

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

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 89 and/or 93.

4.3.2.1 Soil

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

Base background concentration values for inorganic elements in subsurface soil at MCB, Camp Lejeune are presented in Table 4-1. The base background ranges are based on analytical results of background samples collected in areas known to be unimpacted by site operations or disposal activities at MCB, Camp Lejeune. In subsequent sections, which discuss the analytical results of samples collected during the soil investigation, only those inorganic parameters with concentrations exceeding two times the average base background will be considered. Appendix K contains the summary of the base soil background database for inorganics.

4.3.2.2 Groundwater

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., up gradient) samples were compiled as part of a study to evaluate levels of inorganic elements in groundwater at MCB, Camp Lejeune. Appendix L presents Baker's Draft Report Evaluation of Metals in Groundwater, June 1994, prepared for the Department of the Navy, Atlantic Division Naval Facilities Engineering Command. This study provides information which demonstrates that elevated levels of total metals in groundwater have been detected at almost every site at MCB, Camp Lejeune. The report concluded that the elevated levels of total metals is most likely a result of geologic conditions and that total metals concentrations may be biased high due to suspended particles in groundwater samples.

USEPA Region IV requires that unfiltered inorganic concentrations be used in evaluating Applicable Relevant and Appropriate Requirements (ARARs) and risk to human health and the environment. As such, groundwater samples were analyzed for total inorganic parameters. Groundwater in the MCB, Camp Lejeune area is naturally rich in metals and sample results often exceed the Federal Maximum Contaminant Levels (MCLs).

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

4.4 State and Federal Criteria and Standards

Contaminant concentrations can be compared to contaminant-specific established State and Federal criteria and standards such as MCLs or Ambient Water Quality Criteria (AWQC).

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

In general, chemical-specific criteria and standards are not available for soil. Therefore, base-specific background concentrations were compared 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 the majority of organic contaminants detected in the subsurface soil at Sites 89 and 93 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.

Region III Risk Based Concentrations (RBCs) - March, 1997 - RBC values are derived using conservative USEPA promulgated default values and the most recent toxicological criteria available. The RBCs for potentially carcinogenic chemicals are based on a target Incremental Cancer Risk (ICR) of 1×10^{-6}. The RBCs for noncarcinogens are based on a target hazard quotient of 1.0. In order to account for cumulative risk from multiple chemicals in a medium, it is necessary to derive the RBCs based on a target hazard quotient of 0.1. Re-derivation of the 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 screening values. In order to provide the accurate screening values, the noncarcinogenic RBCs were divided by a factor of ten. For potential carcinogens, the toxicity criteria applicable to the derivation of RBC values are oral and inhalation cancer slope factors (CSFs); for noncarcinogens, they are chronic oral and inhalation reference doses (RfDs). 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 RBC values requires that the screening concentrations be updated periodically to reflect changes in the toxicity criteria. The RBC table is issued on a semi-annual basis.

North Carolina Risk Analysis Framework - The NC Risk Framework Analysis is a guidance document used to determine acceptable target concentrations, conduct site-specific risk assessments, and choose appropriate management strategies for applicable sites throughout the state. The risk analysis framework describes scientific procedures for determining contaminant concentrations (concentration of the contaminant at which no further clean-up is required based upon the risk of harm posed by the contaminant) and assessing the risk of harm to human health, the environment and public welfare. The framework presents a tiered approach (Methods I, II, or III). Each sucessive tier uses more site-specific information. Method I involves the use of conservative default target concentrations provided by the NC DENR. Method II involves the calculation of target concentrations using some site-specific data. Method III entails a more complex transport model for calculating target concentrations at sites. In using Methods I, II, and III target concentrations it is necessary to use one of three groundwater and soil catagories. These catagories include the following:

GROUNDWATER CATEGORIES

G-1	Current or potential drinking water and current or potential non-drinking water exposures such as from swimming pools or irrigation
G-2	Transport of contaminant vapors from groundwater to indoor air
G-3	Transport of groundwater contaminants to surface water

SOIL CATEGORIES

S-1	Residential ingestion of soil
S-2	Industrial/commercial ingestion of soil
S-3	Transport of soil contaminants to groundwater

For the purposes of assessing the conditions at OU No. 16 the transport of soil contaminants to groundwater was evaluated by using the S-3:G1 category. Surface water was assessed by considering the transport of groundwater contaminants to the surface water by using the S-3:G-3 criteria.

North Carolina Water Quality Standards (Groundwater) NCWQS, 1994 - 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.

Federal Maximum Contaminant Levels - February, 1996 - Federal MCLs are enforceable standards for public water supplies promulgated under the Safe Drinking Water Act (SDWA) and are designed for the protection of human health. MCLs are based on laboratory or epidemiological studies and apply to drinking water supplies consumed by a minimum of 25 persons. They are designed for prevention of human health effects associated with 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) - human health standard - The NCWQSs for surface water are the standard concentrations, that either alone or in combination with other wastes, in surface waters that will not render waters injurious to aquatic life or wildlife, recreational activities, public health, or impair waters for any designated use.

Ambient Water Quality Standards - Ambient Water Quality Standards (AWQS) 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 10^{-7} to 10^{-5} range).

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

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

4.5 Nature of Site Analytical Sample Results

This section presents the results of the soil, groundwater, surface water, and sediment investigations performed as part of the remedial investigation at OU 16. The data are presented for both sites by media as listed below:

- Site 89
  - soil
  - groundwater
  - surface water
  - sediment
- Site 93
  - soil
  - groundwater

The analytic results are presented in corresponding tables which show all of the positive detections. In addition, summary tables are included which provide a comparison to the appropriate "screening standard".

4.5.1 Site 89

Investigative activities at Site 89 included the collection of soil and groundwater samples in the area of the Defense Reauthorization and Marketing Office (DRMO) and the wooded area east of White Street Extension. Surface water and sediment samples were collected from Edwards Creek near the DRMO facility and from downstream portions of the stream as it flows to the New River. Figure 4-1 illustrates the locations of all sample points at Site 89. Each of the media sampled are presented separately, including soil, groundwater, surface water, and sediment samples.

4.5.1.1 Soil - Site 89

A total of 26 soil samples were collected from Site 89 and analyzed for volatiles, semivolatiles, and metals. Five of the samples were analyzed for pesticides and polychlorinated biphynels (pesticides/PCBs). As mentioned earlier, not all of the samples were analyzed for pesticides due to the fact that previous investigations had identified volatile organic compounds (VOCs) as the contaminant of concern. Nine VOCs were detected in the soil samples collected from Site 89. Table 4-2 provides a list of the positive detections of organic and inorganics detected in the soil at Site 89. The results are summarized and compared to the Region III RBCs for residential soil and the NC Risk Analysis Framework on Table 4-3.

The detected compounds include 1,1,2,2-tetrachloroethane, 1,2-dichloroethene (total), 2-butanone, acetone, benzene, carbon disulfide, tetrachloroethene, toluene, and trichloroethene. Several of the compounds are not believed to be related to specific site operations. They include acetone, 2-butanone, and carbon disulfide. Acetone and 2-butanone are typically a result of laboratory and/or field procedures and are not considered to be related to site conditions. For example, acetone was detected in rinsate blank IR89-RBSB03 at a concentration of 70 microgram per liter (µg/L). The maximum concentration of acetone in the environmental samples was 100 microgram per kilogram (µg/kg) from sample IR89-MW05IW-06, making the concentration less than 10 times the maximum concentration for QA/QC blanks. The compound carbon disulfide can occur naturally by the action of microorganisms living in marshy environments. It is related to the natural biodegradation of organic material. The detections of carbon disulfide are presented on Tables 4-2 and 4-3. However the distribution and extent of these compounds are not discussed in detail because they are considered to be naturally occurring and not related to previous site operations.

Of the compounds detected, 1,1,2,2-tetrachloroethane, 1,2-dichloroethene (total), benzene, tetrachloroethene, toluene, and trichloroethene are believed to be related to previous site operations. These compounds have been consistently detected in groundwater samples and would be expected to be present in the soil based upon the site history.

None of the organic compounds exceeded the Region III RBCs for soil, however five of the seven detections of trichloroethene exceeded the screening criteria for transfer of soil contaminants to groundwater as set by the NC Risk Analysis Framework. None of the soil detections exceeded the criteria of transferring soil contaminants to surface water.

The majority of the detections were present in samples collected from monitoring well clusters IR89-MW03 and IR89-MW05. Monitoring well location IR89-MW03 is a three well cluster consisting of a shallow, intermediate, and deep well located within the DRMO area adjacent to the drying rack and soil storage facility. This is the location of former underground storage tank (UST STC-868) and is suspected to be at least one of the source areas for the existing volatile contamination at the site. Monitoring well cluster IR89-MW05 consists of a shallow, intermediate and deep well, located immediately west of the DRMO facility at the end of F Street. Well cluster IR89-MW05 is approximately 800 feet west of the former UST location and well cluster IR89-MW03. Detections at this location of the site are not related to the former UST near IR89-MW03, but may be linked to various operations which certainly occurred as part of the motor pool operations.

Semivolatile organics were detected sporadically across the study area at locations IR89-MW06 and IR89-MW03. Three compounds were detected including bis(2-ethylhexyl)phthalate, fluoranthene, and pyrene. The maximum semivolatile detection was bis(2-ethylhexyl)phthalate which occurred in soil sample IR89-MW06DW-01. Fluoranthene was detected at a maximum concentration of 43J µg/kg at IR89-MW03DW-02 and IR-89MW03IW-05. Pyrene was detected at a maximum concentration of 66J µg/kg in sample IR-MW03IW-05. These semivolatile compounds are considered polynuclear aromatic hydrocarbons (PAHs). They are formed during various anthropogenic processes such as waste incineration and the combustion of fossil fuels. PAHs are ubiquitous in the modern environment and researched has linked fossil fuels as a major source of their presence in soil (Jones, J.C., et al., 1989). Their presence in soil at site 89 is likely to be related to various anthropogenic processes than to specific site activities. None of the detections of PAHs in the soil samples exceeded the Region III RBCs.

Three pesticides were detected in the soil samples collected at Site 89. All three detections occurred from sample IR89-MW03IW-02. The compounds and concentrations included 4,4'-DDD, 4,4-'DDE, 4,4'-DDT at concentrations of 19J µg/kg, 17J µg/kg, and 91 µg/kg, respectively. None of these concentrations exceeded the Region III RBCs for soil. Pesticides have been used extensively in the past at MCB, Camp Lejeune. These organic compounds tend to be quite stable in the environment and do not break down readily through natural processes. The presence of pesticides at Site 89 is not unusual based on the fact that these compounds have been detected in various background areas and their documented historic use at the base. Their presence in the soil samples is not considered to be related to specific activities at Site 89.

Inorganic compounds were detected across the site in a uniform pattern. Results of the analytical data were compared to both the Region III RBCs for residential soil and twice the average base background values. As provided on Table 4-3, many of the inorganics detected in the soil samples exceeded both the Region III RBCs and the base background values. However, the detections of the inorganics in the soil is considered to be a result of natural soil conditions and not site operations or disposal activities. The detections of inorganics in the soil samples do not exhibit excessive concentrations or present a pattern which would indicate specific disposal activities.

4.5.1.2 Groundwater - Site 89

The groundwater investigation at Site 89 entailed the collection of groundwater samples from the surficial and Castle Hayne aquifer. Shallow and intermediate wells were screened at approximately 25 and 40 feet below ground surface (bgs), respectively while the deep wells were screened approximately 70 feet bgs. Groundwater samples were collected from both temporary and permanent monitoring wells to assess site conditions. All of the positive detections in the groundwater samples are presented on Table 4-4. The analytical results are summarized on Table 4-5.

Twelve VOCs were detected in the groundwater samples collected at Site 89. They included, 1,1,1-trichloroethane, 1,1,2,2-tetrachloroethane, 1,1,2-trichloroethane, 1,1-dichloroethene, 1,2-dichloroethene (total), chloroform, cis-1,2-dichloroethene, tetrachloroethene, toluene, trans-1,2-dichloroethene, trichloroethene, and vinyl chloride.

The majority of these volatile compounds are considered to be a result of previous site operations, however, as presented in Section 4.3, the detections of chloroform in the groundwater samples is not considered to be site related. The presence of chloroform in the groundwater samples is most likely related to the potable water source used during drilling operations of the temporary monitoring wells. Detections of chloroform in a potable water source are not uncommon as it is introduced as part of the chlorination process used for water treatment purposes. This compound was detected in the field blanks obtained from the potable water source used during drilling and was common in all the groundwater samples collected from temporary wells in which potable water was used while drilling. Its presence in the environmental samples is not considered to be site related.

Concentrations of the VOCs which are considered to be related to previous site activities, ranged from 0.1 µg/L of tetrachloroethene to 880 µg/L of 1,2-dichloroethene (total). The most frequently detected compound was trichloroethene, which was detected in 28 of 55 samples. The highest concentration of trichloroethene was 744.3 µg/L, detected in the sample collected from monitoring well IR89-MW02 which is located near the former underground storage tank (UST SCT-868) location inside the DRMO facility. Of the volatile compounds detected, six were detected at concentrations which exceeded either the Federal MCL or the NCWQS. The compounds which exceeded the criteria included, chloroform, cis-1,2-dichloroethene, tetrachloroethene, trans-1,2-dichloroethene, trichloroethene, and vinyl chloride.

Only one semivolatile compound, bis(2-ethylhexyl)phthalate, was detected in the groundwater samples obtained from the monitoring wells at Site 89. This compound was detected in 4 of 14 samples, however it is not considered to be site related. Bis(2-ethylhexyl)phthalate is a common laboratory contaminant and may also be attributed to materials used during the field program. For example, this compound is used as a plasticizer for polyvinylchloride (PVC), which was used during the field program as monitoring wells. Bis(2-ethylhexyl)phthalate is also used in processes involving the production of rubbing alcohol, liquid soap, detergents, decorative inks and as a pesticide carrier. There were no pesticides/PCBs detected in any of the groundwater samples from Site 89.

Inorganics were detected in the majority of the groundwater samples obtained from Site 89. Of the metals detected, iron and manganese concentrations exceeded their respective Federal MCLs and NCWQS. The maximum concentrations of iron and manganese occurred in the sample collected from monitoring well IR89-MW05. Iron was detected at a concentration of 20,000J µg/L while manganese was detected in the sample at 379 µg/L. The detections of iron and manganese, while above the water quality standards, are not considered to be a contaminant of concern at the site. As discussed above, the presence of inorganics in groundwater, particularly iron and manganese, are a result of the natural site conditions, and not due to site operations.

4.5.1.3 Surface Water - Site 89

A total of 11 surface water samples were collected at Site 89. Samples IR89-EC-SW01 through IR89-EC-SW04 were analyzed according the contract laboratory program (CLP) protocol for target compound list (TCL) volatile organic analyses (VOAs), TCL semivolatile organic analyses (SVOAs), and target analyte list (TAL) metals. Sample IR89-EC-SW05 was analyzed for all fractions including TCL Pesticides/PCBs. In addition, each of these five samples were analyzed for VOCs by the on-site laboratory according to Environmental Protection Agency (EPA) Method 8240. Samples IR89-EC-SW05 through IR89-EC-SW11 were analyzed by the on-site laboratory for VOAs only, these sample locations were not sent to the fixed based laboratory. The positive detections of the surface water samples are provided on Table 4-6 and compared to Federal AWQS on Table 4-7.

Eight volatile compounds were detected in the samples obtained from Edwards Creek. The compounds detected included 1,1,2,2-tetrachloroethane, 1,2-dichloroethene (total), chloroform, cis-1,2-dichloroethene, tetrachloroethene, trans-1,2-dichloroethene, trichloroethene, and vinyl chloride. Concentrations of the VOCs ranged from a low of 0.1 μg/L of tetrachloroethene to a high of 150J μg/L of 1,1,2,2-tetrachloroethane. The most frequently detected compounds were cis-1,2-dichloroethene and trichloroethene which were detected in 9 of the 11 surface water samples. The sample stations recording the highest number of maximum detections were sample stations IR89-EC-SW02 and IR89-EC-SW04. These stations are located south and hydraulically downgradient of the DRMO area. Sample station IR89-EC-SW06, located to the west of the DRMO area and at the headwaters of Edwards Creek, was the only station where VOCs were not detected. Four of the compounds including 1,1,2,2-tetrachloroethane, tetrachloroethene, trichloroethene, and vinyl chloride were detected at concentrations exceeding the Federal AWQC.

There were no SVOAs or pesticides/PCBs detected in the surface water samples collected from Edwards Creek. Metals including iron and manganese were detected in the samples at concentrations which exceeded the Federal AWQCs. Given the nature of the soils and the detected concentrations, the presence of metals is most likely attributed to natural conditions. Metals in the surface water is not considered to be a result of site operations. As mentioned above the results are presented on Table 4-6 and summarized on Table 4-7.

4.5.1.4 Sediment - Site 89

Ten sediment samples were collected at 5 sample locations within Edwards Creek and analyzed by the fixed base laboratory. Two samples were taken at each station, one from 0 to 6 inches and a second from 6 to 12 inches. Samples IR89-EC-SD01 through IR89-EC-SD04 were analyzed at the fixed based laboratory for TCL VOAs, TCL SVOAs, and TAL metals. Sample number IR89-EC-SD05 was analyzed for these same fractions, but also included an analysis for TCL pesticides/PCBs. Several other sediment samples were collected within Edwards Creek and analyzed by the mobile laboratory for volatile organic compounds only. Table 4-8 presents the results of the analytical data for the sediment samples. The results are summarized and compared to USEPA Region IV screening levels on Table 4-9.

The maximum detection of volatile organic compounds occurred at sample stations IR89-EC-SD03 and IR89-EC-SD10. Nine volatile organic compounds were detected in the sediment samples collected from the stream bed. The majority of the detections occurred in the samples collected from the 0 to 6 inch sample depth. However, there were detections of volatile organic compounds in the samples taken from 6 to 12 inches. The detected compounds included 1,1,2,2-tetrachloroethane, 1,1,2-trichloroethane, 1,1-dichloroethene, 1,2-dichloroethene (total), cis-1,2-dichloroethene, toluene, trans-1,2-dichloroethene, trichloroethene, and vinyl chloride. Concentrations of the volatile organic compounds ranged from 1 μg/kg of trans-1,2-dichloroethene to 2,400 μg/kg of trichloroethene. At present, there are no Region IV screening levels for volatile organic compounds in sediment.

Ten of the sediment samples were analyzed for semivolatile organic compounds (SVOCs). Each of the samples detected SVOCs. Eleven different SVOCs were detected in the samples, however, only benzo(a)pyrene was detected at a concentration which exceeded the Region IV sediment screening levels. The type of semivolatile compounds which were detected are ubiquitous in the environment and can be a result of decomposition of organic material or combustion of fossil fuels. Further, the concentrations detected are similar to what is normally expected in environments where soil has a high organic content. The results of the SVOCs shown on Table 4-8 and 4-9 are not considered to be related to site operations at Site 89.

Analysis for pesticide/PCBs was performed at station IR89-EC-SD05 only. There were no PCBs detected in the sample, however, several pesticide compounds were detected including 4,4'-DDD, 4,4'-DDE, 4,4'-DDT, alpha-chlordane, and gamma-chlordane. Several of the pesticides exceeded the Region IV Sediment Screening Levels. The compounds included 4,4'-DDD, 4,4'-DDE, and 4,4'-DDT. Pesticide compounds were commonly used in the past at MCB, Camp Lejeune, and have been detected in many samples at various sites across the base. Their presence in the sediment samples are most likely due to overland runoff and to organic matter present in the sediment samples. Pesticides tend to be very stable in the environment with little degradation occurring, therefore they are commonly detected in soil and sediment samples throughout the base at concentrations similar to what was observed at Site 89. The reported concentrations of these organic compounds are not considered to be related to site operations at Site 89, but rather previous basewide applications. The results of the pesticide analyses are provided on Tables 4-8 and 4-9.

Inorganic analyses were conducted on ten sediment samples from sampling stations IR89-EC-SD01 through IR89-EC-SD05. As shown on Table 4-9, each of the sample stations detected the presence of metals in the samples. Only lead, with a maximum concentration of 35.4J mg/kg exceeded the Region IV Sediment Screening Levels of 35 mg/kg. Based upon the natural occurrence of metals in soil and sediment, occasional exceedences of relative standards are to be expected. The concentrations of the metals observed in the sediment samples are similar to concentrations observed in other samples throughout the base. Their presence is most likely a result of natural conditions and are not considered to be related to site activities.

4.5.2 Site 93

The investigation at Site 93 involved the collection of soil and groundwater samples in the area centered around Building TC-942. Each of the media sampled are presently separately. The locations of the sampling points at Site 93 are shown on Figure 4-2.

4.5.2.1 Soil - Site 93

Twenty-two soil samples were collected at Site 93 and analyzed for volatiles, semivolatiles, and metals. Of these 22 samples, 3 were analyzed for pesticides/PCBs. Table 4-10 provides a list of the positive detections at Site 93 and Table 4-11 summarizes the results of the analytical data.

Two VOCs were detected in the soil samples collected from Site 93, including 2-butanone and acetone. These compounds are not believed to be related to specific site operations. They are typically a result of laboratory and/or field procedures and are not considered to be related to site conditions. As mentioned above, acetone was detected in a rinsate blank during the soil investigation at a concentration of 70 µg/L. Neither acetone or 2-butanone exceeded the Region III Risk Based Concentrations (RBCs) for soil.

Two semivolatile compounds were detected including bis(2-ethylhexyl)phthalate and benzo(a)pyrene. Bis(2-ethylhexyl)phthalate was detected in 5 of 22 samples however, none of the detections exceeded the Region III RBCs for residential soil. Benzo(a)pyrene was detected only once, in sample IR93-MW02IW-04, at a concentration of 400J µg/kg which is greater than the Region III RBC of 88 µg/kg. The maximum semivolatile detection was bis(2-ethylhexyl)phthalate which occurred in the same sample.

Three pesticides were detected in the samples collected at Site 93. All three detections occurred from sample IR89-MW02DW-02. The compounds and concentrations included 4,4'-DDD, 4,4'-DDE, and 4,4'-DDT at concentrations of 55 µg/kg, 22 µg/kg, and 33 µg/kg, respectively. None of these concentrations exceeded the Region III RBCs for soil.

Inorganic compounds were detected across the site in a uniform pattern. Results of the analytical data were compared to both the Region III RBCs for residential soil and twice the average base background values. As provided on Table 4-11, many of the inorganics detected in the soil samples exceeded both the Region III RBCs and the base background values. Although exceedences of inorganics in the soil samples were present, the metals are not considered to be related to any operations at Site 93.

4.5.2.2 Groundwater - Site 93

The groundwater investigation at Site 93 entailed the collection of groundwater samples from the surficial and Castle Hayne aquifer. Shallow and intermediate wells were screened at approximately 25 and 40 feet below ground surface (bgs), respectively while the deep monitoring wells were screened approximately 70 feet bgs. Groundwater samples were collected from both temporary and permanent monitoring wells to assess site conditions. All of the groundwater analytical results for Site 93 are listed on Table 4-12 and summarized on Table 4-13.

Six separate VOCs were detected in the groundwater samples collected at Site 93. They included, 1,2-dichloroethene (total), chloroform, cis-1,2-dichloroethene, tetrachloroethene, trans-1,2-dichloroethene, and trichloroethene. Concentrations ranged from 0.1 µg/L of tetrachloroethene to 175 µg/L of cis-1,2-dichloroethene. The most frequently detected compound was trichloroethene, which was detected in 8 of 26 samples. The highest concentration of trichloroethene was 39.4 µg/L, detected in the sample collected from monitoring well IR93-TW01 which is located in the gravel parking area, immediately south of Building TC-942 and the original UST location. Of the volatile compounds present, four were detected at concentrations which exceeded either the Federal MCL or the NCWQS. The compounds which exceeded the criteria included, chloroform, cis-1,2-dichloroethene, tetrachloroethene, and trichloroethene.

Two semivolatile compounds including bis(2-ethylhexyl)phthalate and naphthalene were detected in the groundwater samples obtained from the monitoring wells at Site 93. Bis(2-ethylhexyl)phthalate was detected in 4 of 11 samples, however, only one of the detections exceeded the NCWQS. Bis(2-ethylhexyl)phthalate is not considered to be site related as it is a common laboratory contaminant. Naphthalene was detected at a concentration of 6J µg/L in the sample collected from IR93-MW05. This concentration is below the NCWQS of 21 µg/L. There were no pesticides/PCBs detected in any of the groundwater samples from Site 93.

Inorganics were detected in the majority of the groundwater samples obtained from Site 93. Of the metals detected, iron, manganese and lead were present at concentrations above the Federal MCLs and NCWQS. Lead exceeded both the federal MCL and the NCWQS in one sample which was collected from monitoring well IR93-MW02IW. The concentration of lead in this sample was 164 µg/L as compared to its corresponding Federal MCL and NCWQS of 15 µg/L. Iron exceeded the Federal MCL and the NCWQS in each of the eleven groundwater samples analyzed. The maximum concentration of iron, 4,330 µg/L, occurred in the sample taken from monitoring well IR93-MW01IW. Manganese exceeded the Federal MCL and NCWQS in 2 of the 11 groundwater samples. The maximum concentrations of manganese occurred in the sample collected from monitoring well IR93-MW01. The detections of iron manganese and lead, while above the water quality standards, are not considered to be contaminants of concern at the site. As discussed above, the presence of inorganics in groundwater, particularly iron and manganese, are a result of the natural site conditions, and not due to site operations.

4.6 Extent of Site Analytical Results

The sections below discuss the extent of contamination to the media sampled at OU No. 16 (Sites 89 and 93). The material presented below focus on the impact of volatile contamination to soil, groundwater, surface water, and sediment. Other fractions, including semivolatiles, pesticides/PCBs, and metals are not presented on figures or discussed in detail as they were infrequently detected at a concentration greater than established standards and were sporadic across the sites.

Figures are presented in the following sections which illustrate the spatial relationships of the volatile analytical data only. The information presented on the figures focuses on the detections which exceed relevant standards, such as the NCWQS and Federal MCLs. Tables have been included with the figures which provide information concerning the specific compounds detected in the various media and their respective concentrations.

4.6.1 Site 89

Sampling activities at Site 89 included the collection of soil and groundwater samples in the area of the DRMO and the wooded area east of White Street Extension. In addition, surface water and sediment samples were collected from Edwards Creek. The extent of volatile contamination concerning each of these media are discussed separately in the following sections.

4.6.1.1 Soil - Site 89

Soil at Site 89 has been impacted by organic compounds including volatiles, semivolatiles, and pesticides. The majority of the detections of volatile compounds occurred at monitoring well clusters IR89-MW03 and IR89-MW05 both of which are located in the western portion of Site 89. Monitoring well cluster IR89-MW03 is located near the original UST location within the DRMO. This area, inside the DRMO facility, is considered to be one of the potential source areas of site contamination. Impact to the soil is also apparent at monitoring well location IR89-MW05 located just west of the DRMO facility at the end of F Street. Monitoring well IR89-MW04, located in the wooded area, immediately east of White Street Extension, noted one detection of 1,2-dichloroethene (total) at a concentration of 27 μg/kg in a soil sample collected from 9 to 11 feet bgs.

In general, the data demonstrate that contaminated soil occurs at depth, and is most likely due to volatile organic compounds which are present in the groundwater affecting the local soil conditions. The majority of the maximum detections occur from the samples collected from approximately 11 to 13 feet bgs, which is within the saturated zone. Impacted soil is primarily concentrated in the area of the DRMO and is in general, present at depths of approximately 10 to 15 feet bgs.

The extent of soil contamination at Site 89 is not presented on a figure, but is likely to be present within select areas of the DRMO facility. As mentioned previously in this report, this area of Site 89 was a former motor pool facility. In addition to the original UST, typical day to day operations of the motor pool, such as parts cleaning, washing or occasional spills may have impacted soil in specific areas of the site. These potential sources may be present in soil within select areas local to the DRMO facility. There were no significant areas of soil contamination identified in the wooded portion of Site 89.

4.6.1.2 Groundwater - Site 89

Groundwater in the surficial and upper portions of the Castle Hayne aquifers at Site 89 has been impacted by VOCs. This includes groundwater to depths of approximately 40 to 50 feet bgs. Groundwater contamination in the surficial aquifer has been defined by the shallow monitoring wells which are screened at approximately 15 to 20 feet bgs. Intermediate wells have detected groundwater contamination at approximately 40 to 50 feet bgs. The intermediate wells are screened in the upper portions of the Castle Hayne Aquifer, immediately above the first semi-confining layer. Figure 4-3 presents the results of the VOCs detected in groundwater samples collected from the shallow wells. Figure 4-4 provides information on the extent of groundwater contamination detected in the intermediate wells at the site. The figures present results from temporary and permanent monitoring wells in which groundwater samples contained concentrations of VOCs greater than the NCWQS and/or the Federal MCLs.

As shown on Figure 4-3 , the majority of the VOCs detected in samples collected from the shallow monitoring wells at Site 89 are concentrated in the area of the DRMO facility and to the south in the direction of Edwards Creek. Areas to the west and slightly north (hydraulically upgradient) of the DRMO have also been impacted, but at lower concentrations compared to down gradient locations. Significant concentrations of VOCs were detected at monitoring well location IR89-MW05. This well cluster is located at the end of F Street, immediately west of the DRMO facility. This permanent monitoring well cluster was installed at this location based upon results obtained from temporary monitoring wells. Although the well location is west of the former UST STC-867 and the DRMO Area, it is considered to be part of the Site 89 contaminant plume. The boundaries of groundwater contamination in this portion of the site are further defined by monitoring wells associated with Site 93 located immediately west and northwest of Site 89.

The shallow groundwater in the wooded area east of the DRMO and White Street Extension has not been significantly effected. Several VOCs were detected in monitoring well IR89-MW04 which exceeded the water quality standards, demonstrating that the contaminant plume has migrated beyond White Street Extension at this portion of the site. However additional sample points east of the road demonstrate that the shallow groundwater plume is mostly limited to the area beneath the DRMO.

The groundwater sample collected from temporary monitoring well IR89-TW13 which is just north of Edwards Creek detected tetrachloroethene and trichloroethene at concentrations greater than the applicable groundwater standards. This data indicates that VOCs have migrated as far south as Edwards Creek. Based upon these results and the presence of VOCs in surface water, it appears that Edwards Creek acts as a intercept for contaminants moving with shallow groundwater. Groundwater samples from temporary wells located further south did not detect contaminants which exceeded the water quality standards. In addition, historical analytical data from permanent monitoring wells located in the housing area in the southeast portion of the aired photograph have not detected volatile organics in the groundwater. These analytical results indicate that Edwards Creek is acting as a natural barrier for the majority of VOCs migrating south of the DRMO facility.

Figure 4-4 presents the results of the groundwater samples collected from the intermediate wells at Site 89. As shown on the figure, VOCs are present in the groundwater at the intermediate depth in the area of the DRMO and in the wooded area, east of White Street Extension. The eastern boundary of groundwater contamination at the intermediate depth has been confirmed by both temporary and permanent monitoring well clusters. Specifically, permanent well clusters, IR89-MW06 and MW07, define the easternmost extent of groundwater contamination. The furthest permanent sample point east of the DRMO area is monitoring well cluster IR89-MW08 which did not detect any VOCs in the samples. Likewise, groundwater samples collected from temporary monitoring wells installed in this region of the study area did not detect any VOCs. The samples collected in the wooded portion of Site 89 have established the eastern most edge of the plume to extend approximately 1,500 feet from the DRMO source area.

Permanent deep monitoring wells extending to depths of approximately 70 feet below ground surface (bgs) were installed at monitoring well clusters IR89-MW03, MW04, MW05, MW06, MW07, and MW08. VOCs were not detected in any groundwater samples collected from deep monitoring wells. The absence of VOCs in the deep monitoring wells establishes the vertical extent of groundwater contamination to the depth of the intermediate wells (i.e., approximately 40 to 50 feet bgs).

As presented earlier in this section, groundwater samples noted detections of one semivolatile compound and various inorganics. There were no detections of pesticides or PCBs in the sample results. The presence of the semivolatile compound, bis(2-ethylhexyl)phthalate, is not considered to be site related. The inorganics detected in the groundwater samples are most likely attributable to natural conditions and are not considered to be a threat to the groundwater resource at the site.

4.6.1.3 Surface Water - Site 89

Figure 4-5 illustrates the presence of VOCs in the portion of Edwards Creek downgradient of the DRMO facility. Eight VOCs were detected in the surface water samples. Contaminant concentrations were relatively consistent in each of the samples obtained. The concentrations ranged from 0.1 µg/L of tetrachloroethene to 150J µg/L of 1,1,2,2-tetrachloroethane. Trichloroethene was the most frequently detected compound in the surface water samples. The creek appears to be receiving VOC contamination which has migrated through the shallow groundwater. Analytical findings indicate that the creek is acting as a natural barrier, which significantly limits the migration of VOCs in the shallow groundwater to the south.

It should be noted that surface water samples were obtained from Edwards Creek as part of a Site Inspection (SI) study performed by Baker in 1991 (Baker, 1991) and a RI/FS investigation in 1995 (Baker, 1995). The surface water samples collected during these investigations also detected VOCs in Edwards Creek.

In addition to the previous sampling of Edwards Creek mentioned above, surface water samples have been collected from the discharge point a drainage swale which flows into Edwards Creek. The swale is a man made drainage ditch located on the east side of the DRMO. The approximate location of this swale is shown on Figure 4-5. It was apparently constructed to alleviate drainage problems within the DRMO. It appears that the swale almost always contains some standing water which it discharges to Edwards Creek. During storm events this swale discharges significant amounts of surface water runoff to Edwards Creek. The surface water samples collected from this drainage swale and its discharge point to Edwards Creek, have detected similar concentrations of VOCs as those observed in Edwards Creek. Surface water sample IR89-SW08 was collected from the drainage swale which flows into Edwards Creek from the South. This sample detected very low concentrations of only one VOC, suggesting that this surface water body is not another source of contamination.

The detections of VOCs in Edwards Creek and the drainage swale which borders the eastern edge of the DRMO, coupled with the detection of a low concentration of only tetrachloroethene in the water discharging into Edwards Creek from the south, suggest that the source of the VOC contamination impacting Edwards Creek is located in the vicinity of the DRMO. It appears that VOCs enter the stream by contaminated groundwater which provides base flow to Edwards Creek and by groundwater which is channeled directly to the stream from the drainage swale.

4.6.1.4 Sediment - Site 89

a total of 10 sediment samples were collected at five sample locations within Edwards Creek and sent for fixed base laboratory analysis. Two samples were taken at each station, one from zero to six inches and a second from six to twelve inches. Additional samples were collected for volatile analysis only by the on-site mobile laboratory. VOCs were detected at sample stations IR89-EC-SD03, SD09, SD10, and SD11. However, the contaminants were detected most frequently at sample station IR89-EC-SC03 which is located near the discharge point of the drainage swale. Figure 4-6 provides an illustration of the sampling stations which detected VOCs in sediment.

As mentioned above, nine separate VOCs were detected in the sediment samples collected from the stream bed of Edwards Creek. Concentrations of VOCs in the sediment samples ranged from 1 µg/kg of trans-1,2-dichloroethene at IR89-EC-SD10-06 to 2,400 µg/kg of trichloroethene at IR89-EC-SD03-06. The majority of the maximum detections occurred at IR89-EC-SD03 in the sample collected from 0 to 6 inches.

4.6.2 Site 93

Sampling activities at Site 93 involved the collection of soil and groundwater samples in the area of Camp Gieger local to Building TC-942. The following subsections detail the extent of site contamination.

4.6.2.1 Soil - Site 93

Only two volatile organic compounds were detected at Site 93, including 2-butanone and acetone. Acetone was detected in 13 of 22 samples and at maximum concentration of 340 µg/kg. This compound was most likely introduced to the samples during laboratory analysis or during decontamination procedures used during the field program. It is not considered to be site related. The compound 2-butanone was detected in only one sample at an estimated concentration of 13J µg/kg.

Other detections of organic compounds included two semivolatile compounds and three pesticide compounds. The detections of the semivolatile organic compounds and pesticides are not uncommon as they have most likely been introduced to the environment by non-site related operational activities. For example, pesticides are known to have been applied at many areas across MCB, Camp Lejeune in the past and they are frequently detected in samples collected at other sites on the base.

In general, the analytical results demonstrate that soil at Site 93 has not been significantly impacted organic compounds. The majority of the detections are reasonably low and are most likely attributable to non-site related activities. In addition, none of the detections exceeded the relative RBCs for residential soils.

The presence of inorganics in the soil samples appeared at Site 93 in a relatively normal distribution across the study area, with no indications of extraordinarily high concentrations. However, several analytes including aluminum, arsenic, and iron exceeded their respective RBC values. The presence of the inorganics in the soil is not attributed to site operations and are not considered to be site contamination.

4.6.2.2 Groundwater - Site 93

Figure 4-7 presents the results of the VOCs detected in the shallow groundwater samples at Site 93. Impact to the groundwater at Site 93 is concentrated in the shallow aquifer in the area of the former UST near Building TC-942. Analytical findings indicate contaminated groundwater is confined to this area and has not migrated substantially from the original source area. In addition, low concentrations of VOCs were detected in groundwater samples collected from the intermediate wells, demonstrating that very little vertical migration of the contaminants has occurred. Impact of the shallow groundwater was evident south and west of the site, but decreased readily in these directions. Figure 4-7 provides an estimate of the area that has been impacted by groundwater contamination at Site 93. The estimated area of shallow groundwater contamination is local to the former UST site and extends approximately 650 feet west to IR93-TW07. VOCs were detected in three wells, IR93-TW01IW, TW02IW, and TW06IW. IR93-TW01IW and TW06IW are within the estimated area of shallow groundwater contamination, while IR93-TW02IW is located immediately north of the estimated boundary of shallow groundwater contamination. The detected concentrations were below the applicable groundwater standards and so they are not presented on a figure.

Figure 4-8 shows the estimated boundary of shallow groundwater contamination for OU No. 16, including both Sites 89 and 93. This figure is presented to illustrate that two separate contaminant plumes are present at OU No. 16, one at Site 89 and one at Site 93. Although contaminants are similar at both sites, the data indicate that the plumes are a result of two different source areas. One being the DRMO facility at Site 89 and the other being the former UST located near Building TC-942 at Site 93. The contaminant plumes have been defined separately through specific monitoring well installation at both sites.

In general, the areal extent of the contaminated plume at site 89 is significantly larger. In addition, contaminants at Site 89 have migrated vertically to the upper portions of the Castle Hayne aquifer extending to depths of approximately 40 to 50 feet bgs. Vertical migration of contaminants at Site 93 is insignificant.

4.7 **Summary**

The primary contaminant of concern at OU No. 16 (Sites 89 and 93) are VOCs which have impacted shallow and intermediate groundwater. The data collected as part of the RI demonstrate that two distinct contaminant plumes are present at OU No. 16. At Site 89 shallow groundwater has been impacted by VOCs in the area of the DRMO facility. The shallow contaminant plume has migrated south and slightly east of the DRMO. Edwards Creek has been impacted by the contaminant plume migration to the south. Groundwater at the intermediate depth (approximately 40 to 50 feet bgs) has also been affected at Site 89. The contaminants in the area of the DRMO have migrated vertically and are present in the upper portions of the Castle Hayne Aquifer. A semi-confining layer at approximately 40 feet bgs appears to limit the vertical migration of the volatile compounds. At the intermediate depth, volatiles have migrated east of the DRMO facility across White Street Extension into the wooded portion of the site. The contaminant plume at the intermediate depth extends approximately 1,500 feet east from the assumed source area.

As mentioned above, Edwards Creek has been impacted by VOCs migrating from the source area. This is evident by detections of volatile organic compounds in surface water and sediment samples. The presence of these organic compounds is relatively consistent in portions of the stream located immediately south of the DRMO facility.

Groundwater contamination at Site 93 is apparently associated with the former UST near Building TC-942. The areal extent of this plume is relatively local to the original source area, and much smaller than at Site 89. The contaminants are primarily located within the shallow aquifer, with very low concentrations (i.e., less than applicable groundwater standards) detected in the intermediate wells.

4.8 References

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SECTION 4.0 TABLES

TABLE 4-1

SUMMARY OF BASE
BACKGROUND INORGANIC LEVELS IN SUBSURFACE SOIL
OPERABLE UNIT NO. 16 (SITES 89 AND 93)
RI/FS, CTO-0356
MCB, CAMP LEJEUNE, NORTH CAROLINA

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

Note:

mg/kg = milligram per kilogram

TABLE 4-2
POSITIVE DETECTIONS
SUBSURFACE SOIL - TCL ORGANICS
PHASE II - FIXED BASE LABORATORY
RI/FS CTO-0356
OPERABLE UNIT NO. 16 (SITE 89)
MCB CAMP LEJEUNE, NORTH CAROLINA

SAMPLE ID	IR89-MW03IW-02	IR89-MW03DW-02	IR89-MW03IW-05	IR89-MW03DW-05	IR89-MW04-03	IR89-MW04DW-03
PHASE	PHASE II	PHASE II	PHASE II	PHASE II	PHASE II	PHASE II
DATE SAMPLED	05/15/97	05/15/97	05/15/97	05/15/97	04/15/97	04/17/97
DEPTH	3-5'	3-5'	9-11'	9-11'	5-7'	5-7'
VOLATILES (ug/kg)						
1,1,2,2-TETRACHLOROETHANE	61	98	29	20	13 U	12 U
1,2-DICHLOROETHENE (TOTAL)	33 J	9 J	41	12 U	13 U	12 U
2-BUTANONE	12 U	12 U	13 U	12 U	13 U	12 U
ACETONE	16 J	13 J	16	20 J	90	15
BENZENE	12 U	12 U	13 U	12 U	13 U	12 U
CARBON DISULFIDE	12 U	12 U	13 U	12 U	13 U	12 U
TETRACHLOROETHENE	4 J	12 U	5 J	12 U	13 U	12 U
TOLUENE	12 U	12 U	13 U	12 U	13 U	12 U
TRICHLOROETHENE	30 J	23	25	3 J	13 U	12 U
SEMIVOLATILES (ug/kg)						
BIS(2-ETHYLHEXYL)PHTHALATE	380 U	380 U	480	410 U	430 U	410 U
FLUORANTHENE	380 UJ	43 J	43 J	410 U	430 U	410 U
PYRENE	380 UJ	49 J	66 J	410 U	430 U	410 U
PESTICIDES/PCBS (ug/kg)						
4,4'-DDD	19 J	NA	4.3 U	NA	4.2 UJ	NA
4,4'-DDE	17 J	NA	4.3 U	NA	4.2 UJ	NA
4,4'-DDT	91	NA	4.3 U	NA	4.2 UJ	NA

QUALIFIER DEFINITIONS

U = Not detected at quantitation limit.

UJ = Report quantitation limit is estimated.

J = Estimated quantity.

NA = Not analyzed

NOTES:

ug/kg = micrograms per kilogram

TABLE 4-2 (continued)
POSITIVE DETECTIONS
SUBSURFACE SOIL - TCL ORGANICS
PHASE II - FIXED BASE LABORATORY
RI/FS CTO-0356
OPERABLE UNIT NO. 16 (SITE 89)
MCB CAMP LEJEUNE, NORTH CAROLINA

SAMPLE ID	IR89-MW04-05	IR89-MW04DW-05	IR89-MW05-03	IR89-MW05IW-03	IR89-MW05DW-03	IR89-MW05-06
PHASE	PHASE II	PHASE II	PHASE II	PHASE II	PHASE II	PHASE II
DATE SAMPLED	04/15/97	04/17/97	04/20/97	04/18/97	04/19/97	04/20/97
DEPTH	9-11'	9-11'	5-7'	5-7'	5-7'	11-13'
VOLATILES (ug/kg)						
1,1,2,2-TETRACHLOROETHANE	12 U	15 U	13 U	12 U	13 U	17 U
1,2-DICHLOROETHENE (TOTAL)	27	15 U	13 U	12 U	13 U	57
2-BUTANONE	12 U	15 U	13 U	12 U	13 U	17 U
ACETONE	46	15 U	96 U	17	22 U	39 U
BENZENE	12 U	15 U	13 U	12 U	13 U	17 U
CARBON DISULFIDE	12 U	15 U	13 U	12 U	13 U	4 J
TETRACHLOROETHENE	12 U	15 U	13 U	12 U	13 U	17 U
TOLUENE	12 U	15 U	13 U	12 U	13 U	17 U
TRICHLOROETHENE	12 U	15 U	13 U	12 U	13 U	95
SEMIVOLATILES (ug/kg)						
BIS(2-ETHYLHEXYL)PHTHALATE	98 J	490 U	87 J	42 J	430 U	290 J
FLUORANTHENE	400 U	490 U	430 U	400 U	430 U	570 U
PYRENE	400 U	490 U	430 U	400 U	430 U	570 U
PESTICIDES/PCBS (ug/kg)						
4,4'-DDD	4 UJ	NA	NA	12 UJ	NA	NA
4,4'-DDE	4 UJ	NA	NA	4 UJ	NA	NA
4,4'-DDT	4 UJ	NA	NA	4 UJ	NA	NA

QUALIFIER DEFINITIONS

U = Not detected at quantitation limit.

UJ = Report quantitation limit is estimated.

J = Estimated quantity.

NA = Not analyzed

NOTES:

ug/kg = micrograms per kilogram

TABLE 4-2 (continued)
POSITIVE DETECTIONS
SUBSURFACE SOIL - TCL ORGANICS
PHASE II - FIXED BASE LABORATORY
RI/FS CTO-0356
OPERABLE UNIT NO. 16 (SITE 89)
MCB CAMP LEJEUNE, NORTH CAROLINA

SAMPLE ID	IR89-MW05IW-06	IR89-MW05DW-06	IR89-MW06IW-01	IR89-MW06DW-01	IR89-MW06IW-02	IR89-MW06DW-02
PHASE	PHASE II	PHASE II	PHASE II	PHASE II	PHASE II	PHASE II
DATE SAMPLED	04/18/97	04/19/97	05/02/97	05/02/97	05/02/97	05/02/97
DEPTH	11-13'	11-13'	1-3'	1-3'	3-5'	3-5'
VOLATILES (ug/kg)						
1,1,2,2-TETRACHLOROETHANE	14 U	13 U	12 U	11 U	12 U	12 U
1,2-DICHLOROETHENE (TOTAL)	13 J	68	12 U	11 U	12 U	12 U
2-BUTANONE	17 J	13 U	12 U	11 U	12 U	12 U
ACETONE	100	64 UJ	14 J	11 U	13	12 U
BENZENE	14 U	13 U	12 U	11 U	12 U	12 U
CARBON DISULFIDE	14 U	13 U	12 U	11 U	12 U	12 U
TETRACHLOROETHENE	14 U	13 U	12 U	11 U	12 U	12 U
TOLUENE	110	13 U	12 U	11 U	12 U	12 U
TRICHLOROETHENE	6 J	110	12 U	11 U	12 U	12 U
SEMIVOLATILES (ug/kg)						
BIS(2-ETHYLHEXYL)PHTHALATE	130 J	470 U	58 J	630	400 U	81 J
FLUORANTHENE	460 U	470 U	390 U	380 U	400 U	390 U
PYRENE	460 U	470 U	390 U	380 U	400 U	390 U
PESTICIDES/PCBS (ug/kg)						
4,4'-DDD	NA	NA	NA	NA	NA	NA
4,4'-DDE	NA	NA	NA	NA	NA	NA
4,4'-DDT	NA	NA	NA	NA	NA	NA

QUALIFIER DEFINITIONS

U = Not detected at quantitation limit.

UJ = Report quantitation limit is estimated.

J = Estimated quantity.

NA = Not analyzed

NOTES:

ug/kg = micrograms per kilogram

TABLE 4-2 (continued)
POSITIVE DETECTIONS
SUBSURFACE SOIL - TCL ORGANICS
PHASE II - FIXED BASE LABORATORY
RI/FS CTO-0356
OPERABLE UNIT NO. 16 (SITE 89)
MCB CAMP LEJEUNE, NORTH CAROLINA

SAMPLE ID	IR89-MW07IW-04	IR89-MW07DW-04	IR89-MW07IW-06	IR89-MW07DW-06	IR89-MW08IW-04	IR89-MW08DW-04
PHASE	PHASE II	PHASE II	PHASE II	PHASE II	PHASE II	PHASE II
DATE SAMPLED	05/03/97	05/04/97	05/03/97	05/04/97	05/12/97	05/13/97
DEPTH	7-9'	7-9'	11-13'	11-13'	7-9'	7-9'
VOLATILES (ug/kg)						
1,1,2,2-TETRACHLOROETHANE	11 U	11 U	12 U	12 U	13 U	12 U
1,2-DICHLOROETHENE (TOTAL)	11 U	11 U	12 U	12 U	13 U	12 U
2-BUTANONE	11 U	11 U	12 U	12 U	13 U	12 U
ACETONE	11 U	11 U	12 U	12 U	21 J	34 J
BENZENE	11 U	11 U	12 U	12 U	13 U	12 U
CARBON DISULFIDE	11 U	11 U	12 U	12 U	13 U	12 U
TETRACHLOROETHENE	11 U	11 U	12 U	12 U	13 U	12 U
TOLUENE	11 U	11 U	12 U	12 U	13 U	12 U
TRICHLOROETHENE	11 U	11 U	12 U	12 U	13 U	12 U
SEMIVOLATILES (ug/kg)						
BIS(2-ETHYLHEXYL)PHTHALATE	360 U	95 J	410 U	410 U	430 U	390 U
FLUORANTHENE	360 U	370 U	410 U	410 U	430 U	390 U
PYRENE	360 U	370 U	410 U	410 U	430 U	390 U
PESTICIDES/PCBS (ug/kg)						
4,4'-DDD	NA	NA	NA	NA	NA	NA
4,4'-DDE	NA	NA	NA	NA	NA	NA
4,4'-DDT	NA	NA	NA	NA	NA	NA

QUALIFIER DEFINITIONS

U = Not detected at quantitation limit.

UJ = Report quantitation limit is estimated.

J = Estimated quantity.

NA = Not analyzed

NOTES:

ug/kg = micrograms per kilogram

TABLE 4-2 (continued)
POSITIVE DETECTIONS
SUBSURFACE SOIL - TCL ORGANICS
PHASE II - FIXED BASE LABORATORY
RI/FS CTO-0356
OPERABLE UNIT NO. 16 (SITE 89)
MCB CAMP LEJEUNE, NORTH CAROLINA

SAMPLE ID	IR89-MW08IW-06	IR89-MW08DW-06
PHASE	PHASE II	PHASE II
DATE SAMPLED	05/12/97	05/13/97
DEPTH	11-13'	11-13'
VOLATILES (ug/kg)		
1,1,2,2-TETRACHLOROETHANE	12 U	12 U
1,2-DICHLOROETHENE (TOTAL)	12 U	12 U
2-BUTANONE	12 U	12 U
ACETONE	36 J	12 UJ
BENZENE	3 J	12 U
CARBON DISULFIDE	12 U	12 U
TETRACHLOROETHENE	12 U	12 U
TOLUENE	12 U	12 U
TRICHLOROETHENE	12 U	12 U
SEMIVOLATILES (ug/kg)		
BIS(2-ETHYLHEXYL)PHTHALATE	390 U	76 J
FLUORANTHENE	390 U	380 U
PYRENE	390 U	380 U
PESTICIDES/PCBS (ug/kg)		
4,4'-DDD	NA	NA
4,4'-DDE	NA	NA
4,4'-DDT	NA	NA

QUALIFIER DEFINITIONS
U = Not detected at quantitation limit.
UJ = Report quantitation limit is estimated.
J = Estimated quantity.
NA = Not analyzed
NOTES:
ug/kg = micrograms per kilogram

TABLE 4-2 (continued)
POSITIVE DETECTIONS
SUBSURFACE SOIL - TAL METALS
PHASE II - FIXED BASE LABORATORY
RI/FS CTO-0356
OPERABLE UNIT NO. 16 (SITE 89)
MCB CAMP LEJEUNE, NORTH CAROLINA

SAMPLE ID	IR89-MW03IW-02	IR89-MW03DW-02	IR89-MW03IW-05	IR89-MW03DW-05	IR89-MW04-03	IR89-MW04DW-03
PHASE	PHASE II	PHASE II	PHASE II	PHASE II	PHASE II	PHASE II
DATE SAMPLED	05/15/97	05/15/97	05/15/97	05/15/97	04/15/97	04/17/97
DEPTH	3-5'	3-5'	9-11'	9-11'	5-7'	5-7'
TOTAL METALS (mg/kg)						
ALUMINUM, TOTAL	1630	6080 J	2350	2590 J	8780 J	4640 J
ANTIMONY, TOTAL	0.35 UJ	0.38	0.35 UJ	0.36 U	0.31 U	0.29 U
ARSENIC, TOTAL	0.5 UJ	0.44 UJ	0.5 UJ	0.51 UJ	0.85 U	0.44 J
BARIUM, TOTAL	4.1	13.2	6.7	4.9	29.9	15.8
BERYLLIUM, TOTAL	0.06 U	0.05	0.06 U	0.06 U	0.78	0.37
CADMIUM, TOTAL	0.07 U	0.06 U	0.07 U	0.08 U	0.04 UJ	0.04 UJ
CALCIUM, TOTAL	1420	494	707	131	1620	1140
CHROMIUM, TOTAL	2.2	6.1	6.8	3.4	7.3	5.7
COBALT, TOTAL	0.09 UJ	0.13 J	0.33 J	0.09 UJ	0.61 J	0.23 J
COPPER, TOTAL	0.15 UJ	0.76 J	0.85 J	0.15 UJ	1.5	0.75 J
IRON, TOTAL	1120	3200	1520	507	3070	1890
LEAD, TOTAL	2.9	4.9	2.9	2.4	12.6 J	9.3 J
MAGNESIUM, TOTAL	66	161	81.3	69.3	460	284
MANGANESE, TOTAL	1.4	5.2	4.2	1.9	10.1	7.4
NICKEL, TOTAL	0.13 UJ	0.56 J	0.75 J	0.13 UJ	1.5 J	0.53 J
POTASSIUM, TOTAL	50.7 U	160	166 J	156	327 J	210 J
SELENIUM, TOTAL	0.46 J	0.56	0.66 J	0.41 U	0.37 UJ	0.34 UJ
SILVER, TOTAL	3 J	0.08 U	0.09 U	0.09 U	0.04 U	0.04 U
SODIUM, TOTAL	35.1 U	69.3	42.9	35.3 U	252 J	179 J
VANADIUM, TOTAL	5.7	9.4	5.4	4.5	6.8	5.5
ZINC, TOTAL	0.5 J	2.5 J	1.9 J	0.75 J	4.5 J	3.6 J

QUALIFIER DEFINITIONS
U = Not detected at quantitation limit.
UJ = Report quantitation limit is estimated.
J = Estimated quantity.
NA = Not analyzed
NOTES:
mg/kg = milligrams per kilogram

TABLE 4-2 (continued)
POSITIVE DETECTIONS
SUBSURFACE SOIL - TAL METALS
PHASE II - FIXED BASE LABORATORY
RI/FS CTO-0356
OPERABLE UNIT NO. 16 (SITE 89)
MCB CAMP LEJEUNE, NORTH CAROLINA

SAMPLE ID	IR89-MW04-05		IR89-MW04DW-05		IR89-MW05-03		IR89-MW05IW-03		IR89-MW05DW-03		IR89-MW05-06	
PHASE	PHASE II		PHASE II		PHASE II		PHASE II		PHASE II		PHASE II	
DATE SAMPLED	04/15/97		04/17/97		04/20/97		04/18/97		04/19/97		04/20/97	
DEPTH	9-11'		9-11'		5-7'		5-7'		5-7'		11-13'	
TOTAL METALS (mg/kg)												
ALUMINUM, TOTAL	2280	J	8540	J	9410		7260	JJ	6450		8090	
ANTIMONY, TOTAL	0.32	U	0.38	U	0.27	UJ	0.28	U	0.29	UJ	0.39	UJ
ARSENIC, TOTAL	0.35	UJ	0.72	J	0.77	J	0.56		0.6	J	0.44	UJ
BARIUM, TOTAL	11.6		27.3		17.7		15.4		13.9		15.5	
BERYLLIUM, TOTAL	0.33		0.94		0.07		0.06		0.05		0.55	
CADMIUM, TOTAL	0.04	UJ	0.24	J	0.04	J	0.04	UJ	0.04	UJ	0.05	UJ
CALCIUM, TOTAL	2450		2610		19100		737		1290		3870	
CHROMIUM, TOTAL	3.9		8.7		10		7.5		6.8		6.8	
COBALT, TOTAL	0.25	J	7.7		0.38	J	0.21	J	0.09	J	1.1	J
COPPER, TOTAL	0.96	J	2.7		1.4	J	0.71	J	0.83	J	0.69	J
IRON, TOTAL	12100		9980		3980		2790		2540		2990	
LEAD, TOTAL	3.9	J	9.5	J	9.8		7.2	J	5.4		7.6	
MAGNESIUM, TOTAL	195		496		569		253		223		238	
MANGANESE, TOTAL	10.7		10.9		11		11.7		9.1		13.7	
NICKEL, TOTAL	1	J	11.3		1.2	J	0.79	J	0.71	J	2.5	J
POTASSIUM, TOTAL	163	J	389	J	342	J	273	J	240	J	176	J
SELENIUM, TOTAL	0.37	UJ	0.45	UJ	0.32	UJ	0.34	UJ	0.47	J	0.6	J
SILVER, TOTAL	0.04	U	0.05	U	0.18		0.04	U	0.04	U	0.05	U
SODIUM, TOTAL	68	J	190	J	90.4	J	35.6	J	44.4	J	88.4	J
VANADIUM, TOTAL	3.8		9.5		13.6		10.8		9.3		6.8	
ZINC, TOTAL	2.2	J	111	J	8.8	J	2.5	J	4	J	3.9	J

QUALIFIER DEFINITIONS

U = Not detected at quantitation limit.

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J = Estimated quantity.

NA = Not analyzed

NOTES:

mg/kg = milligrams per kilogram

TABLE 4-2 (continued)
POSITIVE DETECTIONS
SUBSURFACE SOIL - TAL METALS
PHASE II - FIXED BASE LABORATORY
RI/FS CTO-0356
OPERABLE UNIT NO. 16 (SITE 89)
MCB CAMP LEJEUNE, NORTH CAROLINA

SAMPLE ID	IR89-MW05IW-06	IR89-MW05DW-06	IR89-MW06IW-01	IR89-MW06DW-01	IR89-MW06IW-02	IR89-MW06DW-02
PHASE	PHASE II	PHASE II	PHASE II	PHASE II	PHASE II	PHASE II
DATE SAMPLED	04/18/97	04/19/97	05/02/97	05/02/97	05/02/97	05/02/97
DEPTH	11-13'	11-13'	1-3'	1-3'	3-5'	3-5'
TOTAL METALS (mg/kg)						
ALUMINUM, TOTAL	1910 J	4890	4910	5820	11200	9440
ANTIMONY, TOTAL	0.36 U	0.34 UJ	0.26 U	0.34 U	0.27 U	0.31 U
ARSENIC, TOTAL	0.41 UJ	0.39 UJ	0.89 J	0.38 UJ	1.6 J	1.6 J
BARIUM, TOTAL	7.2	10.6	9	11.7	12.3	13.1
BERYLLIUM, TOTAL	0.16	0.44	0.05	0.07	0.08	0.07
CADMIUM, TOTAL	0.05 UJ	0.04 UJ	0.03 UJ	0.04 UJ	0.03 UJ	0.04 UJ
CALCIUM, TOTAL	845	1740	21.1 UJ	51.6	12.8 U	16.2 U
CHROMIUM, TOTAL	2.4	4.8	5.4	3.7	13.2	12.3
COBALT, TOTAL	0.14 J	1.1 J	0.09 J	0.06 UJ	0.52 J	0.32 J
COPPER, TOTAL	0.76 J	0.66 J	0.27	0.17	0.76	0.74
IRON, TOTAL	1310	2290	3630	2620	8110	8350
LEAD, TOTAL	2.8 J	5.3	4	4	8.1	7.1
MAGNESIUM, TOTAL	82.6	183	139	120	372	298
MANGANESE, TOTAL	5.8	8.6	5.7	8.3	5	4.3
NICKEL, TOTAL	0.16 UJ	1.9 J	0.27 UJ	0.44 UJ	0.88 UJ	0.47 UJ
POTASSIUM, TOTAL	78 U	141 J	149 J	117	308 J	282 J
SELENIUM, TOTAL	0.43 UJ	0.41 UJ	0.36 UJ	0.46 UJ	0.37 UJ	0.42 J
SILVER, TOTAL	0.05 U	0.04 U	0.03 U	0.04 U	0.03 U	0.04 U
SODIUM, TOTAL	29.7 UJ	44.1 J	92.1	47.8	97.9	123
VANADIUM, TOTAL	3.4	5.8	9.6	7.1	20.8	22.1
ZINC, TOTAL	1.1 J	5.7 J	0.81 J	0.94 J	2.4 J	1.7 J

QUALIFIER DEFINITIONS

U = Not detected at quantitation limit.

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NA = Not analyzed

NOTES:

mg/kg = milligrams per kilogram

TABLE 4-2 (continued)
POSITIVE DETECTIONS
SUBSURFACE SOIL - TAL METALS
PHASE II - FIXED BASE LABORATORY
RI/FS CTO-0356
OPERABLE UNIT NO. 16 (SITE 89)
MCB CAMP LEJEUNE, NORTH CAROLINA

SAMPLE ID	IR89-MW07IW-04	IR89-MW07DW-04	IR89-MW07IW-06	IR89-MW07DW-06	IR89-MW08IW-04	IR89-MW08DW-04
PHASE	PHASE II	PHASE II	PHASE II	PHASE II	PHASE II	PHASE II
DATE SAMPLED	05/03/97	05/04/97	05/03/97	05/04/97	05/12/97	05/13/97
DEPTH	7-9'	7-9'	11-13'	11-13'	7-9'	7-9'
TOTAL METALS (mg/kg)						
ALUMINUM, TOTAL	2780	1380	7170	4900	2250	7070
ANTIMONY, TOTAL	0.36 U	0.37 U	0.37 U	0.47 U	0.6 J	0.41 UJ
ARSENIC, TOTAL	1.8 J	0.56 J	0.42 J	0.4 UJ	1.1	2.3 J
BARIUM, TOTAL	5.5	3.3	12.9	7.7	3.8	10.9
BERYLLIUM, TOTAL	0.03	0.02 U	0.06	0.04	0.07 U	0.07
CADMIUM, TOTAL	0.03 UJ	0.04 UJ	0.04 UJ	0.04 UJ	0.09 U	0.09 U
CALCIUM, TOTAL	21.7 UJ	361	41 UJ	29 UJ	11.9	11.6
CHROMIUM, TOTAL	4	2.6	6.6	3.9	4.2	10.3
COBALT, TOTAL	0.05 J	0.05 UJ	0.27 J	0.14 J	0.11 UJ	0.18 J
COPPER, TOTAL	0.32	0.12 U	0.32	0.16 U	0.17 UJ	1.1 J
IRON, TOTAL	2260	1490	3300	1770	3600	4020
LEAD, TOTAL	3	2.4	7	6.2	3.9	6.2
MAGNESIUM, TOTAL	81.4	61.2	285	170	54.4	228
MANGANESE, TOTAL	2.3	1.7 UJ	2.5	2.6	1.2	11.1
NICKEL, TOTAL	0.11 UJ	0.12 UJ	0.15 UJ	0.16 UJ	0.15 UJ	0.24 J
POTASSIUM, TOTAL	149 J	98.7 U	158 J	121 J	108 U	330 J
SELENIUM, TOTAL	0.34 UJ	0.39 UJ	0.4 UJ	0.49 UJ	0.52	0.53 J
SILVER, TOTAL	0.03 U	0.04 U	0.04 U	0.04 U	0.11 U	0.11 U
SODIUM, TOTAL	42.5	23.1 U	50.9	47.9	41.3 U	80.7
VANADIUM, TOTAL	10.5	4.2	9.9	5.1	11	15.3
ZINC, TOTAL	0.45 J	0.04 UJ	0.81 J	0.12 J	0.13 J	1.8 J

QUALIFIER DEFINITIONS

U = Not detected at quantitation limit.

UJ = Report quantitation limit is estimated.

J = Estimated quantity.

NA = Not analyzed

NOTES:

mg/kg = milligrams per kilogram

TABLE 4-2 (continued)
POSITIVE DETECTIONS
SUBSURFACE SOIL - TAL METALS
PHASE II - FIXED BASE LABORATORY
RI/FS CTO-0356
OPERABLE UNIT NO. 16 (SITE 89)
MCB CAMP LEJEUNE, NORTH CAROLINA

SAMPLE ID	IR89-MW08IW-06	IR89-MW08DW-06
PHASE	PHASE II	PHASE II
DATE SAMPLED	05/12/97	05/13/97
DEPTH	11-13'	11-13'
TOTAL METALS (mg/kg)		
ALUMINUM, TOTAL	1900	1390
ANTIMONY, TOTAL	0.53	0.36 UJ
ARSENIC, TOTAL	0.56 UJ	0.51 UJ
BARIUM, TOTAL	4.8	4.7
BERYLLIUM, TOTAL	0.06 U	0.06 U
CADMIUM, TOTAL	0.08 U	0.08 U
CALCIUM, TOTAL	44.7	51.2
CHROMIUM, TOTAL	2.5	1.4
COBALT, TOTAL	0.1 UJ	0.1 UJ
COPPER, TOTAL	0.17 UJ	0.15 UJ
IRON, TOTAL	714	497
LEAD, TOTAL	1.8	1.8
MAGNESIUM, TOTAL	51.2	42.2
MANGANESE, TOTAL	1.3	0.43
NICKEL, TOTAL	0.2 J	0.13 UJ
POTASSIUM, TOTAL	89.3 U	63.2 U
SELENIUM, TOTAL	0.55	0.5 J
SILVER, TOTAL	0.1 U	0.1 U
SODIUM, TOTAL	39.1 U	35.9 U
VANADIUM, TOTAL	2.3	1.2
ZINC, TOTAL	0.18 J	0.08 UJ

QUALIFIER DEFINITIONS
U = Not detected at quantitation limit.
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J = Estimated quantity.
NA = Not analyzed
NOTES:
mg/kg = milligrams per kilogram

TABLE 4-3
SUMMARY OF POSITIVE DETECTIONS
SUBSURFACE SOIL - TCL ORGANICS
PHASE II - FIXED BASE LABORATORY
RI/FS CTO-0356
OPERABLE UNIT NO. 16 (SITE 89)
MCB CAMP LEJEUNE, NORTH CAROLINA

	Region III Residential RBCs (Risk) (ug/kg)	Min Detect	Max Detect	Location of Maximum Detect	Detection Frequency	Region III Residential RBCs (Risk) Exceedance Count
VOLATILES (ug/kg)						
1,1,2,2-TETRACHLOROETHANE	3200	20	98	IR89-MW03DW-02	4/26	0
1,2-DICHLOROETHENE (TOTAL)	70000	9 J	68	IR89-MW05DW-06	7/26	0
2-BUTANONE	4700000	17 J	17 J	IR89-MW05IW-06	1/26	0
ACETONE	780000	13	100	IR89-MW05IW-06	14/26	0
BENZENE	22000	3 J	3 J	IR89-MW08IW-06	1/26	0
CARBON DISULFIDE	780000	4 J	4 J	IR89-MW05-06	1/26	0
TETRACHLOROETHENE	12000	4 J	5 J	IR89-MW03IW-05	2/26	0
TOLUENE	1600000	110	110	IR89-MW05IW-06	1/26	0
TRICHLOROETHENE	58000	3 J	110	IR89-MW05DW-06	7/26	0
SEMIVOLATILES (ug/kg)						
BIS(2-ETHYLHEXYL)PHTHALATE	46000	42 J	630	IR89-MW06DW-01	11/26	0
FLUORANTHENE	310000	43 J	43 J	IR89-MW03DW-02, IR89-MW03IW-05	2/26	0
PYRENE	230000	49 J	66 J	IR89-MW03IW-05	2/26	0
PESTICIDES/PCBS (ug/kg)						
4,4'-DDD	2700	19 J	19 J	IR89-MW03IW-02	1/5	0
4,4'-DDE	1900	17 J	17 J	IR89-MW03IW-02	1/5	0
4,4'-DDT	1900	91	91	IR89-MW03IW-02	1/5	0

QUALIFIER DEFINITIONS
U = Not detected at quantitation limit.
UJ = Report quantitation limit is estimated.
J = Estimated quantity.
NA = Not analyzed
NOTES:
ug/kg = micrograms per kilogram

TABLE 4-3 (continued)
SUMMARY OF POSITIVE DETECTIONS
SUBSURFACE SOIL - TAL METALS
PHASE II - FIXED BASE LABORATORY
RI/FS CTO-0356
OPERABLE UNIT NO. 16 (SITE 89)
MCB CAMP LEJEUNE, NORTH CAROLINA

	Region III Residential RBCs (Risk) (mg/kg)	Subsurface Soil Bkg 2x Average Values Camp Lejeune	Min Detect	Max Detect	Location of Maximum Detect	Detection Frequency	Region III Residential RBCs (Risk) Exceedance Count	Subsurface Soil Bkg 2x Average Values Exceedance Count
TOTAL METALS (mg/kg)								
ALUMINUM, TOTAL	7800	7375.302	1380	11200	IR89-MW06IW-02	26/26	6	6
ANTIMONY, TOTAL	3.1	6.408	0.38	0.6 J	IR89-MW08IW-04	3/26	0	0
ARSENIC, TOTAL	0.43	1.968	0.42 J	2.3 J	IR89-MW08DW-04	13/26	12	1
BARIUM, TOTAL	550	14.204	3.3	29.9	IR89-MW04-03	26/26	0	6
BERYLLIUM, TOTAL	0.15	0.191	0.03	0.94	IR89-MW04DW-05	19/26	7	6
CADMIUM, TOTAL	3.9	0.712	0.04 J	0.24 J	IR89-MW04DW-05	2/26	0	0
CALCIUM, TOTAL	NE	391.509	11.6	19100	IR89-MW05-03	20/26	0	13
CHROMIUM, TOTAL	7800	12.562	1.4	13.2	IR89-MW06IW-02	26/26	0	1
COBALT, TOTAL	470	1.504	0.05 J	7.7	IR89-MW04DW-05	19/26	0	1
COPPER, TOTAL	310	2.416	0.17	2.7	IR89-MW04DW-05	19/26	0	1
IRON, TOTAL	2300	7252.076	497	12100	IR89-MW04-05	26/26	15	4
LEAD, TOTAL	400	8.327	1.8	12.6 J	IR89-MW04-03	26/26	0	4
MAGNESIUM, TOTAL	NE	260.718	42.2	569	IR89-MW05-03	26/26	0	7
MANGANESE, TOTAL	180	7.919	0.43	13.7	IR89-MW05-06	25/26	0	10
NICKEL, TOTAL	160	3.714	0.2 J	11.3	IR89-MW04DW-05	13/26	0	1
POTASSIUM, TOTAL	NE	347.236	117	389 J	IR89-MW04DW-05	20/26	0	1
SELENIUM, TOTAL	39	0.801	0.42 J	0.66 J	IR89-MW03IW-05	10/26	0	0
SILVER, TOTAL	39	0.866	0.18	3 J	IR89-MW03IW-02	2/26	0	1
SODIUM, TOTAL	NE	52.676	35.6 J	252 J	IR89-MW04-03	19/26	0	11
VANADIUM, TOTAL	55	13.454	1.2	22.1	IR89-MW06DW-02	26/26	0	4
ZINC, TOTAL	2300	6.662	0.12 J	111 J	IR89-MW04DW-05	24/26	0	2

QUALIFIER DEFINITIONS
U = Not detected at quantitation limit.
UJ = Report quantitation limit is estimated.
J = Estimated quantity.
NA = Not analyzed
NOTES:
ug/kg = micrograms per kilogram

TABLE 4-4
POSITIVE DETECTIONS
GROUNDWATER - TCL ORGANICS
PHASE I AND PHASE II - MOBILE LABORATORY AND PHASE II - FIXED BASE LABORATORY
RI/FS CTO-0356
OPERABLE UNIT NO. 16 (SITE 89)
MCB CAMP LEJEUNE, NORTH CAROLINA

SAMPLE ID	IR89-MW01-01	IR89-MW02-01	IR89-MW03-01	IR89-MW42B-02	IR89-TW04-01	IR89-TW04IW-01	IR89-TW08-01
PHASE	PHASE I	PHASE I	PHASE I	PHASE I	PHASE I	PHASE I	PHASE I
DATE SAMPLED	7/31/96	7/30/96	7/31/96	7/31/96	7/31/96	7/31/96	8/3/96
VOLATILES (ug/L)							
1,1,1-TRICHLOROETHANE	0.1 U	0.1 U	0.1 U	0.1 U	0.1 U	0.1 U	0.1 U
1,1,2,2-TETRACHLOROETHANE	NA	NA	NA	NA	NA	NA	NA
1,1,2-TRICHLOROETHANE	NA	NA	NA	NA	NA	NA	NA
1,1-DICHLOROETHENE	NA	NA	NA	NA	NA	NA	NA
1,2-DICHLOROETHENE (TOTAL)	NA	NA	NA	NA	NA	NA	NA
CHLOROFORM	1 U	1 U	1 U		2.3	2.1	1 U
CIS-1,2-DICHLOROETHENE	261	818	150	37	1 U	1 U	253
TETRACHLOROETHENE	42.4	9.4	13.1	0.1 U	0.1 U	0.1 U	27
TOLUENE	NA	NA	NA	NA	NA	NA	NA
TRANS-1,2-DICHLOROETHENE	177	451	82	6	1 U	1 U	61
TRICHLOROETHENE	323.1	744.3	131	85.8	0.1 U	0.1 U	638.4
VINYL CHLORIDE	50 U	130	50 U	50 U	50 U	50 U	50 U
SEMIVOLATILES (ug/L)							
BIS(2-ETHYLHEXYL)PHTHALATE	NA	NA	NA	NA	NA	NA	NA

QUALIFIER DEFINITIONS
U = Not detected at quantitation limit.
UJ = Report quantitation limit is estimated.
J = Estimated quantity.
NA = Not analyzed
NOTES:
ug/L = milligrams per liter

TABLE 4-4 (continued)
POSITIVE DETECTIONS
GROUNDWATER - TCL ORGANICS
PHASE I AND PHASE II - MOBILE LABORATORY AND
PHASE II - FIXED BASE LABORATORY
RI/FS CTO-0356
OPERABLE UNIT NO. 16 (SITE 89)
MCB CAMP LEJEUNE, NORTH CAROLINA

SAMPLE ID	IR89-TW08IW-01	IR89-TW09-01	IR89-TW09IW-01	IR89-TW10-01	IR89-TW10IW-01	IR89-TW11-01	IR89-TW11IW-01
PHASE	PHASE I	PHASE I	PHASE I	PHASE I	PHASE I	PHASE I	PHASE I
DATE SAMPLED	8/3/96	8/3/96	8/3/96	8/4/96	8/4/96	8/4/96	8/4/96
VOLATILES (ug/L)							
1,1,1-TRICHLOROETHANE	0.1 U	0.1 U	0.1 U	0.1 U	0.1 U	0.1 U	0.1 U
1,1,2,2-TETRACHLOROETHANE	NA	NA	NA	NA	NA	NA	NA
1,1,2-TRICHLOROETHANE	NA	NA	NA	NA	NA	NA	NA
1,1-DICHLOROETHENE	NA	NA	NA	NA	NA	NA	NA
1,2-DICHLOROETHENE (TOTAL)	NA	NA	NA	NA	NA	NA	NA
CHLOROFORM	0.8	4.8	1.9	5.2	0.4	3.9	2.2
CIS-1,2-DICHLOROETHENE	1 U	1 U	114	1 U	27	1 U	14
TETRACHLOROETHENE	0.1 U	0.1 U	8.8	0.1 U	0.1 U	0.1 U	0.1 U
TOLUENE	NA	NA	NA	NA	NA	NA	NA
TRANS-1,2-DICHLOROETHENE	1 U	1 U	20	1 U	5	1 U	1 U
TRICHLOROETHENE	0.3	0.1 U	233.4	0.2	36.3	0.1 U	3.3
VINYL CHLORIDE	50 U	50 U	50 U	50 U	50 U	50 U	50 U
SEMIVOLATILES (ug/L)							
BIS(2-ETHYLHEXYL)PHTHALATE	NA	NA	NA	NA	NA	NA	NA

QUALIFIER DEFINITIONS
U = Not detected at quantitation limit.
UJ = Report quantitation limit is estimated.
J = Estimated quantity.
NA = Not analyzed
NOTES:
ug/L = milligrams per liter

TABLE 4-4 (continued)
POSITIVE DETECTIONS
GROUNDWATER - TCL ORGANICS
PHASE I AND PHASE II - MOBILE LABORATORY AND
PHASE II - FIXED BASE LABORATORY
RI/FS CTO-0356
OPERABLE UNIT NO. 16 (SITE 89)
MCB CAMP LEJEUNE, NORTH CAROLINA

SAMPLE ID	IR89-TW12-01	IR89-TW12IW-01	IR89-TW13-01	IR89-TW13IW-01	IR89-TW15-01	IR89-TW15IW-01	IR89-TW16-01
PHASE	PHASE I	PHASE I	PHASE I	PHASE I	PHASE I	PHASE I	PHASE I
DATE SAMPLED	8/4/96	8/4/96	8/5/96	8/5/96	8/6/96	8/6/96	8/6/96
VOLATILES (ug/L)							
1,1,1-TRICHLOROETHANE	0.1 U	0.1 U	0.1 U	0.1 U	0.1 U	0.1 U	0.1 U
1,1,2,2-TETRACHLOROETHANE	NA	NA	NA	NA	NA	NA	NA
1,1,2-TRICHLOROETHANE	NA	NA	NA	NA	NA	NA	NA
1,1-DICHLOROETHENE	NA	NA	NA	NA	NA	NA	NA
1,2-DICHLOROETHENE (TOTAL)	NA	NA	NA	NA	NA	NA	NA
CHLOROFORM	1 U	0.5	1 U	0.7	7.2	1.7	8.6
CIS-1,2-DICHLOROETHENE	1 U	1 U	18	21	162	3	102
TETRACHLOROETHENE	0.1 U	0.1 U	4.8	7.4	13.7	0.1	42.7
TOLUENE	NA	NA	NA	NA	NA	NA	NA
TRANS-1,2-DICHLOROETHENE	1 U	1 U	3	1	53	1 U	44
TRICHLOROETHENE	0.1 U	0.1 U	136.9	57.9	355.9	6	562.9
VINYL CHLORIDE	50 U	50 U	50 U	50 U	50 U	50 U	50 U
SEMIVOLATILES (ug/L)							
BIS(2-ETHYLHEXYL)PHTHALATE	NA	NA	NA	NA	NA	NA	NA

QUALIFIER DEFINITIONS
U = Not detected at quantitation limit.
UJ = Report quantitation limit is estimated.
J = Estimated quantity.
NA = Not analyzed
NOTES:
ug/L = milligrams per liter

TABLE 4-4 (continued)
POSITIVE DETECTIONS
GROUNDWATER - TCL ORGANICS
PHASE I AND PHASE II - MOBILE LABORATORY AND
PHASE II - FIXED BASE LABORATORY
RI/FS CTO-0356
OPERABLE UNIT NO. 16 (SITE 89)
MCB CAMP LEJEUNE, NORTH CAROLINA

SAMPLE ID	IR89-TW16IW-01	IR89-TW17IW-01	IR89-TW18-01	IR89-TW18IW-01	IR89-TW19-01	IR89-TW19IW-01	IR89-TW20-01
PHASE	PHASE I	PHASE I	PHASE I	PHASE I	PHASE I	PHASE I	PHASE I
DATE SAMPLED	8/6/96	8/7/96	8/13/96	8/13/96	8/13/96	8/13/96	8/14/96
VOLATILES (ug/L)							
1,1,1-TRICHLOROETHANE	0.1 U	0.1 U	0.2	0.1 U	0.1 U	0.1 U	0.1 U
1,1,2,2-TETRACHLOROETHANE	NA	NA	NA	NA	NA	NA	NA
1,1,2-TRICHLOROETHANE	NA	NA	NA	NA	NA	NA	NA
1,1-DICHLOROETHENE	NA	NA	NA	NA	NA	NA	NA
1,2-DICHLOROETHENE (TOTAL)	NA	NA	NA	NA	NA	NA	NA
CHLOROFORM	1.7	2.6	6.6	2.4	1.3	0.5	0.1 U
CIS-1,2-DICHLOROETHENE	1 U	287	1 U	1 U	1 U	11	1 U
TETRACHLOROETHENE	0.1 U	1.5	0.2	0.1 U	0.1 U	0.1 U	0.1 U
TOLUENE	NA	NA	NA	NA	NA	NA	NA
TRANS-1,2-DICHLOROETHENE	1 U	90	1 U	1 U	1 U	1 U	1 U
TRICHLOROETHENE	0.6	425.7	0.1 U	0.1 U	0.1 U	3.8	0.1 U
VINYL CHLORIDE	50 U	50 U	50 U	50 U	50 U	50 U	50 U
SEMIVOLATILES (ug/L)							
BIS(2-ETHYLHEXYL)PHTHALATE	NA	NA	NA	NA	NA	NA	NA

QUALIFIER DEFINITIONS
U = Not detected at quantitation limit.
UJ = Report quantitation limit is estimated.
J = Estimated quantity.
NA = Not analyzed
NOTES:
ug/L = milligrams per liter

TABLE 4-4 (continued)
POSITIVE DETECTIONS
GROUNDWATER - TCL ORGANICS
PHASE I AND PHASE II - MOBILE LABORATORY AND
PHASE II - FIXED BASE LABORATORY
RI/FS CTO-0356
OPERABLE UNIT NO. 16 (SITE 89)
MCB CAMP LEJEUNE, NORTH CAROLINA

SAMPLE ID	IR89-TW20IW-01	IR89-TW21-01	IR89-TW21IW-01	IR89-TW22-01	IR89-TW22IW-01	IR89-TW23IW-01
PHASE	PHASE I	PHASE I	PHASE I	PHASE I	PHASE I	PHASE I
DATE SAMPLED	8/14/96	8/15/96	8/15/96	8/16/96	8/16/96	8/21/96
VOLATILES (ug/L)						
1,1,1-TRICHLOROETHANE	0.1 U	0.1 U	0.1 U	0.1 U	0.1 U	0.1 U
1,1,2,2-TETRACHLOROETHANE	NA	NA	NA	NA	NA	NA
1,1,2-TRICHLOROETHANE	NA	NA	NA	NA	NA	NA
1,1-DICHLOROETHENE	NA	NA	NA	NA	NA	NA
1,2-DICHLOROETHENE (TOTAL)	NA	NA	NA	NA	NA	NA
CHLOROFORM	0.4	0.1 U	1.7	0.7	0.3	0.5
CIS-1,2-DICHLOROETHENE	57	1 U	9	1 U	106	84
TETRACHLOROETHENE	0.4	0.1 U	0.1 U	0.1 U	13	0.1
TOLUENE	NA	NA	NA	NA	NA	NA
TRANS-1,2-DICHLOROETHENE	8	1 U	1	1 U	17	9
TRICHLOROETHENE	59.1	0.1 U	10.4	0.1 U	293.9	123.9
VINYL CHLORIDE	50 U	50 U	50 U	50 U	50 U	50 U
SEMIVOLATILES (ug/L)						
BIS(2-ETHYLHEXYL)PHTHALATE	NA	NA	NA	NA	NA	NA

QUALIFIER DEFINITIONS
U = Not detected at quantitation limit.
UJ = Report quantitation limit is estimated.
J = Estimated quantity.
NA = Not analyzed
NOTES:
ug/L = milligrams per liter

TABLE 4-4 (continued)
POSITIVE DETECTIONS
GROUNDWATER - TCL ORGANICS
PHASE I AND PHASE II - MOBILE LABORATORY AND PHASE II - FIXED BASE LABORATORY
RI/FS CTO-0356
OPERABLE UNIT NO. 16 (SITE 89)
MCB CAMP LEJEUNE, NORTH CAROLINA

SAMPLE ID	IR89-MW03IW-01	IR89-MW03DW-01	IR89-MW04-01	IR89-MW04IW-01	IR89-MW04DW-01	IR89-MW05-01
PHASE	PHASE II	PHASE II	PHASE II	PHASE II	PHASE II	PHASE II
DATE SAMPLED	05/28/97	05/28/97	05/29/97	05/29/97	05/29/97	05/28/97
VOLATILES (ug/L)						
1,1,1-TRICHLOROETHANE	10 U	10 U	10 U	10 U	10 U	10 U
1,1,2,2-TETRACHLOROETHANE	10 U	10 U	4 J	10 U	10 U	10 U
1,1,2-TRICHLOROETHANE	10 U	10 U	3 J	10 U	10 U	10 U
1,1-DICHLOROETHENE	10 U	10 U	10 U	2 J	10 U	10 U
1,2-DICHLOROETHENE (TOTAL)	300	10 U	880	560	10 U	180 J
CHLOROFORM	10 U	10 U	10 U	10 U	10 U	10 U
CIS-1,2-DICHLOROETHENE	NA	NA	NA	NA	NA	NA
TETRACHLOROETHENE	10 U	10 U	7 J	10 U	10 U	10 U
TOLUENE	10 U	10 U	10 U	10 U	10 U	10 U
TRANS-1,2-DICHLOROETHENE	NA	NA	NA	NA	NA	NA
TRICHLOROETHENE	400	10 U	640	510	10 U	280
VINYL CHLORIDE	10 U	10 U	43	9 J	10 U	6 J
SEMIVOLATILES (ug/L)						
BIS(2-ETHYLHEXYL)PHTHALATE	64	80	75	37 U	12 U	150

QUALIFIER DEFINITIONS
U = Not detected at quantitation limit.
UJ = Report quantitation limit is estimated.
J = Estimated quantity.
NA = Not analyzed
NOTES:
ug/L = milligrams per liter

TABLE 4-4 (continued)
POSITIVE DETECTIONS
GROUNDWATER - TCL ORGANICS
PHASE I AND PHASE II - MOBILE LABORATORY AND PHASE II - FIXED BASE LABORATORY
RI/FS CTO-0356
OPERABLE UNIT NO. 16 (SITE 89)
MCB CAMP LEJEUNE, NORTH CAROLINA

SAMPLE ID	IR89-MW05IW-01	IR89-MW05DW-01	IR89-MW06IW-01	IR89-MW06DW-01	IR89-MW07IW-01	IR89-MW07DW-01
PHASE	PHASE II	PHASE II	PHASE II	PHASE II	PHASE II	PHASE II
DATE SAMPLED	05/28/97	05/28/97	05/19/97	05/19/97	05/20/97	05/20/97
VOLATILES (ug/L)						
1,1,1-TRICHLOROETHANE	10 U	10 U	10 U	10 U	10 U	10 U
1,1,2,2-TETRACHLOROETHANE	10 U	10 U	10 U	10 U	10 U	10 U
1,1,2-TRICHLOROETHANE	10 U	10 U	10 U	10 U	10 U	10 U
1,1-DICHLOROETHENE	10 U	10 U	10 U	10 U	10 U	10 U
1,2-DICHLOROETHENE (TOTAL)	10 U	10 U	32	10 U	29	10 U
CHLOROFORM	10 U	10 U	10 U	10 U	10 U	10 U
CIS-1,2-DICHLOROETHENE	NA	NA	NA	NA	NA	NA
TETRACHLOROETHENE	10 U	10 U	10 U	10 U	10 U	10 U
TOLUENE	10 U	10 U	10 U	10 U	10 U	10 U
TRANS-1,2-DICHLOROETHENE	NA	NA	NA	NA	NA	NA
TRICHLOROETHENE	10 U	10 U	18	10 U	10 J	10 U
VINYL CHLORIDE	10 U	10 U	10 U	10 U	10 U	10 U
SEMIVOLATILES (ug/L)						
BIS(2-ETHYLHEXYL)PHTHALATE	10 U	10 U	10 U	11 U	10 U	10 U

QUALIFIER DEFINITIONS
U = Not detected at quantitation limit.
UJ = Report quantitation limit is estimated.
J = Estimated quantity.
NA = Not analyzed
NOTES:
ug/L = milligrams per liter

TABLE 4-4 (continued)
POSITIVE DETECTIONS
GROUNDWATER - TCL ORGANICS
PHASE I AND PHASE II - MOBILE LABORATORY AND PHASE II - FIXED BASE LABORATORY
RI/FS CTO-0356
OPERABLE UNIT NO. 16 (SITE 89)
MCB CAMP LEJEUNE, NORTH CAROLINA

SAMPLE ID	IR89-MW08IW-01	IR89-MW08DW-01	IR89-TW24IW-01	IR89-TW25IW-01	IR89-TW26IW-01	IR89-TW27IW-01
PHASE	PHASE II	PHASE II	PHASE II	PHASE II	PHASE II	PHASE II
DATE SAMPLED	05/19/97	05/19/97	04/20/97	04/20/97	04/20/97	04/20/97
VOLATILES (ug/L)						
1,1,1-TRICHLOROETHANE	10 U	10 U	0.1 U	0.1 U	0.1 U	0.1 U
1,1,2,2-TETRACHLOROETHANE	10 U	10 U	10 U	10 U	10 U	10 U
1,1,2-TRICHLOROETHANE	10 U	10 U	1 U	1 U	1 U	1 U
1,1-DICHLOROETHENE	10 U	10 U	0.1 U	0.1 U	0.1 U	0.1 U
1,2-DICHLOROETHENE (TOTAL)	10 U	10 U	1 U	1 U	1 U	1 U
CHLOROFORM	10 U	10 U	0.1 U	0.1 U	0.1 U	0.1 U
CIS-1,2-DICHLOROETHENE	NA	NA	1 U	1 U	1 U	1 U
TETRACHLOROETHENE	10 U	10 U	0.1 U	0.1	0.1 U	0.1 U
TOLUENE	10 U	10 U	2 U	2 U	2 U	2 U
TRANS-1,2-DICHLOROETHENE	NA	NA	NA	NA	NA	NA
TRICHLOROETHENE	10 U	10 U	0.1 U	0.1 U	0.1 U	0.1 U
VINYL CHLORIDE	10 U	10 U	50 U	50 U	50 U	50 U
SEMIVOLATILES (ug/L)						
BIS(2-ETHYLHEXYL)PHTHALATE	15 U	10 U	NA	NA	NA	NA

QUALIFIER DEFINITIONS
U = Not detected at quantitation limit.
UJ = Report quantitation limit is estimated.
J = Estimated quantity.
NA = Not analyzed
NOTES:
ug/L = milligrams per liter

TABLE 4-4 (continued)
POSITIVE DETECTIONS
GROUNDWATER - TCL ORGANICS
PHASE I AND PHASE II - MOBILE LABORATORY AND PHASE II - FIXED BASE LABORATORY
RI/FS CTO-0356
OPERABLE UNIT NO. 16 (SITE 89)
MCB CAMP LEJEUNE, NORTH CAROLINA

SAMPLE ID	IR89-TW28IW-01	IR89-TW29IW-01	IR89-TW30IW-01
PHASE	PHASE II	PHASE II	PHASE II
DATE SAMPLED	04/29/97	04/29/97	04/29/97
VOLATILES (ug/L)			
1,1,1-TRICHLOROETHANE	0.1 U	0.1 U	0.1 U
1,1,2,2-TETRACHLOROETHANE	10 U	10 U	10 U
1,1,2-TRICHLOROETHANE	1 U	1 U	1 U
1,1-DICHLOROETHENE	0.1 U	0.1 U	0.1 U
1,2-DICHLOROETHENE (TOTAL)	1 U	1 U	1 U
CHLOROFORM	1.2	0.1 U	0.1 U
CIS-1,2-DICHLOROETHENE	1 U	1 U	1 U
TETRACHLOROETHENE	0.1 U	0.1 U	0.1 U
TOLUENE	2 U	6	2 U
TRANS-1,2-DICHLOROETHENE	NA	NA	NA
TRICHLOROETHENE	0.1 U	0.1 U	0.1 U
VINYL CHLORIDE	50 U	50 U	50 U
SEMIVOLATILES (ug/L)			
BIS(2-ETHYLHEXYL)PHTHALATE	NA	NA	NA

QUALIFIER DEFINITIONS
U = Not detected at quantitation limit.
UJ = Report quantitation limit is estimated.
J = Estimated quantity.
NA = Not analyzed
NOTES:
ug/L = milligrams per liter

TABLE 4-4 (continued)
POSITIVE DETECTIONS
GROUNDWATER - TAL METALS
PHASE II - FIXED BASE LABORATORY
RI/FS CTO-0356
OPERABLE UNIT NO. 16 (SITE 89)
MCB CAMP LEJEUNE, NORTH CAROLINIA

SAMPLE ID	IR89-MW03IW-01	IR89-MW03DW-01	IR89-MW04-01	IR89-MWO4IW-01	IR89-MW04DW-01	IR89-MW05-01	IR89-MW05IW-01
PHASE	PHASE II	PHASE II	PHASE II	PHASE II	PHASE II	PHASE II	PHASE II
DATE SAMPLED	05/28/97	05/28/97	05/29/97	05/29/97	05/29/97	05/28/97	05/28/97
TOTAL METALS (ug/L)							
ANTIMONY, TOTAL	1.9 U	2.2	1.9 U	1.9 U	1.9 U	1.9 U	2
BARIUM, TOTAL	22.1	4.8	14.1	12.2	12.7	23.1	3.2
CALCIUM, TOTAL	92800	33200	89700	85300	33300	69400	77600
CHROMIUM, TOTAL	0.5	0.5 U	0.5 U	0.5 U	0.5 U	0.88	0.5
IRON, TOTAL	394 J	477 J	12200	386	57.3	20000 J	4330 J
MAGNESIUM, TOTAL	2210	4390	2670	2190	9910	4350	1790
MANGANESE, TOTAL	20.8	34.9	135	20.6	9.8	379	60.2
NICKEL, TOTAL	0.7 U	0.83	1.5 U	1.3 U	1.3 U	0.7 U	0.7 U
POTASSIUM, TOTAL	1170 J	9810 J	1740	1370	17400	3910 J	2450 J
SELENIUM, TOTAL	2.2 U	2.2 U	2.2 U	2.2 U	2.2 U	2.2 U	2.2 U
SODIUM, TOTAL	8160	NA	10900	9700	NA	10200	12600
VANADIUM, TOTAL	1.1	1.1	0.7 U	0.7 U	0.7 U	1	1

QUALIFIER DEFINITIONS
U = Not detected at quantitation limit.
UJ = Report quantitation limit is estimated.
J = Estimated quantity.
NA = Not analyzed
NOTES:
ug/L = milligrams per liter

TABLE 4-4 (continued)
POSITIVE DETECTIONS
GROUNDWATER - TAL METALS
PHASE II - FIXED BASE LABORATORY
RI/FS CTO-0356
OPERABLE UNIT NO. 16 (SITE 89)
MCB CAMP LEJEUNE, NORTH CAROLINIA

SAMPLE ID	IR89-MW05DW-01	IR89-MW06IW-01	IR89-MW06DW-01	IR89-MW07IW-01	IR89-MW07DW-01	IR89-MW08IW-01	IR89-MW08DW-01
PHASE	PHASE II	PHASE II	PHASE II	PHASE II	PHASE II	PHASE II	PHASE II
DATE SAMPLED	05/28/97	05/19/97	05/19/97	05/20/97	05/20/97	05/19/97	05/19/97
TOTAL METALS (ug/L)							
ANTIMONY, TOTAL	1.9 U	1.9 U	1.9 U	1.9 U	1.9 U	1.9 U	1.9 U
BARIUM, TOTAL	5.4	4.7	8.4	4.4	6.9	2.5	14.2
CALCIUM, TOTAL	43500	51800	45300	62400	46900	46800	57200
CHROMIUM, TOTAL	0.67	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U
IRON, TOTAL	1120 J	115	30.7	163	13.4 U	59.3	54.3
MAGNESIUM, TOTAL	3530	1280	11300	1450	11300	1320	26400
MANGANESE, TOTAL	35.4	24.2	22.3	22.2	22.2	20.1	15.4
NICKEL, TOTAL	0.7 U	0.7 U	0.7 U	0.7 U	0.7 U	0.7 U	1
POTASSIUM, TOTAL	9120 J	1460	13700	1480	13400	2350	25700
SELENIUM, TOTAL	2.7	2.2 U	2.2 U	2.2 U	2.2 U	2.2 U	2.4
SODIUM, TOTAL	NA	8600	96400	6300	78900	13500	80000
VANADIUM, TOTAL	0.75	0.7 U	0.7 U	0.79	0.7 U	0.88	0.7 U

QUALIFIER DEFINITIONS
U = Not detected at quantitation limit.
UJ = Report quantitation limit is estimated.
J = Estimated quantity.
NA = Not analyzed
NOTES:
ug/L = milligrams per liter

TABLE 4-5
SUMMARY OF POSITIVE DETECTIONS
GROUNDWATER - TCL ORGANICS
PHASE I AND PHASE II - MOBILE LABORATORY AND PHASE II - FIXED BASE LABORATORY
RI/FS CTO-0356
OPERABLE UNIT NO. 16 (SITE 89)
MCB CAMP LEJEUNE, NORTH CAROLINA

	NC WQS (ug/L)	US - Primary MCL (ug/L)	Min Detect	Max Detect	Location of Maximum Detect	Detection Frequency	NC WQS Exceedance Count	US - Primary MCL Exceedance Count
VOLATILES (ug/L)								
1,1,1-TRICHLOROETHANE	200	200	0.2	0.2	IR89-TW18-01	1/55	0	0
1,1,2,2-TETRACHLOROETHANE	NE	NE	4 J	4 J	IR89-MW04-01	1/21	0	0
1,1,2-TRICHLOROETHANE	NE	5	3 J	3 J	IR89-MW04-01	1/21	0	0
1,1-DICHLOROETHENE	7	7	2 J	2 J	IR89-MW04IW-01	1/21	0	0
1,2-DICHLOROETHENE (TOTAL)	NE	NE	29	880	IR89-MW04-01	6/21	0	0
CHLOROFORM	0.19	100/80	0.3	8.6	IR89-TW16-01	26/54	26	0
CIS-1,2-DICHLOROETHENE	70	70	3	818	IR89-MW02-01	19/41	10	10
TETRACHLOROETHENE	0.7	5	0.1	42.7	IR89-TW16-01	17/55	12	10
TOLUENE	1000	1000	6	6	IR89-TW29IW-01	1/21	0	0
TRANS-1,2-DICHLOROETHENE	70	100	1	451	IR89-MW02-01	16/34	4	2
TRICHLOROETHENE	2.8	5	0.2	744.3	IR89-MW02-01	28/55	25	23
VINYL CHLORIDE	0.015	2	6 J	130	IR89-MW02-01	4/55	4	4
SEMIVOLATILES (ug/L)								
BIS(2-ETHYLHEXYL)PHTHALATE	3	6	64	150	IR89-MW05-01	4/14	4	4

QUALIFIER DEFINITIONS
U = Not detected at quantitation limit.
UJ = Report quantitation limit is estimated.
J = Estimated quantity.
NA = Not analyzed
NOTES:
ug/L = milligrams per liter

TABLE 4-5 (continued)
SUMMARY OF POSITIVE DETECTIONS
GROUNDWATER - TAL METALS
PHASE II - FIXED BASE LABORATORY
RI/FS CTO-0356
OPERABLE UNIT NO. 16 (SITE 89)
MCB CAMP LEJEUNE, NORTH CAROLINA

	NC WQS (ug/L)	US - Primary MCL (ug/L)	Min Detect	Max Detect	Location of Maximum Detect	Detection Frequency	NC WQS Exceedance Count	US - Primary MCL Exceedance Count
TOTAL METALS (ug/L)								
ANTIMONY, TOTAL	NE	6	2	2.2	IR89-MW03DW-01	2/14	0	0
BARIUM, TOTAL	2000	2000	2.5	23.1	IR89-MW05-01	14/14	0	0
CALCIUM, TOTAL	NE	NE	33200	92800	IR89-MW03IW-01	14/14	0	0
CHROMIUM, TOTAL	50	100	0.5	0.88	IR89-MW05-01	4/14	0	0
IRON, TOTAL	300	**300**	30.7	20000 J	IR89-MW05-01	13/14	7	**7**
MAGNESIUM, TOTAL	NE	NE	1280	26400	IR89-MW08DW-01	14/14	0	0
MANGANESE, TOTAL	50	**50**	9.8	379	IR89-MW05-01	14/14	3	**3**
NICKEL, TOTAL	100	100	0.83	1	IR89-MW08DW-01	2/14	0	0
POTASSIUM, TOTAL	NE	NE	1170 J	25700	IR89-MW08DW-01	14/14	0	0
SELENIUM, TOTAL	50	50	2.4	2.7	IR89-MW05DW-01	2/14	0	0
SODIUM, TOTAL	NE	NE	6300	96400	IR89-MW06DW-01	11/11	0	0
VANADIUM, TOTAL	NE	NE	0.75	1.1	IR89-MW03IW-01, IR89-MW03DW-01	7/14	0	0

QUALIFIER DEFINITIONS
U = Not detected at quantitation limit.
UJ = Report quantitation limit is estimated.
J = Estimated quantity.
NA = Not analyzed
NOTES:
ug/L = milligrams per liter

TABLE 4-6
POSITIVE DETECTIONS
SURFACE WATER - VOLATILE ORGANICS
PHASE I - MOBILE LABORATORY AND FIXED BASE LABORATORY
RI/FS CTO-0356
OPERABLE UNIT NO. 16 (SITE 89)
MCB CAMP LEJEUNE, NORTH CAROLINA

SAMPLE ID	IR89-EC-SW01-01	IR89-EC-SW02-01	IR89-EC-SW03-01	IR89-EC-SW04-01	IR89-EC-SW05-01	IR89-EC-SW06-01-01
PHASE	07/27/96	07/27/96	07/27/96	07/26/96	07/26/96	8/1/96
DATE SAMPLED	PHASE I	PHASE I	PHASE I	PHASE I	PHASE I	PHASE I
VOLATILES (ug/L)						
1,1,2,2-TETRACHLOROETHANE	10 UJ	150 J	130 J	72	80	NA
1,2-DICHLOROETHENE (TOTAL)	10 U	120	100	80	78	NA
CHLOROFORM	10 U	10 U	10 U	10 U	10 U	1 U
CIS-1,2-DICHLOROETHENE	2	48	44	52	44	1 U
TETRACHLOROETHENE	10 U	10 U	10 U	10 U	10 U	0.1 U
TRANS-1,2-DICHLOROETHENE	1 U	37	31	19	15	1 U
TRICHLOROETHENE	3 J	18	16	26	24	0.1 U
VINYL CHLORIDE	10 U	25	21	10 U	10 U	50 U

QUALIFIER DEFINITIONS
U = Not detected at quantitation limit.
UJ = Report quantitation limit is estimated.
J = Estimated quantity.
NA = Not analyzed

TABLE 4-6 (continued)
POSITIVE DETECTIONS
SURFACE WATER - VOLATILE ORGANICS
PHASE I - MOBILE LABORATORY AND FIXED BASE LABORATORY
RI/FS CTO-0356
OPERABLE UNIT NO. 16 (SITE 89)
MCB CAMP LEJEUNE, NORTH CAROLINA

SAMPLE ID	IR89-EC-SW07-01	IR89-EC-SW08-01	IR89-EC-SW09-01	IR89-EC-SW10-01	IR89-EC-SW11-01
PHASE	8/1/96	8/1/96	8/15/96	8/15/96	8/15/96
DATE SAMPLED	PHASE I	PHASE I	PHASE I	PHASE I	PHASE I
VOLATILES (ug/L)					
1,1,2,2-TETRACHLOROETHANE	NA	NA	NA	NA	NA
1,2-DICHLOROETHENE (TOTAL)	NA	NA	NA	NA	NA
CHLOROFORM	1 U	1 U	0.4	0.4	0.4
CIS-1,2-DICHLOROETHENE	27	1 U	44	43	43
TETRACHLOROETHENE	1.2	0.4	0.2	0.1	0.2
TRANS-1,2-DICHLOROETHENE	21	1 U	16	15	14
TRICHLOROETHENE	14.8	0.1 U	28.5	27.9	27.6
VINYL CHLORIDE	50 U	50 U	50 U	50 U	50 U

QUALIFIER DEFINITIONS
U = Not detected at quantitation limit.
UJ = Report quantitation limit is estimated.
J = Estimated quantity.
NA = Not analyzed
NOTES:
ug/L = milligrams per liter

TABLE 4-6 (continued)
POSITIVE DETECTIONS
SURFACE WATER - SEMIVOLATILE ORGANICS, PESTICIDES/PCBs
PHASE I - FIXED BASE LABORATORY
RI/FS CTO-0356
OPERABLE UNIT NO. 16 (SITE 89)
MCB CAMP LEJEUNE, NORTH CAROLINA

SAMPLE ID	IR89-EC-SW01-01	IR89-EC-SW02-01	IR89-EC-SW03-01	IR89-EC-SW04-01	IR89-EC-SW05-01
PHASE	PHASE I	PHASE I	PHASE I	PHASE I	PHASE I
DATE SAMPLED	07/27/96	07/27/96	07/27/96	07/26/96	07/26/96
SEMIVOLATILES (ug/L)	No Detects				
PESTICIDES/PCBS (ug/L)	No Detects				

QUALIFIER DEFINITIONS
U = Not detected at quantitation limit.
UJ = Report quantitation limit is estimated.
J = Estimated quantity.
NA = Not analyzed
NOTES:
ug/L = milligrams per liter

TABLE 4-6 (continued)
POSITIVE DETECTIONS
SURFACE WATER - TAL METALS
PHASE I - MOBILE LABORATORY AND FIXED BASE LABORATORY
RI/FS CTO-0356
OPERABLE UNIT NO. 16 (SITE 89)
MCB CAMP LEJEUNE, NORTH CAROLINA

SAMPLE ID	IR89-EC-SW01-01	IR89-EC-SW0201	IR89-EC-SW03-01	IR89-EC-SW04-01	IR89-EC-SW05-01
PHASE	PHASE I	PHASE I	PHASE I	PHASE I	PHASE I
DATE SAMPLED	07/27/96	07/27/96	07/27/96	07/26/96	07/26/96
TOTAL METALS (ug/L)					
ALUMINUM, TOTAL	41.8	189	201	554	275
ANTIMONY, TOTAL	14.4 U	14.4 U	14.4 U	18.5	14.4 U
BARIUM, TOTAL	17.9	23.6	25	22.4	20.6
CALCIUM, TOTAL	42500	46300	46900	41800	37300
CHROMIUM, TOTAL	3.3 U	3.3 U	3.3 U	3.6	3.3 U
COPPER, TOTAL	2.6	3.9	2 U	4.7	5.7 U
IRON, TOTAL	803	1500	1510	1570	1220
LEAD, TOTAL	1.2 U	1.2 U	5.4	3.8	1.3 J
MAGNESIUM, TOTAL	3560	2560	2480	2450	2200
MANGANESE, TOTAL	28.2	50.4	47.9	31.9	25.7
POTASSIUM, TOTAL	4270	2530	2300	2890	2240
SODIUM, TOTAL	38500	16600	15900	13400	11500
VANADIUM, TOTAL	2.5 U	2.8	2.5 U	4.2	2.5 U
ZINC, TOTAL	17.2	13.3	9.2	17.7	9.3

QUALIFIER DEFINITIONS
U = Not detected at quantitation limit.
UJ = Report quantitation limit is estimated.
J = Estimated quantity.
NA = Not analyzed
NOTES:
ug/L = milligrams per liter

TABLE 4-7
SUMMARY OF POSITIVE DETECTIONS
SURFACE WATER - VOLATILE ORGANICS
PHASE I - MOBILE LABORATORY AND FIXED BASE LABORATORY
RI/FS CTO-0356
OPERABLE UNIT NO. 16 (SITE 89)
MCB CAMP LEJEUNE, NORTH CAROLINA

	US AWQS (ug/L)	Min Detect	Max Detect	Location of Maximum Detect	Detection Frequency	US AWQS Exceedance Count
VOLATILES (ug/L)						
1,1,2,2-TETRACHLOROETHANE	0.17	72	150 J	IR89-EC-SW02-01	4/5	4
1,2-DICHLOROETHENE (TOTAL)	NE	78	120	IR89-EC-SW02-01	4/5	0
CHLOROFORM	5.7	0.4	0.4	IR89-EC-SW09-01, IR89-EC-SW10-01, IR89-EC-SW11-01	3/11	0
CIS-1,2-DICHLOROETHENE	NE	2	52	IR89-EC-SW04-01	9/11	0
TETRACHLOROETHENE	0.8	0.1	1.2	IR89-EC-SW07-01	5/11	1
TRANS-1,2-DICHLOROETHENE	700	14	37	IR89-EC-SW02-01	8/11	0
TRICHLOROETHENE	2.7	3 J	28.5	IR89-EC-SW09-01	9/11	9
VINYL CHLORIDE	2	21	25	IR89-EC-SW02-01	2/11	2
SEMIVOLATILES (ug/L)	No Detects					
PESTICIDES/PCBS (ug/L)	No Detects					

QUALIFIER DEFINITIONS

U = Not detected at quantitation limit.

UJ = Report quantitation limit is estimated.

J = Estimated quantity.

NA = Not analyzed

NOTES:

ug/L = milligrams per liter

TABLE 4-7 (continued)
SUMMARY OF POSITIVE DETECTIONS
SURFACE WATER - TAL METALS
PHASE I - MOBILE LABORATORY AND FIXED BASE LABORATORY
RI/FS CTO-0356
OPERABLE UNIT NO. 16 (SITE 89)
MCB CAMP LEJEUNE, NORTH CAROLINA

	US AWQS (ug/L)	Min Detect		Max Detect	Location of Maximum Detect	Detection Frequency	US AWQS Exceedance Count
TOTAL METALS (ug/L)							
ALUMINUM, TOTAL	NE	41.8		554	IR89-EC-SW04-01	5/5	0
ANTIMONY, TOTAL	14	18.5		18.5	IR89-EC-SW04-01	1/5	1
BARIUM, TOTAL	1000	17.9		25	IR89-EC-SW03-01	5/5	0
CALCIUM, TOTAL	NE	37300		46900	IR89-EC-SW03-01	5/5	0
CHROMIUM, TOTAL	NE	3.6		3.6	IR89-EC-SW04-01	1/5	0
COPPER, TOTAL	1300	2.6		4.7	IR89-EC-SW04-01	3/5	0
IRON, TOTAL	300	803		1570	IR89-EC-SW04-01	5/5	5
LEAD, TOTAL	50	1.3	J	5.4	IR89-EC-SW03-01	3/5	0
MAGNESIUM, TOTAL	NE	2200		3560	IR89-EC-SW01-01	5/5	0
MANGANESE, TOTAL	50	25.7		50.4	IR89-EC-SW0201	5/5	1
POTASSIUM, TOTAL	NE	2240		4270	IR89-EC-SW01-01	5/5	0
SODIUM, TOTAL	NE	11500		38500	IR89-EC-SW01-01	5/5	0
VANADIUM, TOTAL	NE	2.8		4.2	IR89-EC-SW04-01	2/5	0
ZINC, TOTAL	NE	9.2		17.7	IR89-EC-SW04-01	5/5	0

QUALIFIER DEFINITIONS
U = Not detected at quantitation limit.
UJ = Report quantitation limit is estimated.
J = Estimated quantity.
NA = Not analyzed
NOTES:
ug/L = milligrams per liter

TABLE 4-8
POSITIVE DETECTIONS
SEDIMENT - VOLATILE ORGANICS
PHASE I - MOBILE LABORATORY AND FIXED BASE LABORATORY
RI/FS CTO-0356
OPERABLE UNIT NO. 16 (SITE 89)
MCB CAMP LEJEUNE, NORTH CAROLINA

SAMPLE ID	IR89-EC-SD01-06	IR89-EC-SD01-612	IR89-EC-SD02-06	IR89-EC-SD02-612	IR89-EC-SD03-06	IR89-EC-SD03-612
PHASE	PHASE I	PHASE I	PHASE I	PHASE I	PHASE I	PHASE I
DATE SAMPLED	07/27/96	07/27/96	07/27/96	07/27/96	07/27/96	07/27/96
DEPTH	0-6"	6-12"	0-6"	6-12"	0-6"	6-12"
VOLATILES (ug/kg)						
VINYL CHLORIDE	13 U	14 U	13 U	12 U	35	230
1,1,2,2-TETRACHLOROETHANE	13 U	14 U	13 U	12 U	1700	550
1,1,2-TRICHLOROETHANE	13 U	14 U	13 U	12 U	19	13
1,1-DICHLOROETHENE	13 UJ	14 UJ	13 UJ	12 UJ	12 UJ	37 J
1,2-DICHLOROETHENE (TOTAL)	13 U	14 U	13 U	12 U	1600	1500
CIS-1,2-DICHLOROETHENE	NA	NA	NA	NA	NA	NA
TOLUENE	13 U	14 U	13 U	12 U	7 J	12 U
TRANS-1,2-DICHLOROETHENE	NA	NA	NA	NA	NA	NA
TRICHLOROETHENE	13 U	14 U	13 U	12 U	2400	120

QUALIFIER DEFINITIONS
U = Not detected at quantitation limit.
UJ = Report quantitation limit is estimated.
J = Estimated quantity.
NA = Not analyzed
NOTES:
ug/kg = micrograms per kilogram

TABLE 4-8 (continued)
POSITIVE DETECTIONS
SEDIMENT - VOLATILE ORGANICS
PHASE I - MOBILE LABORATORY AND FIXED BASE LABORATORY
RI/FS CTO-0356
OPERABLE UNIT NO. 16 (SITE 89)
MCB CAMP LEJEUNE, NORTH CAROLINA

SAMPLE ID	IR89-EC-SD04-06	IR89-EC-SD04-612	IR89-EC-SD05-06	IR89-EC-SD05-612	IR89-EC-SD09-06	IR89-EC-SD09-612
PHASE	PHASE I	PHASE I	PHASE I	PHASE I	PHASE I	PHASE I
DATE SAMPLED	07/26/96	07/26/96	07/26/96	07/26/96	8/15/96	8/15/96
DEPTH	0-6"	6-12"	0-6"	6-12"	0-6"	6-12"
VOLATILES (ug/kg)						
VINYL CHLORIDE	12 U	20 U	12 U	12 U	100 U	100 U
1,1,2,2-TETRACHLOROETHANE	12 U	20 U	12 U	12 U	NA	NA
1,1,2-TRICHLOROETHANE	12 U	20 U	12 U	12 U	NA	NA
1,1-DICHLOROETHENE	12 UJ	20 UJ	12 UJ	12 U	NA	NA
1,2-DICHLOROETHENE (TOTAL)	12 U	20 U	12 U	12 U	NA	NA
CIS-1,2-DICHLOROETHENE	NA	NA	NA	NA	5	1 U
TOLUENE	12 U	20 U	12 U	12 U	NA	NA
TRANS-1,2-DICHLOROETHENE	NA	NA	NA	NA	1	1 U
TRICHLOROETHENE	12 U	20 U	12 U	12 U	2.2	0.1 U

QUALIFIER DEFINITIONS
U = Not detected at quantitation limit.
UJ = Report quantitation limit is estimated.
J = Estimated quantity.
NA = Not analyzed
NOTES:
ug/kg = micrograms per kilogram

TABLE 4-8 (continued)
POSITIVE DETECTIONS
SEDIMENT - VOLATILE ORGANICS
PHASE I - MOBILE LABORATORY AND FIXED BASE LABORATORY
RI/FS CTO-0356
OPERABLE UNIT NO. 16 (SITE 89)
MCB CAMP LEJEUNE, NORTH CAROLINA

SAMPLE ID	IR89-EC-SD10-06	IR89-EC-SD10-612	IR89-EC-SD11-06	IR89-EC-SD11-612
PHASE	PHASE I	PHASE I	PHASE I	PHASE I
DATE SAMPLED	8/15/96	8/15/96	8/15/96	8/15/96
DEPTH	0-6"	6-12"	0-6"	6-12"
VOLATILES (ug/kg)				
VINYL CHLORIDE	100 U	100 U	100 U	100 U
1,1,2,2-TETRACHLOROETHANE	NA	NA	NA	NA
1,1,2-TRICHLOROETHANE	NA	NA	NA	NA
1,1-DICHLOROETHENE	NA	NA	NA	NA
1,2-DICHLOROETHENE (TOTAL)	NA	NA	NA	NA
CIS-1,2-DICHLOROETHENE	16	1 U	1 U	1 U
TOLUENE	NA	NA	NA	NA
TRANS-1,2-DICHLOROETHENE	5	1 U	1 U	1 U
TRICHLOROETHENE	11.3	0.6	0.9	0.3

QUALIFIER DEFINITIONS
U = Not detected at quantitation limit.
UJ = Report quantitation limit is estimated.
J = Estimated quantity.
NA = Not analyzed
NOTES:
ug/kg = micrograms per kilogram

TABLE 4-8 (continued)
POSITIVE DETECTIONS
SEDIMENT - SEMIVOLATILE ORGANICS, PESTICIDES/PCBs
PHASE I - FIXED BASE LABORATORY
RI/FS CTO-0356
OPERABLE UNIT NO. 16 (SITE 89)
MCB CAMP LEJEUNE, NORTH CAROLINA

SAMPLE ID	IR89-EC-SD01-06	IR89-EC-SD01-612	IR89-EC-SD02-06	IR89-EC-SD02-612	IR89-EC-SD03-06	IR89-EC-SD03-612
PHASE	PHASE I	PHASE I	PHASE I	PHASE I	PHASE I	PHASE I
DATE SAMPLED	07/27/96	07/27/96	07/27/96	07/27/96	07/27/96	07/27/96
DEPTH	0-6"	6-12"	0-6"	6-12"	0-6"	6-12"
SEMIVOLATILES (ug/kg)						
BENZO(A)ANTHRACENE	410 U	440 U	430 U	58 J	410 U	380 U
BENZO(A)PYRENE	410 U	440 U	430 U	75 J	410 U	380 U
BENZO(B)FLUORANTHENE	53 J	440 U	430 U	140 J	410 U	40 J
BENZO(G,H,I)PERYLENE	50 J	440 U	430 U	410 U	410 U	380 U
BENZO(K)FLUORANTHENE	410 U	440 U	430 U	50 J	410 U	380 U
BIS(2-ETHYLHEXYL)PHTHALATE	360 J	97 J	150 J	130 J	140 J	90 J
CHRYSENE	410 U	440 U	51 J	95 J	410 U	380 U
FLUORANTHENE	68 J	440 U	59 J	81 J	410 U	380 U
INDENO(1,2,3-CD)PYRENE	410 U	440 U	430 U	410 U	410 U	380 U
PHENANTHRENE	50 J	440 U	430 U	44 J	42 J	380 U
PYRENE	50 J	440 U	85 J	140 J	410 U	52 J
PESTICIDES/PCBS (ug/kg)						
4,4'-DDE	NA	NA	NA	NA	NA	NA
4,4'-DDD	NA	NA	NA	NA	NA	NA
4,4'-DDT	NA	NA	NA	NA	NA	NA
ALPHA-CHLORDANE	NA	NA	NA	NA	NA	NA
GAMMA-CHLORDANE	NA	NA	NA	NA	NA	NA

QUALIFIER DEFINITIONS

U = Not detected at quantitation limit.

UJ = Report quantitation limit is estimated.

J = Estimated quantity.

NA = Not analyzed

NOTES:

ug/kg = micrograms per kilogram

TABLE 4-8 (continued)
POSITIVE DETECTIONS
SEDIMENT - SEMIVOLATILE ORGANICS, PESTICIDES/PCBs
PHASE I - FIXED BASE LABORATORY
RI/FS CTO-0356
OPERABLE UNIT NO. 16 (SITE 89)
MCB CAMP LEJEUNE, NORTH CAROLINA

SAMPLE ID	IR89-EC-SD04-06	IR89-EC-SD04-612	IR89-EC-SD05-06	IR89-EC-SD05-612
PHASE	PHASE I	PHASE I	PHASE I	PHASE I
DATE SAMPLED	07/26/96	07/26/96	07/26/96	07/26/96
DEPTH	0-6"	6-12"	0-6"	6-12"
SEMIVOLATILES (ug/kg)				
BENZO(A)ANTHRACENE	48 J	650 U	390 U	420 U
BENZO(A)PYRENE	65 J	3100	390 U	420 U
BENZO(B)FLUORANTHENE	140 J	650 U	44 J	420 U
BENZO(G,H,I)PERYLENE	55 J	650 U	390 U	420 U
BENZO(K)FLUORANTHENE	51 J	650 U	390 U	420 U
BIS(2-ETHYLHEXYL)PHTHALATE	240 J	88 J	110 J	13000
CHRYSENE	120 J	650 U	390 U	420 U
FLUORANTHENE	180 J	650 U	51 J	420 U
INDENO(1,2,3-CD)PYRENE	59 J	650 U	390 U	420 U
PHENANTHRENE	100 J	650 U	390 U	420 U
PYRENE	130 J	650 U	63 J	51 J
PESTICIDES/PCBS (ug/kg)				
4,4'-DDE	NA	NA	33 J	44 J
4,4'-DDD	NA	NA	42 J	79
4,4'-DDT	NA	NA	23 J	34
ALPHA-CHLORDANE	NA	NA	2 J	2.9
GAMMA-CHLORDANE	NA	NA	1.6 J	4.6 J

QUALIFIER DEFINITIONS

U = Not detected at quantitation limit.

UJ = Report quantitation limit is estimated.

J = Estimated quantity.

NA = Not analyzed

NOTES:

ug/kg = micrograms per kilogram

TABLE 4-8 (continued)
POSITIVE DETECTIONS
SEDIMENT - TAL METALS
PHASE I - FIXED BASE LABORATORY
RI/FS CTO-0356
OPERABLE UNIT NO. 16 (SITE 89)
MCB CAMP LEJEUNE, NORTH CAROLINA

SAMPLE ID	IR89-EC-SD01-06	IR89-EC-SD01-612	IR89-EC-SD02-06	IR89-EC-SD02-612	IR89-EC-SD03-06	IR89-EC-SD03-612
PHASE	PHASE I	PHASE I	PHASE I	PHASE I	PHASE I	PHASE I
DATE SAMPLED	07/27/96	07/27/96	07/27/96	07/27/96	07/27/96	07/27/96
DEPTH	0-6"	6-12"	0-6"	6-12"	0-6"	6-12"
METALS (mg/kg)						
ALUMINUM, TOTAL	1690 J	2800 J	1980 J	1990 J	2750 J	1820 J
ARSENIC, TOTAL	0.33 UJ	0.28 UJ	0.51	0.39	0.59	0.28 UJ
BARIUM, TOTAL	8.9	13.4	16.3	13.2	18.6	15.5
BERYLLIUM, TOTAL	0.14	0.36	0.16 U	0.15	0.15 U	0.13 U
CADMIUM, TOTAL	0.82	0.59 U	0.58 U	0.53 U	0.77	0.78
CALCIUM, TOTAL	21500 J	8020	18800 J	23000	47700 J	48000
CHROMIUM, TOTAL	4.1	3.6	5.2	3.4	4.5	2.7
COPPER, TOTAL	5.5	2.9 U	38.7	7.9	5.9	3.1 U
IRON, TOTAL	1590 J	1630	3220 J	2930	2340 J	1750
LEAD, TOTAL	14.3 J	6.6	20.7 J	15.7	17.3 J	12.3
MAGNESIUM, TOTAL	413	219	369	409	768	888
MANGANESE, TOTAL	10.4	7.9	11.7	11.1	13.6	13.5
MERCURY, TOTAL	0.06 U	0.07 U	0.05 U	0.05 U	0.05 U	0.05 U
NICKEL, TOTAL	1.7 U	2 U	1.9 U	3.7	2.3	1.6 U
SODIUM, TOTAL	65.2	38.5	62.4	74.1	130	131
VANADIUM, TOTAL	7.1	6.4	8.9	19.7	7.9	5.2
ZINC, TOTAL	53.1	24.9	34	33.5	27.6	40.7

QUALIFIER DEFINITIONS

U= Not detected at quantitation limit.
UJ = Report quantitation limit is estimated.
J = Estimated quantity.
NA = Not analyzed
NOTES:
mg/kg = milligrams per kilogram

TABLE 4-8 (continued)
POSITIVE DETECTIONS
SEDIMENT - TAL METALS
PHASE I - FIXED BASE LABORATORY
RI/FS CTO-0356
OPERABLE UNIT NO. 16 (SITE 89)
MCB CAMP LEJEUNE, NORTH CAROLINA

SAMPLE ID	IR89-EC-SD04-06		IR89-EC-SD04-612		IR89-EC-SD05-06		IR89-EC-SD05-612	
PHASE	PHASE I		PHASE I		PHASE I		PHASE I	
DATE SAMPLED	07/26/96		07/26/96		07/26/96		07/26/96	
DEPTH	0-6"		6-12"		0-6"		6-12"	
METALS (mg/kg)								
ALUMINUM, TOTAL	2040	J	14000	J	1010	J	1110	J
ARSENIC, TOTAL	0.42		0.55	UJ	0.38		0.85	
BARIUM, TOTAL	9.9		30.1		6		10.7	
BERYLLIUM, TOTAL	0.15	U	0.55		0.14	U	0.15	U
CADMIUM, TOTAL	0.56	U	0.89	U	0.53	U	0.55	U
CALCIUM, TOTAL	14000	J	8900		42700	J	26400	
CHROMIUM, TOTAL	4.4		7.6		2.4		4.7	
COPPER, TOTAL	4.3	U	0.77	U	1.8	U	7.9	
IRON, TOTAL	2150	J	3860		1190	J	1380	
LEAD, TOTAL	20.2	J	13.5		35.4	J	14.6	
MAGNESIUM, TOTAL	303		322		603		464	
MANGANESE, TOTAL	10.3		16.3		8.6		7.3	
MERCURY, TOTAL	0.05	U	0.1		0.05	U	0.06	U
NICKEL, TOTAL	1.9	U	3	U	1.8	U	1.9	U
SODIUM, TOTAL	56.4		88.6		125		92	
VANADIUM, TOTAL	5.2		11.2		4		5.5	
ZINC, TOTAL	29.7		11.7		29.2		24.7	

QUALIFIER DEFINITIONS

U= Not detected at quantitation limit.

UJ = Report quantitation limit is estimated.

J = Estimated quantity.

NA = Not analyzed

NOTES:

mg/kg = milligrams per kilogram

TABLE 4-9
SUMMARY OF POSITIVE DETECTIONS
SEDIMENT - VOLATILE ORGANICS
PHASE I - MOBILE LABORATORY AND FIXED BASE LABORATORY
RI/FS CTO-0356
OPERABLE UNIT NO. 16 (SITE 89)
MCB CAMP LEJEUNE, NORTH CAROLINA

	Region IV Sediment Screening Levels (ERLs) (ug/kg)	Min Detect	Max Detect	Location of Maximum Detect	Detection Frequency	Region IV Sediment Screening Levels (ERLs) Exceedance Count
VOLATILES (ug/kg)						
1,1,2,2-TETRACHLOROETHANE	NE	550	1700	IR89-EC-SD03-06	2/10	0
1,1,2-TRICHLOROETHANE	NE	13	19	IR89-EC-SD03-06	2/10	0
1,1-DICHLOROETHENE	NE	37 J	37 J	IR89-EC-SD03-612	1/10	0
1,2-DICHLOROETHENE (TOTAL)	NE	1500	1600	IR89-EC-SD03-06	2/10	0
CIS-1,2-DICHLOROETHENE	NE	5	16	IR89-EC-SD10-06	2/6	0
TOLUENE	NE	7 J	7 J	IR89-EC-SD03-06	1/10	0
TRANS-1,2-DICHLOROETHENE	NE	1	5	IR89-EC-SD10-06	2/6	0
TRICHLOROETHENE	NE	0.3	2400	IR89-EC-SD03-06	7/16	0
VINYL CHLORIDE	NE	35	230	IR89-EC-SD03-612	2/16	0

QUALIFIER DEFINITIONS

U = Not detected at quantitation limit.

UJ = Report quantitation limit is estimated.

J = Estimated quantity.

NA = Not analyzed

NOTES:

ug/kg = micrograms per kilogram

TABLE 4-9 (continued)
SUMMARY OF POSITIVE DETECTIONS
SEDIMENT - SEMIVOLATILE ORGANICS, PESTICIDES/PCBs
PHASE I - FIXED BASE LABORATORY
RI/FS CTO-0356
OPERABLE UNIT NO. 16 (SITE 89)
MCB CAMP LEJEUNE, NORTH CAROLINA

	Region IV Sediment Screening Levels (ERLs) (ug/kg)	Min Detect	Max Detect	Location of Maximum Detect	Detection Frequency	Region IV Sediment Screening Levels (ERLs) Exceedance Count
SEMIVOLATILES (ug/kg)						
BENZO(A)ANTHRACENE	230	48 J	58 J	IR89-EC-SD02-612	2/10	0
BENZO(A)PYRENE	400	65 J	3100	IR89-EC-SD04-612	3/10	1
BENZO(B)FLUORANTHENE	NE	40 J	140 J	IR89-EC-SD02-612, IR89-EC-SD04-06	5/10	0
BENZO(G,H,I)PERYLENE	NE	50 J	55 J	IR89-EC-SD04-06	2/10	0
BENZO(K)FLUORANTHENE	NE	50 J	51 J	IR89-EC-SD04-06	2/10	0
BIS(2-ETHYLHEXYL)PHTHALATE	NE	88 J	13000	IR89-EC-SD05-612	10/10	0
CHRYSENE	400	51 J	120 J	IR89-EC-SD04-06	3/10	0
FLUORANTHENE	600	51 J	180 J	IR89-EC-SD04-06	5/10	0
INDENO(1,2,3-CD)PYRENE	NE	59 J	59 J	IR89-EC-SD04-06	1/10	0
PHENANTHRENE	225	42 J	100 J	IR89-EC-SD04-06	4/10	0
PYRENE	350	50 J	140 J	IR89-EC-SD02-612	7/10	0
PESTICIDES/PCBS (ug/kg)						
4,4'-DDD	2	42 J	79	IR89-EC-SD05-612	2/2	2
4,4'-DDE	2	33 J	44 J	IR89-EC-SD05-612	2/2	2
4,4'-DDT	1	23 J	34	IR89-EC-SD05-612	2/2	2
ALPHA-CHLORDANE	NE	2 J	2.9	IR89-EC-SD05-612	2/2	0
GAMMA-CHLORDANE	NE	1.6 J	4.6 J	IR89-EC-SD05-612	2/2	0

QUALIFIER DEFINITIONS
U= Not detected at quantitation limit.
UJ = Report quantitation limit is estimated.
J = Estimated quantity.
NA = Not analyzed
NOTES:
ug/kg = micrograms per kilogram

TABLE 4-9 (continued)
SUMMARY OF POSITIVE DETECTIONS
SEDIMENT - TAL METALS
PHASE I - FIXED BASE LABORATORY
RI/FS CTO-0356
OPERABLE UNIT NO. 16 (SITE 89)
MCB CAMP LEJEUNE, NORTH CAROLINA

	Region IV Sediment Screening Levels (ERLs) (mg/kg)	Min Detect	Max Detect	Location of Maximum Detect	Detection Frequency	Region IV Sediment Screening Levels (ERLs) Exceedance Count
METALS (mg/kg)						
ALUMINUM, TOTAL	NE	1010 J	14000 J	IR89-EC-SD04-612	10/10	0
ARSENIC, TOTAL	33	0.38	0.85	IR89-EC-SD05-612	6/10	0
BARIUM, TOTAL	NE	6	30.1	IR89-EC-SD04-612	10/10	0
BERYLLIUM, TOTAL	NE	0.14	0.55	IR89-EC-SD04-612	4/10	0
CADMIUM, TOTAL	5	0.77	0.82	IR89-EC-SD01-06	3/10	0
CALCIUM, TOTAL	NE	8020	48000	IR89-EC-SD03-612	10/10	0
CHROMIUM, TOTAL	80	2.4	7.6	IR89-EC-SD04-612	10/10	0
COPPER, TOTAL	70	5.5	38.7	IR89-EC-SD02-06	5/10	0
IRON, TOTAL	NE	1190 J	3860	IR89-EC-SD04-612	10/10	0
LEAD, TOTAL	35	6.6	35.4 J	IR89-EC-SD05-06	10/10	1
MAGNESIUM, TOTAL	NE	219	888	IR89-EC-SD03-612	10/10	0
MANGANESE, TOTAL	NE	7.3	16.3	IR89-EC-SD04-612	10/10	0
MERCURY, TOTAL	0.15	0.1	0.1	IR89-EC-SD04-612	1/10	0
NICKEL, TOTAL	30	2.3	3.7	IR89-EC-SD02-612	2/10	0
SODIUM, TOTAL	NE	38.5	131	IR89-EC-SD03-612	10/10	0
VANADIUM, TOTAL	NE	4	19.7	IR89-EC-SD02-612	10/10	0
ZINC, TOTAL	120	11.7	53.1	IR89-EC-SD01-06	10/10	0

QUALIFIER DEFINITIONS
U= Not detected at quantitation limit.
UJ = Report quantitation limit is estimated.
J = Estimated quantity.
NA = Not analyzed
NOTES:
mg/kg = milligrams per kilogram

TABLE 4-10
POSITIVE DETECTIONS
SUBSURFACE SOIL - TCL ORGANICS
PHASE II - FIXED BASE LABORATORY
RI/FS CTO-0356
OPERABLE UNIT NO. 16 (SITE 93)
MCB CAMP LEJEUNE, NORTH CAROLINA

SAMPLE ID	IR93-MW01-02	IR93-MW01-04	IR93-MW01IW-02	IR93-MW01IW-04	IR93-MW02-02	IR93-MW02-04
PHASE	PHASE II	PHASE II	PHASE II	PHASE II	PHASE II	PHASE II
DATE SAMPLED	04/30/97	04/30/97	04/30/97	04/30/97	04/22/97	04/22/97
DEPTH	3-5'	7-9'	3-5'	7-9'	3-5'	7-9'
VOLATILES (ug/kg)						
2-BUTANONE	11 U	12 U	12 U	12 U	13 U	12 U
ACETONE	19 J	12 U	39	12 U	22 J	44 J
SEMIVOLATILES (ug/kg)						
BENZO(A)PYRENE	370 U	400 U	420 U	400 U	420 U	410 U
BIS(2-ETHYLHEXYL)PHTHALATE	370 U	400 U	420 U	400 U	420 U	410 U
PESTICIDES/PCBS (ug/kg)						
4,4'-DDD	3.7 UJ	NA	NA	NA	NA	NA
4,4'-DDE	3.7 UJ	NA	NA	NA	NA	NA
4,4'-DDT	3.7 UJ	NA	NA	NA	NA	NA

QUALIFIER DEFINITIONS
U= Not detected at quantitation limit.
UJ = Report quantitation limit is estimated.
J = Estimated quantity.
NA = Not analyzed
NOTES:
ug/kg = micrograms per kilogram

TABLE 4-10 (continued)
POSITIVE DETECTIONS
SUBSURFACE SOIL - TCL ORGANICS
PHASE II - FIXED BASE LABORATORY
RI/FS CTO-0356
OPERABLE UNIT NO. 16 (SITE 93)
MCB CAMP LEJEUNE, NORTH CAROLINA

SAMPLE ID	IR93-MW02DW-02	IR93-MW02DW-04	IR93-MW02IW-02	IR93-MW02IW-04	IR93-MW03-02	IR93-MW03-04
PHASE	PHASE II	PHASE II	PHASE II	PHASE II	PHASE II	PHASE II
DATE SAMPLED	05/16/97	05/16/97	04/21/97	04/21/97	04/30/97	04/30/97
DEPTH	3-5'	7-9'	3-5'	7-9'	3-5'	7-9'
VOLATILES (ug/kg)						
2-BUTANONE	11 U	13 U	12 U	12 U	12 U	12 U
ACETONE	11 U	58 J	120 J	30 J	130	22
SEMIVOLATILES (ug/kg)						
BENZO(A)PYRENE	360 U	420 U	380 U	400 J	380 U	380 U
BIS(2-ETHYLHEXYL)PHTHALATE	360 U	420 J	380 U	920 U	380 U	380 U
PESTICIDES/PCBS (ug/kg)						
4,4'-DDD	55	NA	NA	NA	NA	NA
4,4'-DDE	22	NA	NA	NA	NA	NA
4,4'-DDT	33	NA	NA	NA	NA	NA

QUALIFIER DEFINITIONS
U= Not detected at quantitation limit.
UJ = Report quantitation limit is estimated.
J = Estimated quantity.
NA = Not analyzed
NOTES:
ug/kg = micrograms per kilogram

TABLE 4-10 (continued)
POSITIVE DETECTIONS
SUBSURFACE SOIL - TCL ORGANICS
PHASE II - FIXED BASE LABORATORY
RI/FS CTO-0356
OPERABLE UNIT NO. 16 (SITE 93)
MCB CAMP LEJEUNE, NORTH CAROLINA

SAMPLE ID	IR93-MW03IW-02	IR93-MW03IW-04	IR93-MW04-02	IR93-MW04-04	IR93-MW04IW-02	IR93-MW04IW-04
PHASE	PHASE II	PHASE II	PHASE II	PHASE II	PHASE II	PHASE II
DATE SAMPLED	04/29/97	04/29/97	05/06/97	05/06/97	05/06/97	05/06/97
DEPTH	3-5'	7-9'	3-5'	7-9'	3-5'	7-9'
VOLATILES (ug/kg)						
2-BUTANONE	12 U	12 U	12 U	12 U	12 U	12 U
ACETONE	12 U	12 U	12 U	12 U	24 J	12 U
SEMIVOLATILES (ug/kg)						
BENZO(A)PYRENE	410 U	390 U	400 U	400 U	400 U	390 U
BIS(2-ETHYLHEXYL)PHTHALATE	410 U	220 J	52 J	75 J	400 U	390 U
PESTICIDES/PCBS (ug/kg)						
4,4'-DDD	NA	NA	NA	NA	NA	NA
4,4'-DDE	NA	NA	NA	NA	NA	NA
4,4'-DDT	NA	NA	NA	NA	NA	NA

QUALIFIER DEFINITIONS
U= Not detected at quantitation limit.
UJ = Report quantitation limit is estimated.
J = Estimated quantity.
NA = Not analyzed
NOTES:
ug/kg = micrograms per kilogram

TABLE 4-10 (continued)
POSITIVE DETECTIONS
SUBSURFACE SOIL - TCL ORGANICS
PHASE II - FIXED BASE LABORATORY
RI/FS CTO-0356
OPERABLE UNIT NO. 16 (SITE 93)
MCB CAMP LEJEUNE, NORTH CAROLINA

SAMPLE ID	IR93-MW05-02	IR93-MW05-04	IR93-MW05IW-02	IR93-MW05IW-04
PHASE	PHASE II	PHASE II	PHASE II	PHASE II
DATE SAMPLED	04/21/97	04/21/97	04/20/97	04/20/97
DEPTH	3-5'	7-9'	3-5'	7-9'
VOLATILES (ug/kg)				
2-BUTANONE	12 U	12 U	13 J	12 U
ACETONE	43 J	12 UJ	340	60
SEMIVOLATILES (ug/kg)				
BENZO(A)PYRENE	400 U	420 U	410 U	400 U
BIS(2-ETHYLHEXYL)PHTHALATE	400 U	420 U	43 J	400 U
PESTICIDES/PCBS (ug/kg)				
4,4'-DDD	4.1 U	NA	NA	NA
4,4'-DDE	4.1 U	NA	NA	NA
4,4'-DDT	2.4 U	NA	NA	NA

QUALIFIER DEFINITIONS
U= Not detected at quantitation limit.
UJ = Report quantitation limit is estimated.
J = Estimated quantity.
NA = Not analyzed
NOTES:
ug/kg = micrograms per kilogram

TABLE 4-10 (continued)
POSITIVE DETECTIONS
SUBSURFACE SOIL - TAL METALS
PHASE II - FIXED BASE LABORATORY
RI/FS CTO-0356
OPERABLE UNIT NO. 16 (SITE 93)
MCB CAMP LEJEUNE, NORTH CAROLINA

SAMPLE ID	IR93-MW01-02	IR93-MW01-04	IR93-MW01IW-02	IR93-MW01IW-04	IR93-MW02-02	IR93-MW02-04	IR93-MW02DW-02
PHASE	PHASE II	PHASE II	PHASE II	PHASE II	PHASE II	PHASE II	PHASE II
DATE SAMPLED	04/30/97	04/30/97	04/30/97	04/30/97	04/22/97	04/22/97	05/16/97
DEPTH	3-5'	7-9'	3-5'	7-9'	3-5'	7-9'	3-5'
TOTAL METALS (mg/kg)							
ALUMINUM, TOTAL	5970 J	4820 J	15700 J	2570 J	3100	4290 UJ	741 J
ANTIMONY, TOTAL	0.31 U	0.29 U	0.36 U	0.3 U	0.35 UJ	0.31 J	0.43
ARSENIC, TOTAL	0.96 J	0.33 UJ	1.4 J	0.34 UJ	0.39 UJ	0.64	3.1 J
BARIUM, TOTAL	7.8	7.1	19.3	5.2	28.5	40.6	32
BERYLLIUM, TOTAL	0.03	0.04	0.08	0.02	0.13 J	0.18 J	0.5
CADMIUM, TOTAL	0.04 U	0.04 U	0.05	0.04 U	0.04 UJ	0.04 J	0.07 U
CALCIUM, TOTAL	97.2	46	164	37.8	1200 J	2610 J	580
CHROMIUM, TOTAL	7.8 J	8 J	17.9 J	5.1 J	2.8 J	8.4 J	3.5
COBALT, TOTAL	0.17 J	0.12 J	0.42 J	0.06 J	1.1 J	1.2 J	1.6 J
COPPER, TOTAL	0.4 J	0.16 J	0.2 J	0.36 J	0.32 J	0.92 J	5.5
IRON, TOTAL	2960	1640	6880	785	5650	7200 J	2960
LEAD, TOTAL	4.7 J	4.6 J	9.4 J	3.4 J	4.9 J	5.4	3.1
MAGNESIUM, TOTAL	188	184	504	112	86.8	180	40.6
MANGANESE, TOTAL	7.5	9.8	6.7	8.1	10.4	24.6	1.3
NICKEL, TOTAL	0.55 J	0.27 J	1 J	0.15 J	2.1 J	3.1 J	2.9 J
POTASSIUM, TOTAL	188 J	228 J	510 J	161 J	69.8 U	112 J	74.9 U
SELENIUM, TOTAL	0.37 U	0.35 U	0.55	0.36 U	0.41 U	0.37 U	1.6
SILVER, TOTAL	0.04 UJ	0.04 J	0.04 UJ	0.04 UJ	0.04 U	0.04 U	0.09 U
SODIUM, TOTAL	99	56.4	151	42.5	28.3 UJ	41.7 J	57.4
VANADIUM, TOTAL	10.6	8.5	25.3	4.4	4.3	6.8	8.7
ZINC, TOTAL	1.7	1.6	4.2	1.1	11.8	8.4	1.1 J

QUALIFIER DEFINITIONS
U= Not detected at quantitation limit.
UJ = Report quantitation limit is estimated.
J = Estimated quantity.
NA = Not analyzed
NOTES:
mg/kg = milligrams per kilogram

TABLE 4-10 (continued)
POSITIVE DETECTIONS
SUBSURFACE SOIL - TAL METALS
PHASE II - FIXED BASE LABORATORY
RI/FS CTO-0356
OPERABLE UNIT NO. 16 (SITE 93)
MCB CAMP LEJEUNE, NORTH CAROLINA

SAMPLE ID	IR93-MW02DW-04	IR93-MW02IW-02	IR93-MW02IW-04	IR93-MW03-02	IR93-MW03-04	IR93-MW03IW-02
PHASE	PHASE II	PHASE II	PHASE II	PHASE II	PHASE II	PHASE II
DATE SAMPLED	05/16/97	04/21/97	04/21/97	04/30/97	04/30/97	04/29/97
DEPTH	7-9'	3-5'	7-9'	3-5'	7-9'	3-5'
TOTAL METALS (mg/kg)						
ALUMINUM, TOTAL	748 J	3630	2410	14000 J	2070 J	20500 J
ANTIMONY, TOTAL	0.33 U	0.25 UJ	0.32 UJ	0.39 U	0.3 U	0.3 U
ARSENIC, TOTAL	0.46 UJ	0.28 UJ	0.36 UJ	3.4 J	0.34 UJ	0.74 J
BARIUM, TOTAL	4.4	8.1	13.6	13.8	2.5	17.1
BERYLLIUM, TOTAL	0.31	0.15 J	0.13 J	0.13	0.02 U	0.19
CADMIUM, TOTAL	0.07 U	0.03 UJ	0.04 UJ	0.09	0.04 U	0.07
CALCIUM, TOTAL	581	590 J	1300 J	1100	26	26.1
CHROMIUM, TOTAL	1.3	4.1 J	3 J	19.6 J	4.5 J	28.1 J
COBALT, TOTAL	0.09 UJ	0.05 UJ	0.13 J	0.52 J	0.06 UJ	0.66 J
COPPER, TOTAL	0.14 UJ	13.6	0.41 J	1.6	0.4 J	2.5
IRON, TOTAL	546	2170	2340	14900	501	7130
LEAD, TOTAL	1.9	3.5 J	4.2 J	10.6 J	2.1 J	8.7 J
MAGNESIUM, TOTAL	30.2	79.3	83.1	409	86.9	594
MANGANESE, TOTAL	1.7	5.1	4.1	7.5	4.3	6.7
NICKEL, TOTAL	0.12 UJ	0.55 J	0.14 UJ	1 J	0.13 UJ	1.1 J
POTASSIUM, TOTAL	55 U	65.8 U	83.5 U	651 J	131 J	887 J
SELENIUM, TOTAL	0.38 U	0.3 U	0.38 U	0.58	0.35 U	0.47
SILVER, TOTAL	0.09 U	0.03 U	0.04 U	0.04 UJ	0.04 UJ	0.04 UJ
SODIUM, TOTAL	32.3 U	20.5 UJ	48.5 J	91.4	24.4 U	130
VANADIUM, TOTAL	1	5.6	2.1	27.6	4.4	64.9
ZINC, TOTAL	0.21 J	1.2 J	1.1 J	5.8	0.58	5.2

QUALIFIER DEFINITIONS
U= Not detected at quantitation li
UJ = Report quantitation limit is estimated.
J = Estimated quantity.
NA = Not analyzed
NOTES:
mg/kg = milligrams per kilogram

TABLE 4-10 (continued)
POSITIVE DETECTIONS
SUBSURFACE SOIL - TAL METALS
PHASE II - FIXED BASE LABORATORY
RI/FS CTO-0356
OPERABLE UNIT NO. 16 (SITE 93)
MCB CAMP LEJEUNE, NORTH CAROLINA

SAMPLE ID	IR93-MW03IW-04	IR93-MW04-02	IR93-MW04-04	IR93-MW04IW-02	IR93-MW04IW-04	IR93-MW05-02
PHASE	PHASE II	PHASE II	PHASE II	PHASE II	PHASE II	PHASE II
DATE SAMPLED	04/29/97	05/06/97	05/06/97	05/06/97	05/06/97	04/21/97
DEPTH	7-9'	3-5'	7-9'	3-5'	7-9'	3-5'
TOTAL METALS (mg/kg)						
ALUMINUM, TOTAL	1990 J	1390	4590	8260	4060	6920
ANTIMONY, TOTAL	0.29 U	0.26 U	0.27	0.32 U	0.35 U	0.36 UJ
ARSENIC, TOTAL	0.68 J	0.29 UJ	0.29 UJ	0.86 J	0.39 UJ	0.41 UJ
BARIUM, TOTAL	2.7	4.6	8	13.3	6.7	14.8
BERYLLIUM, TOTAL	0.02 U	0.02	0.03	0.05	0.02 U	0.04 J
CADMIUM, TOTAL	0.04 U	0.03 UJ	0.03 UJ	0.04 UJ	0.04 UJ	0.05 UJ
CALCIUM, TOTAL	54.8	91.9	178	993	182	363 J
CHROMIUM, TOTAL	4.4 J	2.9	4.4	9.3	3.9	8.7 J
COBALT, TOTAL	0.05 UJ	0.05 UJ	0.07 J	0.17 J	0.07 J	0.19 J
COPPER, TOTAL	0.4 J	0.11 U	0.11 U	0.56	0.15 U	0.16 UJ
IRON, TOTAL	2620	390	1040	9610	968	4400
LEAD, TOTAL	2.9 J	3.9	5.1	6.4	4.5	7.8 J
MAGNESIUM, TOTAL	70.1	38.7	129	188	98.5	258
MANGANESE, TOTAL	3.5	2.4	3.6	2.4	2.2	2.8
NICKEL, TOTAL	0.12 UJ	0.11 UJ	0.11 UJ	0.17 UJ	0.15 UJ	0.16 UJ
POTASSIUM, TOTAL	121 J	60.2 U	105	152 J	101 U	220 J
SELENIUM, TOTAL	0.42	0.36 U	0.36 U	0.56 J	0.48 UJ	0.43 U
SILVER, TOTAL	0.04 UJ	0.03 U	0.03 U	0.04 U	0.04 U	0.05 U
SODIUM, TOTAL	23.4 U	81	156	88	56.8	77.7 J
VANADIUM, TOTAL	4.6	2	5.5	14.7	4.6	12
ZINC, TOTAL	0.41	0.03 UJ	0.71 J	0.78 J	0.14 J	1.3 J

QUALIFIER DEFINITIONS

U= Not detected at quantitation limit.

UJ = Report quantitation limit is estimated.

J = Estimated quantity.

NA = Not analyzed

NOTES:

mg/kg = milligrams per kilogram

TABLE 4-10 (continued)
POSITIVE DETECTIONS
SUBSURFACE SOIL - TAL METALS
PHASE II - FIXED BASE LABORATORY
RI/FS CTO-0356
OPERABLE UNIT NO. 16 (SITE 93)
MCB CAMP LEJEUNE, NORTH CAROLINA

SAMPLE ID	IR93-MW05-04	IR93-MW05IW-02	IR93-MW05IW-04
PHASE	PHASE II	PHASE II	PHASE II
DATE SAMPLED	04/21/97	04/20/97	04/20/97
DEPTH	7-9'	3-5'	7-9'
TOTAL METALS (mg/kg)			
ALUMINUM, TOTAL	624	9310	1010
ANTIMONY, TOTAL	0.33 UJ	0.28 UJ	0.28 UJ
ARSENIC, TOTAL	0.37 UJ	0.31 UJ	0.32 UJ
BARIUM, TOTAL	5	13	6.5
BERYLLIUM, TOTAL	0.08 J	0.06	0.1
CADMIUM, TOTAL	0.04 UJ	0.03 UJ	0.04 UJ
CALCIUM, TOTAL	143 J	274	81.4
CHROMIUM, TOTAL	2.8 J	9.8	5.9
COBALT, TOTAL	0.06 UJ	0.21 J	0.05 UJ
COPPER, TOTAL	0.14 UJ	0.12 UJ	0.2 J
IRON, TOTAL	387	3830	659
LEAD, TOTAL	2	8.1	2.6
MAGNESIUM, TOTAL	29.2 J	302	71.4
MANGANESE, TOTAL	2.5	4.8	10.6
NICKEL, TOTAL	0.14 UJ	0.4 J	0.12 UJ
POTASSIUM, TOTAL	68.4 U	253 J	115 J
SELENIUM, TOTAL	0.39 U	0.33 UJ	0.34 UJ
SILVER, TOTAL	0.04 U	0.03 U	0.04 U
SODIUM, TOTAL	27 UJ	69.6 J	23.2 UJ
VANADIUM, TOTAL	1.7	9.4	3.9 J
ZINC, TOTAL	0.32 J	2.6 J	0.53 J

QUALIFIER DEFINITIONS
U= Not detected at quantitation limit.
UJ = Report quantitation limit is estimated.
J = Estimated quantity.
NA = Not analyzed
NOTES:
mg/kg = milligrams per kilogram

TABLE 4-11
SUMMARY OF POSITIVE DETECTIONS
SUBSURFACE SOIL - TCL ORGANICS
PHASE II - FIXED BASE LABORATORY
RI/FS CTO-0356
OPERABLE UNIT NO. 16 (SITE 93)
MCB CAMP LEJEUNE, NORTH CAROLINA

	NC Risk Analysis Framework S-3:G-1 (ug/kg)	Region III Rsidential RBCs (Risk) (ug/kg)	Min Detect	Max Detect	Location of Maximum Detect	Detection Frequency	NC Risk Analysis Framework S-3:G-1 Exceedance Count	Region III Residential RBCs (Risk) Exceedance Count
VOLATILES (ug/kg)								
2-BUTANONE	NE	4700000	13 J	13 J	IR93-MW05IW-02	1/22	0	0
ACETONE	11360	780000	19 J	340	IR93-MW05IW-02	13/22	0	0
SEMIVOLATILES (ug/kg)								
BENZO(A)PYRENE	NE	88	400 J	400 J	IR93-MW02IW-04	1/22	0	1
BIS(2-ETHYLHEXYL)PHTHALATE	NE	46000	43 J	420 J	IR93-MW02DW-04	5/22	0	0
PESTICIDES/PCBS (ug/kg)								
4,4'-DDD	NE	2700	55	55	IR93-MW02DW-02	1/3	0	0
4,4'-DDE	NE	1900	22	22	IR93-MW02DW-02	1/3	0	0
4,4'-DDT	NE	1900	33	33	IR93-MW02DW-02	1/3	0	0

QUALIFIER DEFINITIONS
U= Not detected at quantitation limit.
UJ = Report quantitation limit is estimated.
J = Estimated quantity.
NA = Not analyzed
NE = Not established
NOTES:
ug/kg = micrograms per kilogram

TABLE 4-11 (continued)
SUMMARY OF POSITIVE DETECTIONS
SUBSURFACE SOIL - TAL METALS
PHASE II - FIXED BASE LABORATORY
RI/FS CTO-0356
OPERABLE UNIT NO. 16 (SITE 93)
MCB CAMP LEJEUNE, NORTH CAROLINA

	Region III Residential RBCs (Risk) (mg/kg)	Subsurface Soil Bkg 2x Average Values Camp Lejeune	Min Detect	Max Detect	Location of Maximum Detect	Detection Frequency	Region III Residential RBCs (Risk) Exceedance Count	Subsurface Soil Bkg 2x Average Values Exceedance Count
TOTAL METALS (mg/kg)								
ALUMINUM, TOTAL	7800	7375.302	624	20500 J	IR93-MW03IW-02	21/22	5	5
ANTIMONY, TOTAL	3.1	6.409	0.27	0.43	IR93-MW02DW-02	3/22	0	0
ARSENIC, TOTAL	0.43	1.968	0.64	3.4 J	IR93-MW03-02	8/22	8	2
BARIUM, TOTAL	550	14.204	2.5	40.6	IR93-MW02-04	22/22	0	6
BERYLLIUM, TOTAL	0.15	0.191	0.02	0.5	IR93-MW02DW-02	19/22	5	2
CADMIUM, TOTAL	3.9	0.712	0.04 J	0.09	IR93-MW03-02	4/22	0	0
CALCIUM, TOTAL	NE	391.509	26	2610 J	IR93-MW02-04	22/22	0	8
CHROMIUM, TOTAL	7800	12.562	1.3	28.1 J	IR93-MW03IW-02	22/22	0	3
COBALT, TOTAL	470	1.504	0.06 J	1.6 J	IR93-MW02DW-02	15/22	0	1
COPPER, TOTAL	310	2.416	0.16 J	13.6	IR93-MW02IW-02	15/22	0	3
IRON, TOTAL	2300	7252.076	387	14900	IR93-MW03-02	22/22	12	2
LEAD, TOTAL	400	8.327	1.9	10.6 J	IR93-MW03-02	22/22	0	3
MAGNESIUM, TOTAL	NE	260.718	29.2 J	594	IR93-MW03IW-02	22/22	0	4
MANGANESE, TOTAL	180	7.919	1.3	24.6	IR93-MW02-04	22/22	0	5
NICKEL, TOTAL	160	3.714	0.15 J	3.1 J	IR93-MW02-04	11/22	0	0
POTASSIUM, TOTAL	NE	347.236	105	887 J	IR93-MW03IW-02	14/22	0	3
SELENIUM, TOTAL	39	0.801	0.42	1.6	IR93-MW02DW-02	6/22	0	1
SILVER, TOTAL	39	0.866	0.04 J	0.04 J	IR93-MW01-04	1/22	0	0
SODIUM, TOTAL	NE	52.676	41.7 J	156	IR93-MW04-04	15/22	0	12
VANADIUM, TOTAL	55	13.454	1	64.9	IR93-MW03IW-02	22/22	1	4
ZINC, TOTAL	2.3	6.662	0.14 J	11.8	IR93-MW02-02	21/22	6	2

QUALIFIER DEFINITIONS
U= Not detected at quantitation limit.
UJ = Report quantitation limit is estimated.
J = Estimated quantity.
NA = Not analyzed
NOTES:
mg/kg = milligrams per kilogram

TABLE 4-12
POSITIVE DETECTIONS
GROUNDWATER - VOLATILE ORGANICS
PHASE I - MOBILE LABORATORY AND
PHASE II - FIXED BASE LABORATORY
RI/FS CTO-0356
OPERABLE UNIT NO. 16 (SITE 93)
MCB CAMP LEJEUNE, NORTH CAROLINA

SAMPLE ID	IR93-MW05-01	IR93-TW01-01	IR93-TW01IW-01	IR93-TW02-01	IR93-TW02IW-01	IR93-TW03-01	IR93-TW03IW-01
PHASE	PHASE I	PHASE I	PHASE I	PHASE I	PHASE I	PHASE I	PHASE I
DATE SAMPLED	7/29/96	7/30/96	7/30/96	7/30/96	7/30/96	7/31/96	7/31/96
VOLATILES (ug/L)							
1,2-DICHLOROETHENE (TOTAL)	NA	NA	NA	NA	NA	NA	NA
CHLOROFORM	0.1 U	0.5	0.6	0.1 U	0.1 U	0.1 U	0.3
CIS-1,2-DICHLOROETHENE	15	175	1 U	1 U	4	1 U	1 U
TETRACHLOROETHENE	65.1	16.2	0.1 U	0.1 U	0.1 U	0.1 U	0.1 U
TRANS-1,2-DICHLOROETHENE	5	57	1 U	1 U	1 U	1 U	1 U
TRICHLOROETHENE	24.3	39.4	0.1	0.1 U	0.1	0.1 U	0.1 U

QUALIFIER DEFINITIONS

U= Not detected at quantitation limit.

UJ = Report quantitation limit is estimated.

J = Estimated quantity.

NA = Not analyzed

NOTES:

ug/L = milligrams per liter

TABLE 4-12 (continued)
POSITIVE DETECTIONS
GROUNDWATER - VOLATILE ORGANICS
PHASE I - MOBILE LABORATORY AND
PHASE II - FIXED BASE LABORATORY
RI/FS CTO-0356
OPERABLE UNIT NO. 16 (SITE 93)
MCB CAMP LEJEUNE, NORTH CAROLINA

SAMPLE ID	IR93-TW05-01	IR93-TW05IW-01	IR93-TW06-01	IR93-TW06IW-01	IR93-TW07-01	IR93-TW07IW-01	IR93-TW14-01
PHASE	PHASE I	PHASE I	PHASE I	PHASE I	PHASE I	PHASE I	PHASE I
DATE SAMPLED	5/1/96	8/1/96	8/1/96	8/1/96	8/3/96	8/3/96	8/5/96
VOLATILES (ug/L)							
1,2-DICHLOROETHENE (TOTAL)	NA	NA	NA	NA	NA	NA	NA
CHLOROFORM	0.1 U	0.1 U	0.1 U	1.7	0.1 U	0.8	0.8
CIS-1,2-DICHLOROETHENE	1 U	1 U	1 U	1 U	1 U	1 U	1 U
TETRACHLOROETHENE	0.1 U	0.1 U	8.9	0.5	0.8	0.1	0.1 U
TRANS-1,2-DICHLOROETHENE	1 U	1 U	1 U	1 U	1 U	1 U	1 U
TRICHLOROETHENE	0.1 U	0.1 U	1.3	0.1	0.6	0.1 U	0.1 U

QUALIFIER DEFINITIONS

U= Not detected at quantitation limit.

UJ = Report quantitation limit is estimated.

J = Estimated quantity.

NA = Not analyzed

NOTES:

ug/L = milligrams per liter

TABLE 4-12 (continued)
POSITIVE DETECTIONS
GROUNDWATER - VOLATILE ORGANICS
PHASE I - MOBILE LABORATORY AND
PHASE II - FIXED BASE LABORATORY
RI/FS CTO-0356
OPERABLE UNIT NO. 16 (SITE 93)
MCB CAMP LEJEUNE, NORTH CAROLINA

SAMPLE ID	IR93-TW14IW-01	IR93-MW01-01	IR93-MW01IW-01	IR93-MW02-01	IR93-MW02DW-01	IR93-MW02IW-01
PHASE	PHASE I	PHASE II	PHASE II	PHASE II	PHASE II	PHASE II
DATE SAMPLED	8/5/96	05/30/97	05/30/97	06/02/97	05/29/97	06/02/97
VOLATILES (ug/L)						
1,2-DICHLOROETHENE (TOTAL)	NA	10 U	10 U	10 U	10 U	10 U
CHLOROFORM	2.3	10 U	10 U	10 U	10 U	10 U
CIS-1,2-DICHLOROETHENE	1 U	NA	NA	NA	NA	NA
TETRACHLOROETHENE	0.1 U	10 U	10 U	3 J	10 U	10 U
TRANS-1,2-DICHLOROETHENE	1 U	NA	NA	NA	NA	NA
TRICHLOROETHENE	0.1 U	10 U	10 U	10 U	10 U	10 U

QUALIFIER DEFINITIONS

U= Not detected at quantitation limit.

UJ = Report quantitation limit is estimated.

J = Estimated quantity.

NA = Not analyzed

NOTES:

ug/L = milligrams per liter

TABLE 4-12 (continued)
POSITIVE DETECTIONS
GROUNDWATER - VOLATILE ORGANICS
PHASE I - MOBILE LABORATORY AND
PHASE II - FIXED BASE LABORATORY
RI/FS CTO-0356
OPERABLE UNIT NO. 16 (SITE 93)
MCB CAMP LEJEUNE, NORTH CAROLINA

SAMPLE ID	IR93-MW03-01	IR93-MW03IW-01	IR93-MW04-01	IR93-MW04IW-01	IR93-MW05-01	IR93-MW05IW-01
PHASE	PHASE II	PHASE II	PHASE II	PHASE II	PHASE II	PHASE II
DATE SAMPLED	05/20/97	05/20/97	05/30/97	05/30/97	05/27/97	05/27/97
VOLATILES (ug/L)						
1,2-DICHLOROETHENE (TOTAL)	10 U	10 U	10 U	10 U	92	10 U
CHLOROFORM	10 U	10 U	10 U	10 U	10 U	10 U
CIS-1,2-DICHLOROETHENE	NA	NA	NA	NA	NA	NA
TETRACHLOROETHENE	10 U	10 U	10 U	10 U	10 U	10 U
TRANS-1,2-DICHLOROETHENE	NA	NA	NA	NA	NA	NA
TRICHLOROETHENE	10 U	10 U	10 U	10 U	28	10 U

QUALIFIER DEFINITIONS

U= Not detected at quantitation limit.

UJ = Report quantitation limit is estimated.

J = Estimated quantity.

NA = Not analyzed

NOTES:

ug/L = milligrams per liter

TABLE 4-12 (continued)
POSTIVE DETECTIONS
GROUNDWATER - TCL ORGANICS
PHASE II - FIXED BASE LABORATORY
RI/FS CTO-0356
OPERABLE UNIT NO. 16 (SITE 93)
MCB CAMP LEJEUNE, NORTH CAROLINA

SAMPLE ID	IR93-MW01-01	IR93-MW01IW-01	IR93-MW02-01	IR93-MW02DW-01	IR93-MW02IW-01	IR93-MW03-01
PHASE	PHASE II	PHASE II	PHASE II	PHASE II	PHASE II	PHASE II
DATE SAMPLED	05/30/97	05/30/97	06/02/97	05/29/97	06/02/97	05/20/97
VOLATILES (ug/L)						
1,2-DICHLOROETHENE (TOTAL)	10 U	10 U	10 U	10 U	10 U	10 U
TETRACHLOROETHENE	10 U	10 U	3 J	10 U	10 U	10 U
TRICHLOROETHENE	10 U	10 U	10 U	10 U	10 U	10 U
SEMIVOLATILES (ug/L)						
BIS(2-ETHYLHEXYL)PHTHALATE	1 J	10 U	10 U	10 UJ	2 J	2 J
NAPHTHALENE	10 U	10 U	10 U	10 U	10 U	10 U

QUALIFIER DEFINITIONS
U= Not detected at quantitation limit.
UJ = Report quantitation limit is estimated.
J = Estimated quantity.
NA = Not analyzed
NOTES:
ug/L = milligrams per liter

TABLE 4-12 (continued)
POSTIVE DETECTIONS
GROUNDWATER - TCL ORGANICS
PHASE II - FIXED BASE LABORATORY
RI/FS CTO-0356
OPERABLE UNIT NO. 16 (SITE 93)
MCB CAMP LEJEUNE, NORTH CAROLINA

SAMPLE ID	IR93-MW03IW-01	IR93-MW04-01	IR93-MW04IW-01	IR93-MW05-01	IR93-MW05IW-01
PHASE	PHASE II	PHASE II	PHASE II	PHASE II	PHASE II
DATE SAMPLED	05/20/97	05/30/97	05/30/97	05/27/97	05/27/97
VOLATILES (ug/L)					
1,2-DICHLOROETHENE (TOTAL)	10 U	10 U	10 U	92	10 U
TETRACHLOROETHENE	10 U	10 U	10 U	10 U	10 U
TRICHLOROETHENE	10 U	10 U	10 U	28	10 U
SEMIVOLATILES (ug/L)					
BIS(2-ETHYLHEXYL)PHTHALATE	10 U	16 U	13 U	10 U	130
NAPHTHALENE	10 U	10 U	10 U	6 J	10 U

QUALIFIER DEFINITIONS
U= Not detected at quantitation limit.
UJ = Report quantitation limit is estimated.
J = Estimated quantity.
NA = Not analyzed
NOTES:
ug/L = milligrams per liter

TABLE 4-12 (continued)
POSITIVE DETECTIONS
GROUNDWATER - TAL METALS
PHASE II - FIXED BASE LABORATORY
RI/FS CTO-0356
OPERABLE UNIT NO. 16 (SITE 93)
MCB CAMP LEJEUNE, NORTH CAROLINA

SAMPLE ID	IR93-MW01-01	IR93-MW01IW-01	IR93-MW02-01	IR93-MW02DW-01	IR93-MW02IW-01	IR93-MW03-01
PHASE	PHASE II	PHASE II	PHASE II	PHASE II	PHASE II	PHASE II
DATE SAMPLED	05/30/97	05/30/97	06/02/97	05/29/97	06/02/97	05/20/97
TOTAL METALS (ug/L)						
ALUMINUM, TOTAL	140 U	71 U	26 U	32.6 U	2540	98.4 U
ANTIMONY, TOTAL	1.9 U	1.9 U	1.9 U	1.9 U	2.3	1.9 U
ARSENIC, TOTAL	2.7 U	2.7 U	2.7 U	2.7 U	4.3	2.7 U
BARIUM, TOTAL	56.8	18.7	24	4.2	73.9	35.3
CADMIUM, TOTAL	0.4 U	0.4 U	0.4 U	0.4 U	1.6	0.4 U
CALCIUM, TOTAL	14800	92600	84300	61700	15200	7870
CHROMIUM, TOTAL	0.5 U	0.5 U	0.62	0.5 U	17	0.98
COBALT, TOTAL	10.3	0.5 U	0.5 U	0.5 U	1	0.5 U
COPPER, TOTAL	0.8 UJ	0.8 UJ	0.8 U	0.8 UJ	32.1	0.8 UJ
IRON, TOTAL	1190	4330	2810	577	3630	1600
LEAD, TOTAL	1.4 U	1.4 U	1.4 U	1.4 U	164	1.4 U
MAGNESIUM, TOTAL	2460	1890	1800	3440	5220	457
MANGANESE, TOTAL	432	45.8	27.6	41.9	206	9.2
NICKEL, TOTAL	14.8	1.5 U	0.7 U	1.5 U	3.7	0.7 U
POTASSIUM, TOTAL	1340	1870	1260	7620	24500	1080
SELENIUM, TOTAL	2.2 U	2.2 U	2.2 U	2.2 U	2.9	2.2 U
SODIUM, TOTAL	13000	7140	6510	39700	188 UJ	7900
VANADIUM, TOTAL	0.71	0.7 U	0.7 U	0.7 U	6.4	0.71
ZINC, TOTAL	10.8 J	0.4 UJ	4.4	0.4 UJ	316	0.4 UJ

QUALIFIER DEFINITIONS

U= Not detected at quantitation limit.

UJ = Report quantitation limit is estimated.

J = Estimated quantity.

NA = Not analyzed

NOTES:

ug/L = milligrams per liter

TABLE 4-12 (continued)
POSITIVE DETECTIONS
GROUNDWATER - TAL METALS
PHASE II - FIXED BASE LABORATORY
RI/FS CTO-0356
OPERABLE UNIT NO. 16 (SITE 93)
MCB CAMP LEJEUNE, NORTH CAROLINA

SAMPLE ID	IR93-MW03IW-01	IR93-MW04-01	IR93-MW04IW-01	IR93-MW05-01	IR93-MW05IW-01
PHASE	PHASE II	PHASE II	PHASE II	PHASE II	PHASE II
DATE SAMPLED	05/20/97	05/30/97	05/30/97	05/27/97	05/27/97
TOTAL METALS (ug/L)					
ALUMINUM, TOTAL	50.7 U	270	35.4 U	39.3 U	26.6 U
ANTIMONY, TOTAL	1.9 U	1.9 U	1.9 U	1.9 U	1.9 U
ARSENIC, TOTAL	2.7 U	2.7 U	2.7 U	2.7 U	2.7 U
BARIUM, TOTAL	29.4	58.2	11.7	45.2	10.5
CADMIUM, TOTAL	0.4 U	0.4 U	0.4 U	0.4 U	0.4 U
CALCIUM, TOTAL	106000	4760	88000	16300	83000
CHROMIUM, TOTAL	0.57	0.5 U	0.5 U	0.64	0.57
COBALT, TOTAL	0.5 U	1.6	0.5 U	0.5 U	0.5 U
COPPER, TOTAL	0.8 UJ	0.8 UJ	0.8 UJ	0.8 U	0.8 U
IRON, TOTAL	3340	934	3130	1840 J	3400 J
LEAD, TOTAL	1.4 U	1.4 U	1.4 U	1.4 U	1.4 U
MAGNESIUM, TOTAL	2360	1200	1740	1410	1830
MANGANESE, TOTAL	38.7	17.1	37.7	25.8	47.2
NICKEL, TOTAL	0.7 U	4.4	1.5 U	0.7 U	0.7 U
POTASSIUM, TOTAL	1900	892	1240	1330 J	1740 J
SELENIUM, TOTAL	2.2 U	2.2 U	2.2 U	2.2 U	2.2 U
SODIUM, TOTAL	7860	26500	6660	14700	7300
VANADIUM, TOTAL	0.7 U	0.74	0.7 U	1.2 U	0.7 U
ZINC, TOTAL	0.4 UJ	2.7 J	0.4 UJ	0.4 UJ	0.4 UJ

QUALIFICATIONS
Not detected at quantitation limit.
UJ = Report quantitation limit is estimated.
J = Estimated quantity.
NA = Not analyzed
NOTES:
ug/L = milligrams per liter

TABLE 4-13
SUMMARY OF POSITIVE DETECTIONS
GROUNDWATER - VOLATILE ORGANICS
PHASE I - MOBILE LABORATORY AND
PHASE II - FIXED BASE LABORATORY
RI/FS CTO-0356
OPERABLE UNIT NO. 16 (SITE 93)
MCB CAMP LEJEUNE, NORTH CAROLINIA

	NC WQS (ug/L)	US - Primary MCL (ug/L)	Min Detect	Max Detect	Location of Maximum Detect	Detection Frequency	NC WQS Exceedance Count	US - Primary MCL Exceedance Count
VOLATILES (ug/L)								
1,2-DICHLOROETHENE (TOTAL)	NE	NE	92	92	IR93-MW05-01	1/11	0	0
CHLOROFORM	0.19	100/80	0.3	2.3	IR93-TW14IW-01	7/26	7	0
CIS-1,2-DICHLOROETHENE	70	70	4	175	IR93-TW01-01	3/15	1	1
TETRACHLOROETHENE	0.7	5	0.1	65.1	IR93-MW05-01	7/26	5	3
TRANS-1,2-DICHLOROETHENE	70	100	5	57	IR93-TW01-01	2/15	0	0
TRICHLOROETHENE	2.8	5	0.1	39.4	IR93-TW01-01	8/26	3	3
SEMIVOLATILES (ug/L)								
BIS(2-ETHYLHEXYL)PHTHALATE	3	6	1 J	130	IR93-MW05IW-01	4/11	1	1
NAPHTHALENE	21	NE	6 J	6 J	IR93-MW05-01	1/11	0	0

QUALIFIER DEFINITIONS
U= Not detected at quantitation limit.
UJ = Report quantitation limit is estimated.
J = Estimated quantity.
NA = Not analyzed
NOTES:
ug/L = milligrams per liter

TABLE 4-13 (continued)
SUMMARY OF POSITIVE DETECTIONS
GROUNDWATER - TAL METALS
PHASE II - FIXED BASE LABORATORY
RI/FS CTO-0356
OPERABLE UNIT NO. 16 (SITE 93)
MCB CAMP LEJEUNE, NORTH CAROLINA

SAMPLE ID PHASE DATE SAMPLED	NC WQS (ug/L)	US - Primary MCL (ug/L)	Min Detect	Max Detect	Location of Maximum Detect	Detection Frequency	NC WQS Exceedance Count	US - Primary MCL Exceedance Count
TOTAL METALS (ug/L)								
ALUMINUM, TOTAL	NE	**200**	270	2540	IR93-MW02IW-01	2/11	0	**2**
ANTIMONY, TOTAL	NE	6	2.3	2.3	IR93-MW02IW-01	1/11	0	0
ARSENIC, TOTAL	50	50	4.3	4.3	IR93-MW02IW-01	1/11	0	0
BARIUM, TOTAL	2000	2000	4.2	73.9	IR93-MW02IW-01	11/11	0	0
CADMIUM, TOTAL	5	5	1.6	1.6	IR93-MW02IW-01	1/11	0	0
CALCIUM, TOTAL	NE	NE	4760	106000	IR93-MW03IW-01	11/11	0	0
CHROMIUM, TOTAL	50	100	0.57	17	IR93-MW02IW-01	6/11	0	0
COBALT, TOTAL	NE	NE	1	10.3	IR93-MW01-01	3/11	0	0
COPPER, TOTAL	1000	1300	32.1	32.1	IR93-MW02IW-01	1/11	0	0
IRON, TOTAL	300	**300**	577	4330	IR93-MW01IW-01	11/11	11	11
LEAD, TOTAL	15	15	164	164	IR93-MW02IW-01	1/11	1	1
MAGNESIUM, TOTAL	NE	NE	457	5220	IR93-MW02IW-01	11/11	0	0
MANGANESE, TOTAL	50	**50**	9.2	432	IR93-MW01-01	11/11	2	2
NICKEL, TOTAL	100	100	3.7	14.8	IR93-MW01-01	3/11	0	0
POTASSIUM, TOTAL	NE	NE	892	24500	IR93-MW02IW-01	11/11	0	0
SELENIUM, TOTAL	50	50	2.9	2.9	IR93-MW02IW-01	1/11	0	0
SODIUM, TOTAL	NE	NE	6510	39700	IR93-MW02DW-01	10/11	0	0
VANADIUM, TOTAL	NE	NE	0.71	6.4	IR93-MW02IW-01	4/11	0	0
ZINC, TOTAL	2100	**5000**	2.7 J	316	IR93-MW02IW-01	4/11	0	0

QUALIFIER DEFINITIONS

U= Not detected at quantitation limit.

UJ = Report quantitation limit is estimated.

J = Estimated quantity.

NA = Not analyzed

NOTES:

ug/L = milligrams per liter

SECTION 4.0 FIGURES

02020N 42Y

LEGEND

⚑	Staff Gauge
●	Permanent Monitoring Well
✕	Surface Water Sample
☒	Surface Water/Sediment Sample
◎	Temporary Monitoring Well
─	DRMO Fence Line
➤	Edwards Creek with Flow Direction

Scale

400 0 400 800 Feet

MARINE CORPS BASE, CAMP LEJEUNE
NORTH CAROLINA

SAMPLE LOCATIONS
OPERABLE UNIT NO. 16 (SITE 89)
REMEDIAL INVESTIGATION
CTO 0356

Baker

FIGURE 4-1

02020N 43Y

LEGEND

⊕	Permanent Monitoring Well Location
⊙	Temporary Monitoring Well Location
∿	Swale
◀	Edwards Creek with Flow Direction
⌒⌒⌒	Wooded Area

Scale

200 0 200 400 Feet

N W E S

MARINE CORPS BASE, CAMP LEJEUNE
NORTH CAROLINA

SAMPLE LOCATIONS
OPERABLE UNIT NO. 16 (SITE 93)
REMEDIAL INVESTIGATION
CTO 0356

Baker

FIGURE 4-2

GROUNDWATER EXCEEDANCES - SITE 89 SHALLOW WELLS

Loc_ID	Parameter	Qualifier	Result	Units	Date	NCWQS	MCL
IR89-MW01	TETRACHLOROETHENE		42.4000	UG/L	7/31/96	0.7000	5.0000
IR89-MW01	TETRACHLOROETHENE	J	4.0000	UG/L	05/28/97	0.7000	5.0000
IR89-MW01	TRICHLOROETHENE		323.1000	UG/L	7/31/96	2.8000	5.0000
IR89-MW01	TRICHLOROETHENE		67.0000	UG/L	05/28/97	2.8000	5.0000
IR89-MW01	CIS-1,2-DICHLOROETHENE		261.0000	UG/L	7/31/96	70.0000	70.0000
IR89-MW01	TRANS-1,2-DICHLOROETHENE		177.0000	UG/L	7/31/96	70.0000	100.0000
IR89-MW02	VINYL CHLORIDE		130.0000	UG/L	7/30/96	0.0150	2.0000
IR89-MW02	TETRACHLOROETHENE		9.4000	UG/L	7/30/96	0.7000	5.0000
IR89-MW02	TRICHLOROETHENE		744.3000	UG/L	7/30/96	2.8000	5.0000
IR89-MW02	CIS-1,2-DICHLOROETHENE		818.0000	UG/L	7/30/96	70.0000	70.0000
IR89-MW02	TRANS-1,2-DICHLOROETHENE		451.0000	UG/L	7/30/96	70.0000	100.0000
IR89-MW03	TETRACHLOROETHENE		13.1000	UG/L	7/31/96	0.7000	5.0000
IR89-MW03	TRICHLOROETHENE		131.0000	UG/L	7/31/96	2.8000	5.0000
IR89-MW03	CIS-1,2-DICHLOROETHENE		150.0000	UG/L	7/31/96	70.0000	70.0000
IR89-MW03	TRANS-1,2-DICHLOROETHENE		82.0000	UG/L	7/31/96	70.0000	100.0000
IR89-MW04	VINYL CHLORIDE		43.0000	UG/L	05/29/97	0.0150	2.0000
IR89-MW04	TETRACHLOROETHENE	J	7.0000	UG/L	05/29/97	0.7000	5.0000
IR89-MW04	TRICHLOROETHENE		640.0000	UG/L	05/29/97	2.8000	5.0000
IR89-MW05	VINYL CHLORIDE	J	6.0000	UG/L	05/28/97	0.0150	2.0000
IR89-MW05	TRICHLOROETHENE		280.0000	UG/L	05/28/97	2.8000	5.0000
IR89-TW08	TETRACHLOROETHENE		23.0000	UG/L	08/06/96	0.7000	5.0000
IR89-TW08	TETRACHLOROETHENE		27.0000	UG/L	8/3/96	0.7000	5.0000
IR89-TW08	TRICHLOROETHENE		670.0000	UG/L	08/06/96	2.8000	5.0000
IR89-TW08	TRICHLOROETHENE		638.4000	UG/L	8/3/96	2.8000	5.0000
IR89-TW08	CIS-1,2-DICHLOROETHENE		253.0000	UG/L	8/3/96	70.0000	70.0000
IR89-TW13	TETRACHLOROETHENE		4.8000	UG/L	8/5/96	0.7000	5.0000
IR89-TW13	TRICHLOROETHENE		136.9000	UG/L	8/5/96	2.8000	5.0000
IR89-TW15	TETRACHLOROETHENE		13.7000	UG/L	8/6/96	0.7000	5.0000
IR89-TW15	TRICHLOROETHENE		355.9000	UG/L	8/6/96	2.8000	5.0000
IR89-TW15	CIS-1,2-DICHLOROETHENE		162.0000	UG/L	8/6/96	70.0000	70.0000
IR89-TW16	TETRACHLOROETHENE		42.7000	UG/L	8/6/96	0.7000	5.0000
IR89-TW16	TRICHLOROETHENE		562.9000	UG/L	8/6/96	2.8000	5.0000
IR89-TW16	CIS-1,2-DICHLOROETHENE		102.0000	UG/L	8/6/96	70.0000	70.0000
IR89-MW42B	TRICHLOROETHENE		85.8000	UG/L	7/31/96	0.7000	5.0000

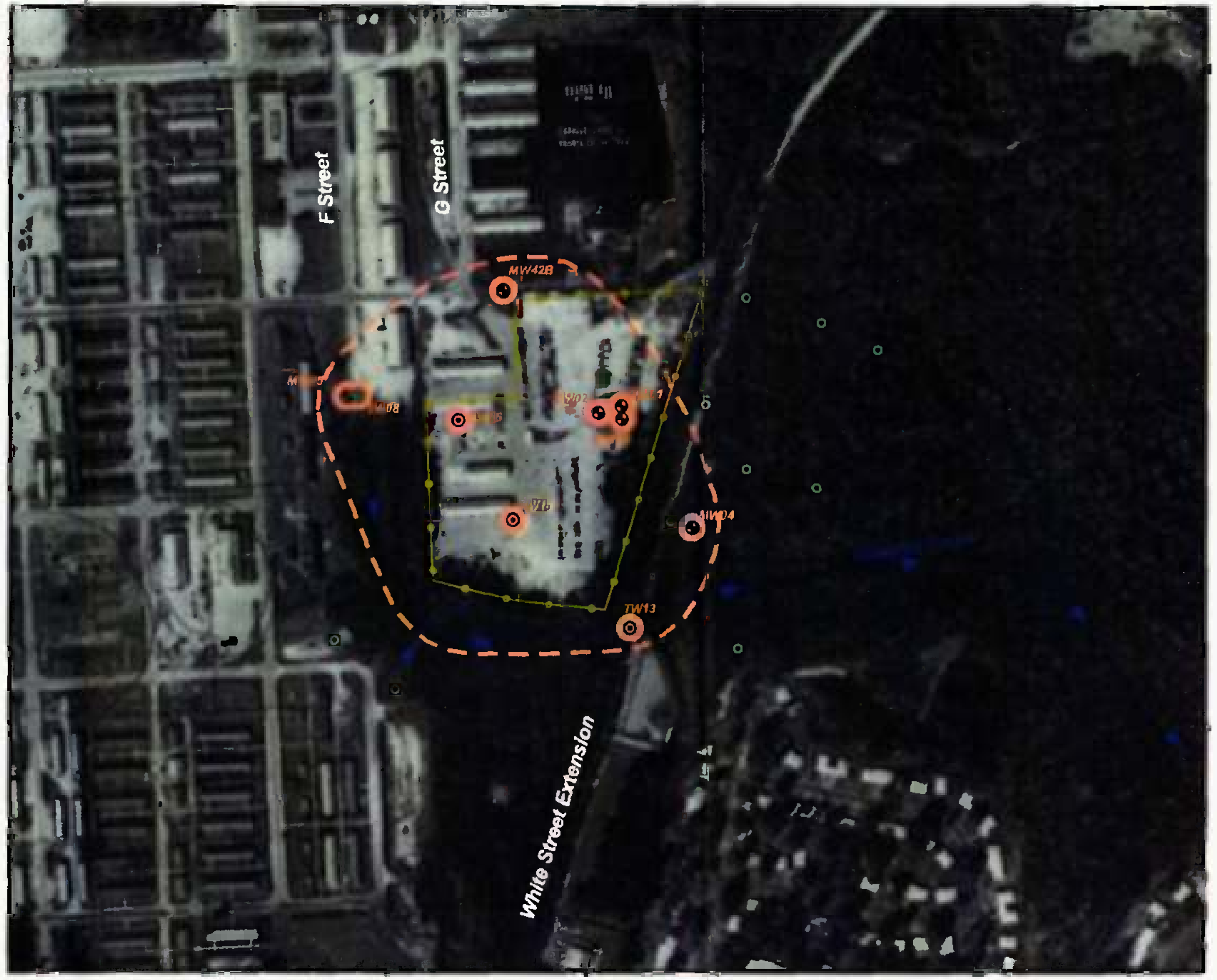
Footnotes:

Table presents concentrations above NCWQS/MCLs

UG/L - Microgram per liter (ppb)

NCWQS - North Carolina Water Quality Standard

MCL - Federal Drinking Water Regulations Maximum Containment Level



LEGEND

- ● Permanent Monitoring Well Location
- ◉ Temporary Monitoring Well Location
- 🟥 Monitoring Well Location and Well ID with concentrations exceeding NCWQS/MCLS
- Estimated Boundary of Groundwater Contamination above Applicable Standards
- DRMO Facility

Graphic Scale
90 0 90 180 Feet

MARINE CORPS BASE, CAMP LEJEUNE
NORTH CAROLINA

VOLATILE ORGANIC COMPOUNDS
IN GROUNDWATER (SHALLOW WELLS)
OPERABLE UNIT NO. 16 (SITE 89)
REMEDIAL INVESTIGATION
CTO 0356

Baker

FIGURE 4 - 3

GROUNDWATER EXCEEDANCES - SITE 89 INTERMEDIATE WELLS

Location ID	Parameter	Date	Result	Qualifier	Units	NCWQS	MCL
IR89-MW03IW	TRICHLOROETHENE	05/28/97	400.0000		UG/L	2.8000	5.0000
IR89-MW04IW	VINYL CHLORIDE	05/29/97	9.0000	J	UG/L	0.0150	2.0000
IR89-MW04IW	TRICHLOROETHENE	05/29/97	510.0000		UG/L	2.8000	5.0000
IR89-MW06IW	TRICHLOROETHENE	05/19/97	18.0000		UG/L	2.8000	5.0000
IR89-MW07IW	TRICHLOROETHENE	05/20/97	10.0000	J	UG/L	2.8000	5.0000
IR89-TW09IW	TETRACHLOROETHENE	8/3/96	8.8000		UG/L	0.7000	5.0000
IR89-TW09IW	TRICHLOROETHENE	08/07/96	260.0000		UG/L	2.8000	5.0000
IR89-TW09IW	TRICHLOROETHENE	8/3/96	233.4000		UG/L	2.8000	5.0000
IR89-TW09IW	CIS-1,2-DICHLOROETHENE	8/3/96	114.0000		UG/L	70.0000	70.0000
IR89-TW10IW	TRICHLOROETHENE	8/4/96	36.3000		UG/L	2.8000	5.0000
IR89-TW11IW	TRICHLOROETHENE	8/4/96	3.3000		UG/L	2.8000	5.0000
IR89-TW13IW	TETRACHLOROETHENE	8/5/96	7.4000		UG/L	0.7000	5.0000
IR89-TW13IW	TRICHLOROETHENE	8/5/96	57.9000		UG/L	2.8000	5.0000
IR89-TW15IW	TRICHLOROETHENE	8/6/96	6.0000		UG/L	2.8000	5.0000
IR89-TW17IW	TETRACHLOROETHENE	8/7/96	1.5000		UG/L	0.7000	5.0000
IR89-TW17IW	TRICHLOROETHENE	08/07/96	390.0000		UG/L	2.8000	5.0000
IR89-TW17IW	TRICHLOROETHENE	8/7/96	425.7000		UG/L	2.8000	5.0000
IR89-TW17IW	CIS-1,2-DICHLOROETHENE	8/7/96	287.0000		UG/L	70.0000	70.0000
IR89-TW17IW	TRANS-1,2-DICHLOROETHENE	8/7/96	90.0000		UG/L	70.0000	100.0000
IR89-TW19IW	TRICHLOROETHENE	8/13/96	3.8000		UG/L	2.8000	5.0000
IR89-TW20IW	TRICHLOROETHENE	8/14/96	59.1000		UG/L	2.8000	5.0000
IR89-TW21IW	TRICHLOROETHENE	8/15/96	10.4000		UG/L	2.8000	5.0000
IR89-TW22IW	TETRACHLOROETHENE	8/16/96	13.0000		UG/L	0.7000	5.0000
IR89-TW22IW	TRICHLOROETHENE	8/16/96	293.9000		UG/L	2.8000	5.0000
IR89-TW22IW	CIS-1,2-DICHLOROETHENE	8/16/96	106.0000		UG/L	70.0000	70.0000
IR89-TW23IW	TRICHLOROETHENE	8/21/96	123.9000		UG/L	2.8000	5.0000
IR89-TW23IW	CIS-1,2-DICHLOROETHENE	8/21/96	84.0000		UG/L	70.0000	70.0000

Footnotes:

Table presents concentrations above NCWQS/MCLs

UG/L - Microgram per liter (ppb)

NCWQS - North Carolina Water Quality Standard

MCL - Federal Drinking Water Regulations Maximum Contaminent Level

LEGEND

●	Permanent Monitoring Well Location
⊙	Temporary Monitoring Well Location
MW0 ●	Monitoring Well Location and Well ID with concentrations exceeding NCWQS/MCLs
- - -	Estimated Boundary of Groundwater Contamination above Applicable Standards
———	DRMO Fence Line
——▶——	Edwards Creek with Flow Direction

Scale

400 0 400 800 Feet

MARINE CORPS BASE, CAMP LEJEUNE
NORTH CAROLINA

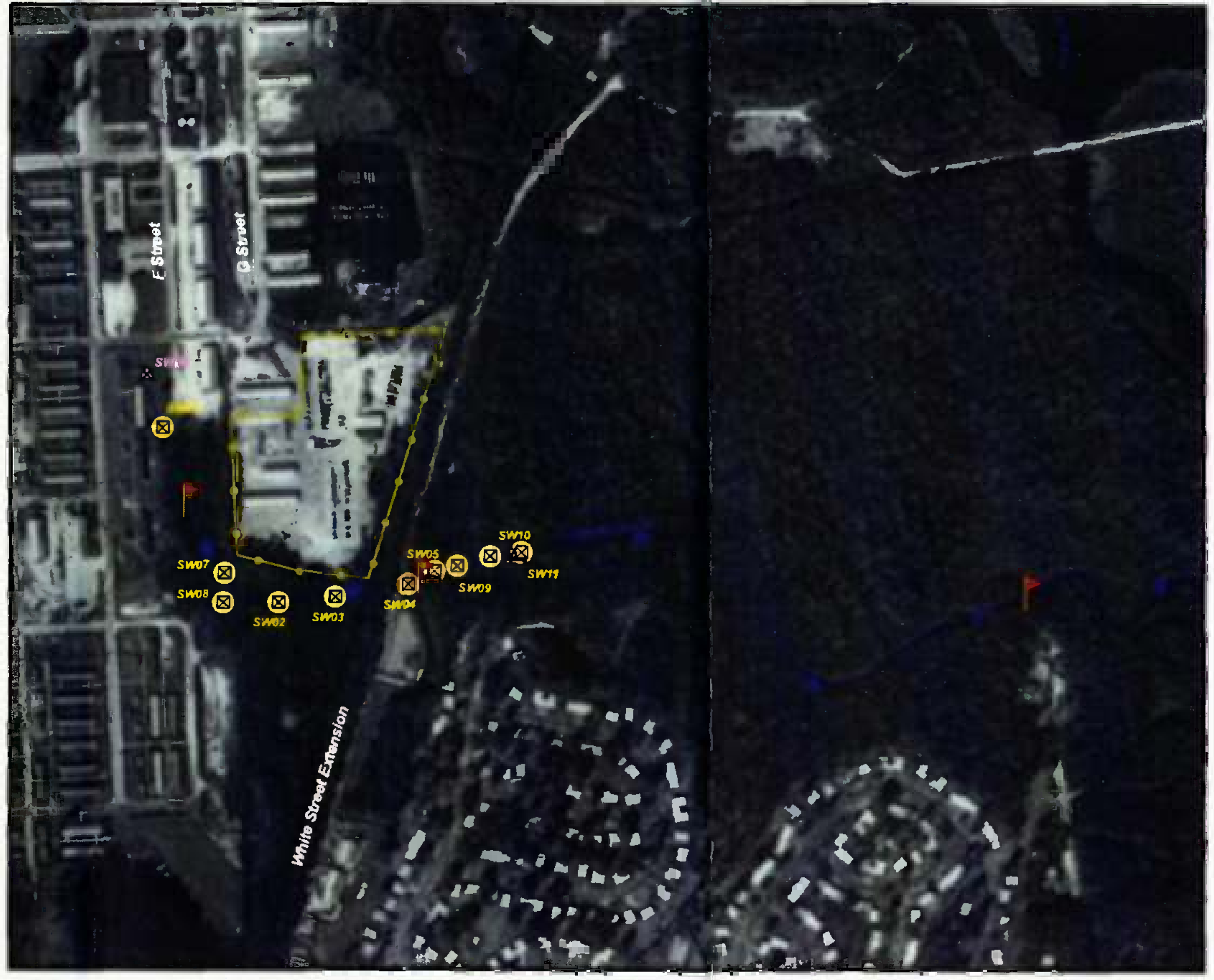
VOLATILE ORGANIC COMPOUNDS IN
GROUNDWATER (INTERMEDIATE WELLS)
OPERABLE UNIT NO. 16 (SITE 89)
REMEDIAL INVESTIGATION
CTO 0356

Baker

FIGURE 4-4

SURFACE WATER DETECTIONS - VOLATILE ORGANIC COMPOUNDS

Loc_ID	Parameter	Qualifier	Result	Units	Date
IR89-SW01	CHLOROFORM		0.3000	UG/L	8/15/96
IR89-SW01	TETRACHLOROETHENE		0.2000	UG/L	8/15/96
IR89-SW01	TRICHLOROETHENE	J	3.0000	UG/L	07/27/96
IR89-SW01	TRICHLOROETHENE		3.8000	UG/L	8/15/96
IR89-SW01	CIS-1,2-DICHLOROETHENE		2.0000	UG/L	8/15/96
IR89-SW02	VINYL CHLORIDE		25.0000	UG/L	07/27/96
IR89-SW02	CHLOROFORM		0.2000	UG/L	8/15/96
IR89-SW02	TETRACHLOROETHENE		0.2000	UG/L	8/15/96
IR89-SW02	TRICHLOROETHENE		18.0000	UG/L	07/27/96
IR89-SW02	TRICHLOROETHENE		7.3000	UG/L	8/15/96
IR89-SW02	CIS-1,2-DICHLOROETHENE		48.0000	UG/L	8/15/96
IR89-SW02	TRANS-1,2-DICHLOROETHENE		37.0000	UG/L	8/15/96
IR89-SW02	1,1,2,2-TETRACHLOROETHANE	J	150.0000	UG/L	07/27/96
IR89-SW02	1,2-DICHLOROETHENE (TOTAL)		120.0000	UG/L	07/27/96
IR89-SW03	VINYL CHLORIDE		21.0000	UG/L	07/27/96
IR89-SW03	CHLOROFORM		0.1000	UG/L	8/15/96
IR89-SW03	TETRACHLOROETHENE		0.2000	UG/L	8/15/96
IR89-SW03	TRICHLOROETHENE		16.0000	UG/L	07/27/96
IR89-SW03	TRICHLOROETHENE		6.4000	UG/L	8/15/96
IR89-SW03	CIS-1,2-DICHLOROETHENE		44.0000	UG/L	8/15/96
IR89-SW03	TRANS-1,2-DICHLOROETHENE		31.0000	UG/L	8/15/96
IR89-SW03	1,1,2,2-TETRACHLOROETHANE	J	130.0000	UG/L	07/27/96
IR89-SW03	1,2-DICHLOROETHENE (TOTAL)		100.0000	UG/L	07/27/96
IR89-SW04	CHLOROFORM		0.4000	UG/L	8/15/96
IR89-SW04	TETRACHLOROETHENE		0.2000	UG/L	8/15/96
IR89-SW04	TRICHLOROETHENE		26.0000	UG/L	07/26/96
IR89-SW04	TRICHLOROETHENE		32.9000	UG/L	8/15/96
IR89-SW04	CIS-1,2-DICHLOROETHENE		52.0000	UG/L	8/15/96
IR89-SW04	TRANS-1,2-DICHLOROETHENE		19.0000	UG/L	8/15/96
IR89-SW04	1,1,2,2-TETRACHLOROETHANE		72.0000	UG/L	07/26/96
IR89-SW04	1,2-DICHLOROETHENE (TOTAL)		80.0000	UG/L	07/26/96
IR89-SW05	CHLOROFORM		0.3000	UG/L	8/15/96
IR89-SW05	TETRACHLOROETHENE		0.1000	UG/L	8/15/96
IR89-SW05	TRICHLOROETHENE		24.0000	UG/L	07/26/96
IR89-SW05	TRICHLOROETHENE		27.3000	UG/L	8/15/96
IR89-SW05	CIS-1,2-DICHLOROETHENE		44.0000	UG/L	8/15/96
IR89-SW05	TRANS-1,2-DICHLOROETHENE		15.0000	UG/L	8/15/96
IR89-SW05	1,1,2,2-TETRACHLOROETHANE		80.0000	UG/L	07/26/96
IR89-SW05	1,2-DICHLOROETHENE (TOTAL)		78.0000	UG/L	07/26/96
IR89-SW07	TETRACHLOROETHENE		1.2000	UG/L	8/1/96
IR89-SW07	TRICHLOROETHENE		14.8000	UG/L	8/1/96
IR89-SW07	CIS-1,2-DICHLOROETHENE		27.0000	UG/L	8/1/96
IR89-SW07	TRANS-1,2-DICHLOROETHENE		21.0000	UG/L	8/1/96
IR89-SW08	TETRACHLOROETHENE		0.4000	UG/L	8/1/96
IR89-SW09	CHLOROFORM		0.4000	UG/L	8/15/96
IR89-SW09	TETRACHLOROETHENE		0.2000	UG/L	8/15/96
IR89-SW09	TRICHLOROETHENE		28.5000	UG/L	8/15/96
IR89-SW09	CIS-1,2-DICHLOROETHENE		44.0000	UG/L	8/15/96
IR89-SW09	TRANS-1,2-DICHLOROETHENE		16.0000	UG/L	8/15/96
IR89-SW10	CHLOROFORM		0.4000	UG/L	8/15/96
IR89-SW10	TETRACHLOROETHENE		0.1000	UG/L	8/15/96
IR89-SW10	TRICHLOROETHENE		27.9000	UG/L	8/15/96
IR89-SW10	CIS-1,2-DICHLOROETHENE		43.0000	UG/L	8/15/96
IR89-SW10	TRANS-1,2-DICHLOROETHENE		15.0000	UG/L	8/15/96
IR89-SW11	CHLOROFORM		0.4000	UG/L	8/15/96
IR89-SW11	TETRACHLOROETHENE		0.2000	UG/L	8/15/96
IR89-SW11	TRICHLOROETHENE		27.6000	UG/L	8/15/96
IR89-SW11	CIS-1,2-DICHLOROETHENE		43.0000	UG/L	8/15/96
IR89-SW11	TRANS-1,2-DICHLOROETHENE		14.0000	UG/L	8/15/96



LEGEND

✱	Surface Water Sample	●	Sample Location and Well ID with concentrations
☒	Surface Water / Sediment Sample		Edwards Creek with Flow Direction
	Staff Gauge		Drainage Swale

NOTE:
Phase II surfacewater samples not shown.
(Chloride ion only)

Graphic Scale
90 0 90 180 Feet

N W E S

MARINE CORPS BASE, CAMP LEJEUNE
NORTH CAROLINA

VOLATILE ORGANIC COMPOUNDS
IN SURFACEWATER
OPERABLE UNIT NO. 16 (SITE 89)
REMEDIAL INVESTIGATION
CTO 0356

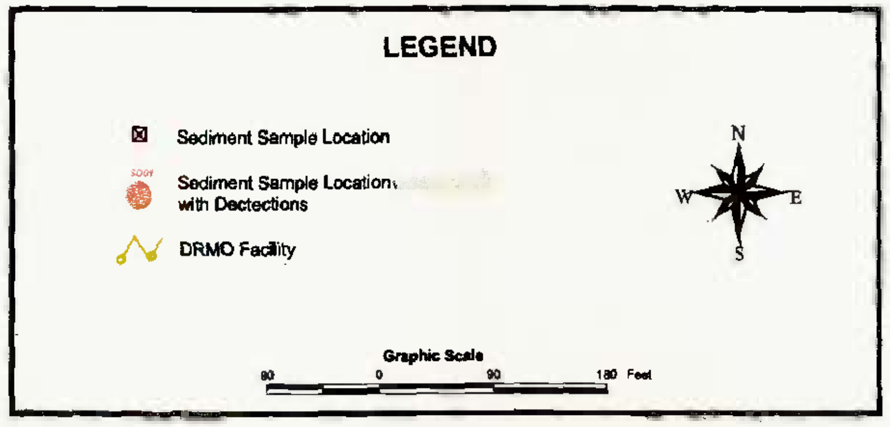
Baker

FIGURE 4 - 5

02020N47Y

SEDIMENT DETECTIONS - VOLATILE ORGANIC COMPOUNDS

Loc_ID	Parameter	Qualifier	Result	Units	Date
IR89-SD03	VINYL CHLORIDE		35.0000	UG/KG	07/27/96
IR89-SD03	VINYL CHLORIDE		230.0000	UG/KG	07/27/96
IR89-SD03	TRICHLOROETHENE		2400.0000	UG/KG	07/27/96
IR89-SD03	TRICHLOROETHENE		120.0000	UG/KG	07/27/96
IR89-SD03	1,1-DICHLOROETHENE	J	37.0000	UG/KG	07/27/96
IR89-SD03	TOLUENE	J	7.0000	UG/KG	07/27/96
IR89-SD03	1,1,2,2-TETRACHLOROETHANE		1700.0000	UG/KG	07/27/96
IR89-SD03	1,1,2,2-TETRACHLOROETHANE		550.0000	UG/KG	07/27/96
IR89-SD03	1,1,2-TRICHLOROETHANE		19.0000	UG/KG	07/27/96
IR89-SD03	1,1,2-TRICHLOROETHANE		13.0000	UG/KG	07/27/96
IR89-SD03	1,2-DICHLOROETHENE (TOTAL)		1600.0000	UG/KG	07/27/96
IR89-SD03	1,2-DICHLOROETHENE (TOTAL)		1500.0000	UG/KG	07/27/96
IR89-SD09	TRICHLOROETHENE		2.2000	UG/KG	8/15/96
IR89-SD09	CIS-1,2-DICHLOROETHENE		5.0000	UG/KG	8/15/96
IR89-SD09	TRANS-1,2-DICHLOROETHENE		1.0000	UG/KG	8/15/96
IR89-SD10	TRICHLOROETHENE		11.3000	UG/KG	8/15/96
IR89-SD10	TRICHLOROETHENE		0.6000	UG/KG	8/15/96
IR89-SD10	CIS-1,2-DICHLOROETHENE		16.0000	UG/KG	8/15/96
IR89-SD10	TRANS-1,2-DICHLOROETHENE		5.0000	UG/KG	8/15/96
IR89-SD11	TRICHLOROETHENE		0.9000	UG/KG	8/15/96
IR89-SD11	TRICHLOROETHENE		0.3000	UG/KG	8/15/96



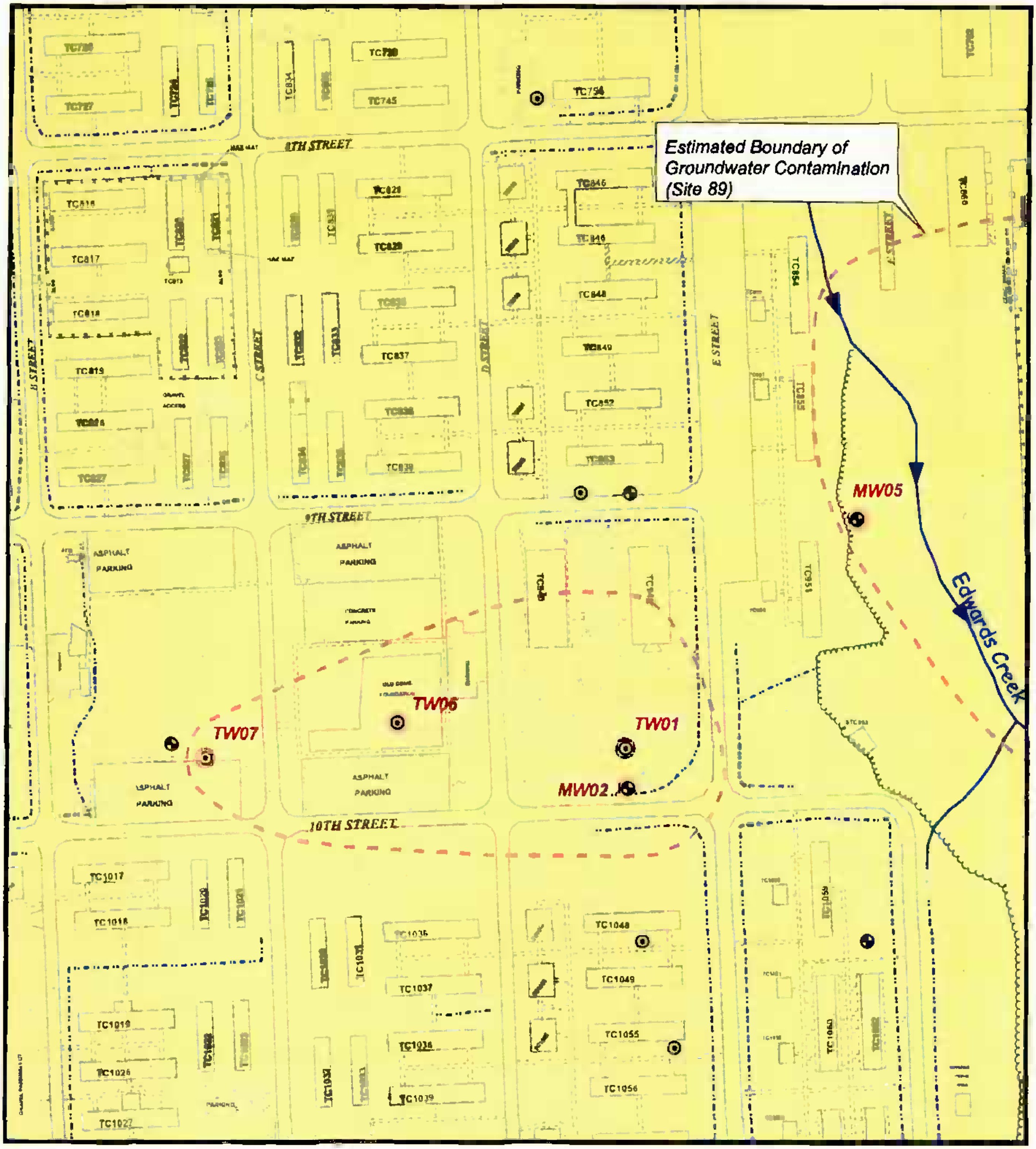
MARINE CORPS BASE, CAMP LEJEUNE
NORTH CAROLINA

VOLATILE ORGANIC COMPOUNDS
IN SEDIMENT SAMPLES
OPERABLE UNIT NO. 16 (SITE 89)
REMEDIAL INVESTIGATION
CTO 0356

Baker

FIGURE 4 - 6

02020N48Y



LEGEND

- ● Permanent Monitoring Well Location
- ⊙ Temporary Monitoring Well Location
- MW01 Monitoring Well Location and Well ID with concentrations exceeding NCWQS/MCLS
- ╱ ╲ Estimated Boundary of Groundwater Contamination above Applicable Standards

Scale

200 0 200 400 Feet

N W E S

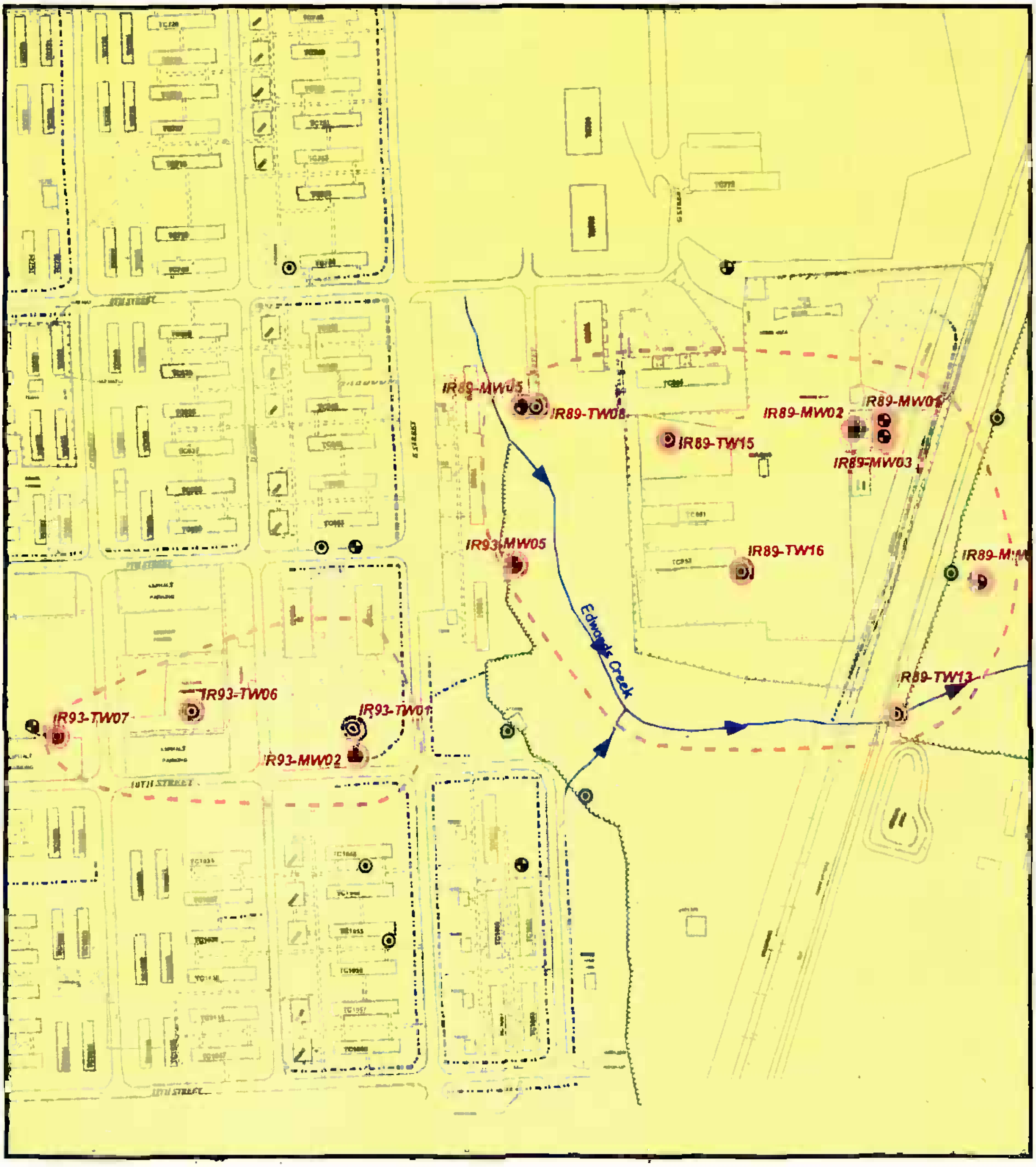
MARINE CORPS BASE, CAMP LEJEUNE
NORTH CAROLINA

VOLATILE ORGANIC COMPOUNDS
IN GROUNDWATER (SHALLOW WELLS)
OPERABLE UNIT NO. 16 (SITE 93)
REMEDIAL INVESTIGATION
CTO 0356

Baker

FIGURE 4 - 7

02020N49Y



LEGEND

- ● Permanent Monitoring Well Location
- ⊙ Temporary Monitoring Well Location
- MW01 ● Monitoring Well Location and Well ID with concentrations exceeding NCWQS/MCLS
- ╱ ╲ Estimated Boundary of Groundwater Contamination above Applicable Standards

Scale

200 0 200 400 Feet

**MARINE CORPS BASE, CAMP LEJEUNE
NORTH CAROLINA**

VOLATILE ORGANIC COMPOUNDS
IN GROUNDWATER (SHALLOW WELLS)
OPERABLE UNIT NO. 16 (SITE 89 & 93)
REMEDIAL INVESTIGATION
CTO 0356

Baker

FIGURE 4 - 8

5.0 CONTAMINANT FATE AND TRANSPORT

The potential for a contaminant to migrate and persist in an environmental medium is critical when evaluating the potential for a chemical to elicit an adverse human health or ecological effect. The environmental mobility of a chemical is influenced by its physical and chemical properties, the physical characteristics of the site, and the site chemistry. This section presents a discussion of the various physical and chemical properties of contaminants detected at Operable Unit (OU) No. 16 (Sites 89 and 93), and their fate and transport through the environment.

5.1 Chemical and Physical Properties Impacting Fate and Transport

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

- Vapor Pressure
- Water Solubility
- Octanol/Water Partition Coefficient
- Organic Carbon Adsorption Coefficient (sediment partition)
- Specific Gravity
- Henry's Law Constant
- Mobility Index

A discussion of the environmental significance of each of these properties is discussed in the following subsections.

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

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

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

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

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

Henry's Law Constant is a relationship between pressure and 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.

Mobility Index is a qualitative assessment which takes into consideration water solubility (S), vapor pressure (VP), and organic carbon partition coefficient (K_{oc}). It is defined as:

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

A scale to evaluate MI has been prepared by Ford and Gurba (1984) and is presented below:

Relative MI	**Mobility Description**
>5	Extremely Mobil
0 to 5	Very Mobil
-5 to 0	Slightly Mobil
-10 to -5	Immobile
<-10	Very Immobile

The relative mobilities of the detected organic constituents are presented in **Table 5-1.**

5.2 Contaminant Transport Pathways

Based on the evaluation of existing conditions at Sites 89 and 93, the following potential contaminant pathways have been defined.

- Leaching of soil contaminants to groundwater.
- Migration of groundwater contaminants.
- Leaching of sediment contaminants to surface water.
- Migration of contaminants in 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 transformations:	biodegradation
Accumulation in one or more media	

The following paragraphs describe the potential transport pathways listed above.

5.2.1 Leaching of Soil Contaminants to Groundwater

The contaminants present in the soil samples at OU 16 are primarily volatiles, with small amounts of pesticides and PAHs. Contaminants that adhere to soil particles or have accumulated in pore spaces can leach and migrate vertically to the groundwater as a result of the infiltration of precipitation. The rate and extent of leaching is influenced by the depth to the water table, amount of precipitation, rate of infiltration, the physical and chemical properties of the soil and the contaminants.

Groundwater samples were collected from shallow monitoring wells at Sites 89 and 93. The groundwater analytical results can be compared to soil sample analytical results to determine if contaminants detected in soil have migrated or may migrate in the future, to underlying groundwater. These results were discussed in detail in Section 4.0, Nature and Extent of Contamination.

More VOCs were detected in groundwater samples than those detected in the subsurface soil. This may be due to a number of reasons, including:

- VOCs in soil may have degraded, decomposed, or volatilized out of the soil column over time.

- The source of VOC contamination, either contaminated soil or materials disposed of on site, may have been removed.

- The VOC source may be unrelated to the site, or a result of sampling or laboratory introduction.

Semivolatile compounds were only detected at low concentrations from a few sample locations at Sites 89 and 93. The contaminants detected in soil samples such as PAHs were not detected in groundwater samples, suggesting that these compounds have not leached to the groundwater. Considering the physical and chemical properties of PAHs and their "moderately immobile" nature (Table 5-1), this is expected.

5.2.2 Migration of Groundwater Contaminants

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

Advection

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

Thus, when monitoring wells or supply wells in silty sand aquifers are located hundreds of thousands of meters downgradient of a contaminated source, the average travel time for the groundwater to flow from the source to the well point is typically on the order of decades. The southern portion of Site 89 borders Edwards Creek where shallow groundwater appears to discharge directly to this surface water body. Therefore, this transport pathway is significant at this site.

Dispersion

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

Chemical Mechanisms

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

Organic contaminants can be transformed into other organic compounds by a complex set of chemical and biological mechanisms. The principle 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 product. Biotransformation of common groundwater contaminants, such as trichloroethane, 1,1,1-trichloroethane, and tetrachloroethane, can result in the formation of such intermediates as vinyl chloride, and 1,1-dichloroethene (Mackay, et al., 1985).

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

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

Table 5-2 presents the general processes which influence the aquatic fate of contaminants at Sites 89 and 93; these processes include: sorption, volatilization, biodegradation, photolysis, hydrolysis, and bioaccumulation. For organic priority pollutants, consulting the rates contained in this table concerning the relative importance of aquatic processes for the fate of each compound, may aid in the elimination of unimportant processes.

5.2.3 Leaching of Sediment Contaminants to Surface Water

Contaminants that adhere to sediment particles or have accumulated in sediment pore spaces can leach and migrate to the surface water. The rate and extent of this migration is influenced by the physical and chemical properties of the soil, and the physical and chemical properties of the contaminant.

5.2.4 Migration of Contaminants in Surface Water

Contaminants leaching from soils to surface water can migrate as dissolved constituents in surface water in the direction of surface water flow. Three general processes govern the migration of dissolved contaminants caused by the flow of water: (1) movement caused by the flow of surface water, (2) movement caused by the irregular mixing of water, and (3) chemical mechanisms occurring during the movement of surface water. As stated earlier, sediment particles can disassociate from the sediment into surface water and migrate by one of the aforementioned methods.

Edwards Creek is located at the southern most portion of Site 89 and has been impacted by volatile organic compounds. Therefore, this transport pathway may be significant at this site.

5.3 Fate and Transport Summary

The following paragraphs summarize the contaminant group fate and transport data for contaminants detected in media at Sites 89 and 93. Although the primary contaminants of concern include volatile organic compounds, the text below includes brief discussions of polynuclear aromatic hydrocarbons, pesticides/PCBs, and inorganics.

5.3.1 Volatile Organic Compounds

Volatile organic compounds (i.e., 1,1,1-trichloroethane, 1,1,2,2-tetrachloroethane, 1,1,2-tetrachloroethane, 1,1-dichloroethene, 1,2-dichloroethene, chloroform, cis-1,2-dichloroethene, tetrachloroethane, toluene, trans-1,2-dichloroethene, trichloroethene, and vinyl chloride) tend to be mobile in environmental media as indicated by their presence in groundwater and their corresponding MI values. Their environmental mobility is a function of high water solubilities, high vapor pressures, low K_{ow} and K_{oc} values, and high mobility indices.

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

5.3.2 Polynuclear Aromatic Hydrocarbons (PAHs)

Low water solubilities, high K_{ow} and K_{oc} indicate a strong tendency for PAHs to adsorb to soils. Of the PAHs, flouranthene, 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 anthracene, benzo(a)anthracene, chrysene, pyrene, fluorene, benzo(g,h,i,)perylene, benzo(b)pluoranthene, benzo(k)fluoranthene, benzo(a)pyrene, indeno(1,2,3-cd)pyrene, naphthalene, and phenanthrene. Their mobility indices indicate that they are relatively immobile from a physical-chemical standpoint. An exception is naphthalene, which is considered only slightly immobile because of somewhat higher water solubility (Jones, et al., 1989).

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

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

5.3.3 Pesticides/Polychlorinated Biphenyls

Pesticides/PCBs are persistent and immobile contaminants in environmental media. Pesticides travel at varying rates through soil, mainly due to their affinity for soil surfaces. The soil sorption coefficient (K_d) is the distribution of a pesticide between soil and water. In general, the K_d values are higher for high organic carbon soil than for low organic carbon soils. Therefore, soils with high K_d values will retain pesticides (i.e., 4,4'-DDT, 4,4'-DDE, and 4,4'-DDD). As evidenced by the ubiquitous nature of 4,4'-DDT, 4,4'-DDE, and 4,4'-DDD, volatilization is an important transport process from soils to 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 groundwater, where oxidation reduction potential (Eh) and pH play critical roles. Table 5-3 presents an assessment of relative inorganic environmental mobilities as a function of Eh and pH. pH in the soils at OU No. 16, Sites 89 and 93 range from relatively neutral to slightly alkaline, 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 advertion with the groundwater to occur. Generally, dynamic and reversible processes control solubility and transport of the dissolved metal ions. Such process include precipitation/dissolution, adsorption/desorption, and ion exchange.

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

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

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SECTION 5.0 TABLES

TABLE 5-1

PHYSICAL AND CHEMICAL PROPERTIES FOR ORGANIC CHEMICALS OF POTENTIAL CONCERN
OPERABLE UNIT NO. 16 (SITES 89 AND 93)
REMEDIAL INVESTIGATION, CTO-0356
MCB CAMP LEJEUNE, NORTH CAROLINA

Constituents	Vapor Pressure (mm Hg)	Water Solubility (mg/L)	Log K_{oc}	Log K_{ow}	Specific Gravity (g/cm^3)	Henry's Law Constant (atm-m^3/mole)	Mobility Index	Comments
Volatiles:								
1,1,2,2-Tetrachloroethane	5.95	2,870	1.66	2.39	1.59	4.70E-04	--	--
1,1,2-Trichloroethane	30	4,500	1.75	2.47	1.44	1.17E-03	3.4	Very mobile
1,1-Dichloroethene	500	400	2.26	1.48	1.22	1.90E-01	3.0	Very mobile
1,2-Dichloroethene (Total)$^{(1)}$	--	--	--	--	--	--	--	--
Cis-1,2-Dichloroethene	208	3,500	0.70	1.69	--	7.58E-03	--	--
Toluene	28.1	535	2.48	2.73	0.87	6.37E-03	1.5	Very mobile
Trans-1,2-Dichloroethene	324	6,300	1.77	1.48	1.26	6.56E-03	2.9	Very mobile
Trichloroethene	57.9	1,100	2.10	2.38	1.46	9.10E-03	2.7	Very mobile
Vinyl Chloride	2,660	2,763	1.99	1.36	0.91	1.07E-02	--	--
Semivolatiles:								
Benzo(a)pyrene	5.6×10^{-09}	3.8×10^{-03}	--	6.08	1.274	4.89×10^{-07}	--	--

Notes: -- = Value not available.

(1) Refer to values for cis-1,2-Dichloroethene and trans-1,2-Dichloroethene

TABLE 5-2

RELATIVE IMPORTANCE OF PROCESSES INFLUENCING AQUATIC FATE OF ORGANIC POLLUTANTS
OPERABLE UNIT NO. 16 (SITES 89 AND 93)
REMEDIAL INVESTIGATION, CTO-0356
MCB CAMP LEJEUNE, NORTH CAROLINA

Constituents	Sorption	Volatilization	Biodegradation	Photolysis-Direct	Hydrolysis	Bioaccumulation
Volatiles: 1,1,2,2-Tetrachloroethane	?	+	--	--	--	?
1,1,2-Tetrachloroethane	?	+	--	--	--	?
1,1-Dichlrooethene (Total)	?	+	?	--	--	?
Cis-1,2-Dichloroethene	--	+	?	--	--	--
Toluene	+	+	?	--	--	--
Trans-1,2-Dichloroethene	--	+	?	--	--	--
Trichloroethene	--	+	?	--	--	--
Vinyl chloride	+	--	--	--	--	--
Semivolatiles: Benzo(a)pyrene	+	+	+	+	--	--

Key to Symbols:

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

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

TABLE 5-3

RELATIVE MOBILITIES OF INORGANICS AS A FUNCTION OF ENVIRONMENTAL CONDITIONS (Eh, pH)
OPERABLE UNIT NO. 16 (SITES 89 AND 93)
REMEDIAL INVESTIGATION, CTO-0356
MCB CAMP LEJEUNE, NORTH CAROLINA

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

Notes:

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

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

6.0 BASELINE RISK ASSESSMENT

6.1 Introduction

This Baseline Risk Assessment (BRA) evaluates the projected impact of contaminants of potential concern (COPCs) on human health and/or the environment, now and in the future, in a "no further remedial action scenario." The BRA process examines the data generated during the sampling and analytical phase of the RI and identifies areas of concern (AOCs) and COPCs with respect to geographical, demographic, physical and biological characteristics of the study area. These factors are combined with an understanding of physical and chemical properties of site-associated contaminants, (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. 16 (Sites 89 and 93) has been conducted in accordance with current USEPA Risk Assessment Guidance (USEPA, 1989a and USEPA, 1991b) and USEPA Region IV Supplemental Risk Guidance (USEPA, 1995).

The components of the BRA include:

- Hazard Identification
- 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 beginning with the introduction. Section 6.2 presents the Hazard Identification, which 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 presents the Exposure Assessment, which lists site characteristics, identifies potential exposure pathways, and describes current and future exposure scenarios. In section 6.4, the Toxicity Assessment, advisory criteria for evaluating human health risk is presented. Section 6.5 is the 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 Hazard Identification

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

6.2.1 Data Evaluation and Reduction

The initial hazard identification step entailed the validation and evaluation of the site data to determine its usability in the risk assessment. This process resulted in the identification of COPCs for the site. During this validation and evaluation, data that would result in inaccurate conclusions (e.g., data that were rejected or attributed to blank contamination, as qualified by the validator) were reduced within the data set. Data reduction entailed the removal of unreliable data from the original data set based on the guidelines established by USEPA. A summary of the data quality was presented in Section 4.0.

6.2.2 Identification of Data Suitable for Use in a Quantitative Risk Assessment

To provide for accurate conclusions to be drawn from sampling results, analytical data were reviewed and evaluated. This section presents the criteria that were used to review, reduce, and summarize the analytical data. These criteria are consistent with USEPA guidance for data reduction.

The RI investigation for Sites 89 and 93 was comprised of two phases (referred to as Phase I and Phase II). A total of four environmental media were investigated at OU 16 during this RI: subsurface soil (one to thirteen feet below ground surface [bgs]), groundwater, surface water, and sediment. Surface soil was not sampled at these sites since OU 16 is an industrialized area that is predominantly covered with either asphalt or hard-packed gravel. As a result, there is no direct exposure pathway with which to evaluate surface soil. Groundwater, surface water, and sediment samples collected under Phase I were used in this risk assessment. Groundwater and subsurface soil samples collected under Phase II were also used in this risk assessment. It should be noted that all four media were investigated at Site 89, while only subsurface soil and groundwater were investigated at Site 93. There were no surface water bodies at Site 93. For each site, these media were assessed for potential risk to human receptors. Surface water and sediment samples were collected from Edwards Creek.

The environmental groundwater samples collected under Phase I were analyzed by a mobile (on-site) laboratory. The environmental surface water and sediment samples were collected under Phase I and analyzed by a fixed base (off-site) laboratory. The environmental soil and groundwater samples collected during the Phase II sampling effort were analyzed by two separate laboratories: a mobile (on-site) laboratory and fixed base (off-site) laboratory. Soil and groundwater samples were submitted to the mobile laboratory for VOC analysis only in order to determine the nature and extent of VOC contamination at Sites 89 and 93. A fraction of the samples were sent to the fixed base laboratory for confirmation purposes and analyzed for VOCs, SVOCs, pesticides/PCBs, and metals. It should be noted that only ten percent of the samples for each site were analyzed for pesticides/PCBs. For a more detailed discussion on sampling procedure, refer to Section 2.0.

Analytical data from both laboratories were used in this human health risk assessment. USEPA Method 8240 was used to complete the mobile laboratory analysis. This data was subjected to rigorous QA/QC measures, including blank and duplicate analyses. Select analytical findings generated in the mobile laboratory were confirmed in a fix-based laboratory with CLP procedures. Completing the analysis by a USEPA approved method, statistically strong correlation with confirmation analysis, and the USEPA acceptance of data generated by analytical methods other than CLP for risk assessment justifies the use of mobile laboratory data in the preparation of the human health risk assessment.

Although shallow groundwater is not utilized as a potable source at either site, the shallow and deep groundwater at the site were evaluated as a single exposure source since it has been shown that there is a potential interconnection between the shallow and deep aquifers. Consequently, exposure to both sources of groundwater combined were evaluated. It should be noted that development of the shallow aquifer for potable use is unlikely because of the general water quality in the shallow zone and poor flow rates. However, there remains the possibility that upon closure of this facility, residential housing could be constructed and shallow groundwater used for potable purposes in the future. Therefore, in accordance with USEPA guidance, groundwater exposure was conservatively evaluated for future residential receptors.

For current receptors (residents of Site 89 housing), potable water is supplied by the base treatment facilities via water supply wells that are set in the lower reaches of the Castle Hayne aquifer (200 to 300 feet bgs). Current operating wells are periodically monitored for control purposes. Hence, assessing current risks to contaminants detected in the shallow aquifer for current receptors is unnecessary and, if estimated, may present an unlikely risk. Therefore, groundwater exposure to current receptors was not estimated for this investigation.

Information relating to the nature and extent of contamination at the site is provided in Section 4.0 of this report. The discussion provided in Section 4.0 also was utilized in the selection of COPCs at the site. The reduced data sets for all media of concern at the site are provided in Appendix H of this report.

6.2.3 Criteria for Selecting Contaminants of Potential Concern

As recommended in the Region IV Bulletin (USEPA, 1995), criteria used in selecting COPCs from constituents detected during the field sampling and analytical phase of the investigation are:

- Comparison to USEPA Region III Risk-Based Concentrations (RBCs)
- Comparison to field and laboratory blank data

In addition, some criteria used in the general assessment of COPCs selected from the media investigated during this RI include:

- Historical information
- Prevalence
- Persistence
- Mobility
- Comparison to anthropogenic levels
- Toxicity
- Comparison to background or naturally occurring levels
- State and federal standards and criteria

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

6.2.3.1 USEPA Region III RBCs

RBC values are derived using conservative USEPA promulgated default values and the most recent toxicological criteria available. The RBCs for potentially carcinogenic chemicals are based on a target ICR of $1x10^{-6}$. The RBCs for noncarcinogens are based on a target hazard quotient of 1.0. In order to account for cumulative risk from multiple chemicals in a medium, it is necessary to derive the RBCs based on a target hazard quotient of 0.1. Re-derivation of the 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 screening values. In order to provide the accurate screening values, the noncarcinogenic RBCs were divided by a factor of ten. For potential carcinogens, the toxicity criteria applicable to the derivation of RBC values are oral and inhalation cancer slope factors (CSFs); for noncarcinogens, they are chronic oral and inhalation reference doses (RfDs). 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 RBC values requires that the screening concentrations be updated periodically to reflect changes in the toxicity criteria. The RBC table is issued on a semi-annual basis. It should be noted that the most recent update was published in April of 1998.

6.2.3.2 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 laboratory 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 laboratory, concentrations exceeding five times the maximum blank concentration indicate contamination resulting from site activities (USEPA, 1991a).

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

Eliminating a sample result correlates directly to a reduction in the contaminant prevalence in that medium. Consequently, if elimination due to blank concentration reduces the prevalence of a contaminant to less than five percent, a contaminant that may have been included according to its prevalence is eliminated as a COPC. Maximum concentrations of common laboratory contaminants detected in blanks are presented in Table 6-1.

Blanks containing organic constituents that are not considered common laboratory contaminants (i.e., all other TCL compounds) are regarded as positive results only when observed concentrations exceed five times the maximum concentration detected in any blank (USEPA, 1989b). All TCL compounds at concentrations less than five times the maximum level of contamination noted in any blank are considered to be attributed to blank contamination. Maximum concentrations of other contaminants detected in blanks are presented in Table 6-1. QA/QC data summaries are presented in Appendix J.

6.2.3.3 Historical Information

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

6.2.3.4 Prevalence

The frequency of positive detections in sample sets and the level at which a contaminant is detected in a given medium are factors that determine a chemical's prevalence. The judicious use of data sets limits for including infrequently detected contaminants. Chemical occurrence must be evaluated with respect to the number of samples taken in order to determine frequency criteria warranting the inclusion of a chemical as a COPC. Contaminants that are infrequently detected, (i.e., less than five 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.

6.2.3.5 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.

6.2.3.6 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.

6.2.3.7 Anthropogenic Levels

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

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

6.2.3.9 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. Sample concentrations for surface and subsurface soil were compared to base-specific (i.e., twice the base-wide average concentration) background levels. It should be noted that background data was used for qualitative analysis of COPCs only. COPCs were not chosen based on comparison to background data. Background soil data is presented in Appendix K.

6.2.3.10 State and Federal Criteria and Standards

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

Regulatory guidelines are used, when necessary, to infer potential health risks and environmental impacts. Health Advisories (HA) are relevant regulatory guidelines. An explanation of the federal and state criteria and standards used for qualitative evaluation of contaminants is presented below.

It should be emphasized that COPCs were not chosen based on comparison to state and federal criteria. However, these standards and criteria were used for a qualitative analysis of the COPCs.

Method I, Category S-1 Target Concentrations, North Carolina Risk Analysis Framework - Soil - These soil concentrations were derived using standard EPA risk assessment equations for the ingestion of soil in residential exposures.

Method I, Category G-1 Target Concentrations, North Carolina Risk Analysis Framework - Groundwater - These target concentrations for drinking water and non-drinking water exposures, such as swimming pools or irrigation, are the groundwater quality standards or interim standards established in 15A NCAC 2L.0202 (i.e., North Carolina Water Quality Standards described below). The groundwater standards and interim standards are developed using state and federal guidelines for the protection of human health.

North Carolina Water Quality Standards (NCWQSs) - 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) - Federal Groundwater Standards - 40 CFR 161 - 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 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 10^{-7} to 10^{-5} range).

As stated previously, COPCs in all media of concern at the site were compared with these aforementioned criteria. The results of the standards/criteria/TBC comparison for the site are presented in Tables 6-2 through 6-7.

6.2.4 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. The primary criterion used in selecting a chemical as a COPC at each site was comparing the maximum detected sample concentration to the USEPA Region III RBCs (USEPA, 1997). In conjunction with the concentration comparisons to the USEPA Region III RBCs, evaluation of laboratory contaminants, chemical prevalence, and site history was conducted. Furthermore, calcium, magnesium, potassium, and sodium were detected in almost every sample, regardless of the medium; however, these constituents were considered to be essential nutrients (USEPA, 1995) and were therefore, not retained as COPCs in any medium under investigation at Sites 89 or 93.

Tables 6-2 through 6-7 present the selection of COPCs for each environmental medium based on a comparison of the maximum detected concentration with the USEPA Region III RBC values, and other applicable criteria. Information is presented in these tables only for those constituents detected at least once, in the medium of interest. Other statistical information is presented in Appendix M.

6.2.4.1 Site 89

Subsurface Soil

Site 89 subsurface soil organic data summary and COPC selection results are presented in Table 6-2. Twenty-six subsurface soil samples were analyzed for volatile organic compounds (VOCs). The following VOCs were detected: 1,1,2,2-tetrachloroethane, 1,2-dichloroethene (total), 2-butanone, acetone, benzene, carbon disulfide, tetrachloroethene, toluene, and trichloroethene. These VOC were detected at maximum concentrations less than their respective residential soil RBCs. Therefore, these VOCs were not retained as Site 89 subsurface soil COPCs.

Twenty-six subsurface soil samples were analyzed for semivolatile organic compounds (SVOCs). The following SVOCs were detected: bis(2-ethylhexyl)phthalate, fluoranthene, and pyrene. These SVOCs were detected at maximum concentrations less than their respective residential soil RBCs. These SVOCs were, therefore, not retained as Site 89 subsurface soil COPCs.

Five subsurface soil samples were analyzed for pesticides and PCBs. The following pesticides were detected: 4,4'-DDD, 4,4'-DDE, and 4,4'-DDT. These pesticides were detected at concentrations less than corresponding residential soil RBCs. There were no PCBs detected in the subsurface soil samples. Therefore, no pesticides or PCBs were retained as Site 89 subsurface soil COPCs.

Site 89 subsurface soil inorganic data summary and COPC selection results are presented in Table 6-2. Twenty-six subsurface soil samples were analyzed for inorganic analytes. Inorganics were detected in every sample. Aluminum, arsenic, beryllium, and iron were detected in almost every sample. The maximum detected concentrations of aluminum, arsenic, and iron exceeded their respective background levels and residential soil RBCs. Beryllium exceeded its Method I, Category S-1 target concentration. Consequently, aluminum, arsenic, beryllium, and iron were retained as Site 89 subsurface soil COPCs.

Groundwater

Site 89 groundwater organic data summary and COPC selection results are presented in Table 6-3. A maximum of 55 groundwater samples were analyzed for VOCs. 1,1,1-Trichloroethane and toluene were detected at maximum concentrations less than corresponding tap water RBCs and were not retained as COPCs. Chloroform was detected at in 26 out of 54 samples at a maximum concentration that exceeded its tap water RBC. However, chloroform was also detected in blanks at a concentration of 12 µg/L. Therefore, chloroform was not retained as a COPC. 1,1,2,2-Tetrachloroethane, 1,1,2-trichloroethane, 1,1-dichloroethene, 1,2-dichloroethene (total), cis-1,2-dichloroethene, tetrachloroethene, trans-1,2-dichloroethene, trichloroethene, and vinyl chloride were all detected at maximum concentrations that exceeded their respective tap water RBCs. Therefore, these VOCs were retained as Site 89 groundwater COPCs.

Fourteen groundwater samples were analyzed for SVOCs. Bis(2-ethylhexyl)phthalate was the only SVOC detected. It was detected in four out of fourteen samples at a maximum concentration (150 µg/L) that exceeded its tap water RBC. However, bis(2-ethylhexyl)phthalate was detected in blanks at a concentration of 120 µg/L. Therefore, since the maximum detected concentration of bis(2-ethylhexyl)phthalate was less than ten times the concentration detected in blanks, it was not retained as a Site 89 COPC.

Two groundwater samples were analyzed for pesticides and PCBs. There were no pesticides or PCBs detected in the groundwater samples. Therefore, no pesticides or PCBs were retained as Site 89 groundwater COPCs.

Site 89 groundwater inorganic data summary and COPC selection results are presented in Table 6-3. Fourteen groundwater samples were analyzed for inorganic analytes. Inorganics were detected in every sample. Antimony, iron, and manganese were detected frequently. The maximum detected concentrations of these analytes exceeded their respective tap water RBCs. Consequently, antimony, iron, and manganese were retained as Site 89 groundwater COPCs.

Surface Water

Site 89 surface water organic data summary and COPC selection results are presented in Table 6-4. A maximum of eleven surface water samples were analyzed for VOCs. Chloroform was detected at a maximum concentration less than its respective NCWQS and was not retained as a surface water COPC. 1,1,2,2-Tetrachloroethane, was detected at a maximum detected concentration that exceeded its respective NCWQS and was retained as a COPC. 1,2-Dichloroethene (total), cis-1,2-dichloroethene, tetrachloroethene, trans-1,2-dichloroethene, trichloroethene, and vinyl chloride were detected at maximum concentrations below corresponding NCWQS. However, these VOCs were re-included as COPCs based on their toxicity and the fact that they are site-related.

Five surface water samples were analyzed for SVOCs. There were no SVOCs detected in the surface water samples. Therefore, no SVOCs were retained as Site 89 surface water COPCs.

Five surface water samples were analyzed for pesticides and PCBs. There were no pesticides or PCBs detected in the surface water samples. Therefore, no pesticides or PCBs were retained as Site 89 surface water COPCs.

Site 89 surface water inorganic data summary and COPC selection results are presented in Table 6-4. Five surface water samples were analyzed for inorganic analytes. Inorganics were detected in every sample. Aluminum, copper, iron, and vanadium were detected frequently. The maximum detected concentrations of these analytes exceeded their respective NCWQS. Consequently, aluminum, copper, iron, and vanadium were retained as Site 89 surface water COPCs.

Sediment

Site 89 sediment organic data summary and COPC selection results are presented in Table 6-5. A maximum of sixteen sediment samples were analyzed for VOCs. The following VOCs were detected in Site 89 sediment samples: 1,1,2,2-tetrachloroethane, 1,1,2-trichloroethane, 1,1-dichloroethene, 1,2-dichloroethene (total), cis-1,2-dichloroethene, toluene, trans-1,2-dichloroethene, trichloroethene, and vinyl chloride. These VOCs were detected at maximum concentrations less than corresponding residential soil RBCs Therefore, these VOCs were not retained as Site 89 sediment COPCs.

Ten sediment samples were analyzed for SVOCs. Four noncarcinogenic polyaromatic hydrocarbons (nPAHs) were detected at maximum concentrations less than their respective residential soil RBCs and were not retained as sediment COPCs. Also, bis(2-ethylhexyl)phthalate was detected at a maximum concentration less than its residential soil RBC and was not retained as a sediment COPC. Six carcinogenic polyaromatic hydrocarbons (cPAHs) were detected in Site 89 sediment samples. Of the six cPAHs, benzo(a)pyrene was detected at a maximum concentration that exceeded its residential soil RBC and was therefore, retained as a Site 89 sediment COPC. Since cPAHs may act synergistically, the other cPAHs, benzo(a)anthracene, benzo(b)fluoranthene, benzo(k)fluoranthene, chrysene, and indeno(1,2,3-cd)pyrene, were re-included as COPCs

Two sediment samples were analyzed for pesticides and PCBs. 4,4'-DDD, 4,4'-DDE, 4,4'-DDT, alpha-chlordane, and gamma-chlordane were detected in the Site 89 sediment samples. They were detected at maximum concentrations less than corresponding residential soil RBCs. Therefore, these pesticides were not retained as Site 89 sediment COPCs. There were no PCBs detected in the sediment samples. Therefore, no PCBs were retained as Site 89 sediment COPCs.

Site 89 sediment inorganic data summary and COPC selection results are presented in Table 6-5. Ten sediment samples were analyzed for inorganic analytes. Inorganics were detected in every sample. Aluminum, arsenic, and iron were detected in almost every sample. The maximum detected concentrations of these analytes exceeded their respective residential soil RBCs. Consequently, aluminum, arsenic, and iron were retained as Site 89 sediment COPCs.

6.2.4.2 Site 93

Subsurface Soil

Site 93 subsurface soil organic data summary and COPC selection results are presented in Table 6-6. Twenty-two subsurface soil samples were analyzed for VOCs. 2-Butanone and acetone were detected in the Site 93 subsurface soil samples. They were detected at maximum concentrations less than their respective residential soil RBCs. Therefore, these VOCs were not retained as Site 93 subsurface soil COPCs.

Twenty-two subsurface soil samples were analyzed for SVOCs. Only two SVOCs were detected in the subsurface soil samples. Bis(2-ethylhexyl)phthalate was detected at a maximum concentration less than its residential soil RBC. This SVOC was, therefore, not retained as a Site 93 subsurface soil COPC. Benzo(a)pyrene was detected at a concentration that exceeded its residential soil RBC and was therefore, retained as a subsurface soil COPC.

Three subsurface soil samples were analyzed for pesticides and PCBs. 4,4'-DDD, 4,4'-DDE, and 4,4'-DDT were detected in the subsurface soil samples. These pesticides were detected at concentrations less than corresponding residential soil RBCs. There were no PCBs detected in the subsurface soil samples. Therefore, no pesticides or PCBs were retained as Site 93 subsurface soil COPCs.

Site 93 subsurface soil inorganic data summary and COPC selection results are presented in Table 6-6. Twenty-two subsurface soil samples were analyzed for inorganic analytes. Inorganics were detected in every sample. Aluminum, arsenic, beryllium, iron, and vanadium were detected in almost every sample. The maximum detected concentrations of aluminum, arsenic, iron, and vanadium exceeded their respective background levels and residential soil RBCs. Beryllium exceeded its Method I, Category S-1 target concentration. Consequently, aluminum, arsenic, beryllium, iron, and vanadium were retained as Site 93 subsurface soil COPCs.

Groundwater

Site 93 groundwater organic data summary and COPC selection results are presented in Table 6-7. A maximum of 26 groundwater samples were analyzed for VOCs. Chloroform was detected at in 7 out of 26 samples at a maximum concentration that exceeded its tap water RBC. However, chloroform was also detected in blanks at a concentration of 12 μg/L. Therefore, chloroform was not retained as a COPC. 1,2-Dichloroethene (total), cis-1,2-dichloroethene, tetrachloroethene, trans-1,2-dichloroethene, and trichloroethene were also detected in the Site 93 groundwater samples. These VOCs were detected at maximum concentrations that exceeded their respective tap water RBCs. Therefore, these VOCs were retained as Site 93 groundwater COPCs.

Eleven groundwater samples were analyzed for SVOCs. Only two SVOCs were detected in the groundwater samples. Bis(2-ethylhexyl)phthalate was detected in four out of eleven samples at maximum concentration that exceeded its tap water RBC. However, it was detected in blanks at a concentration of 120 μg/L. Therefore, bis(2-ethylhexyl)phthalate was not retrained as a Site 93 COPC. Naphthalene was detected at a maximum concentration less than its tap water RBC and was not retained as a Site 93 groundwater COPC.

Two groundwater samples were analyzed for pesticides and PCBs. There were no pesticides or PCBs detected in the groundwater samples. Therefore, no pesticides or PCBs were retained as Site 93 groundwater COPCs.

Site 93 groundwater inorganic data summary and COPC selection results are presented in Table 6-7. Eleven groundwater samples were analyzed for inorganic analytes. Inorganics were detected in every sample. Antimony, arsenic, iron, lead, and manganese were detected frequently. The maximum detected concentrations of these analytes exceeded their respective tap water RBCs. Consequently, antimony, arsenic, iron, lead, and manganese were retained as Site 93 groundwater COPCs.

6.2.4.7 Summary of COPCs

Table 6-8 presents a detailed summary of COPCs identified in each environmental medium sampled at Sites 89 and 93.

6.3 Exposure Assessment

This section addresses potential human exposure pathways at Sites 89 and 93 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 Sites 89 and 93. Figures 6-1 and 6-2 present the Site 89 and 93 conceptual models, respectively. Inputs to the conceptual model include qualitative descriptions of current and future land use patterns in the vicinity of the sites. The following list of receptors is developed for a quantitative health risk analysis:

- Current on-site residents (child [1-6 years] and adult)
- Future on-site residents (child [1-6 years] and adult)
- Future construction worker

Contaminants detected in 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:

- Leaching of contaminants from subsurface soil to water-bearing zones.
- Vertical migration from shallow water-bearing zones to deeper flow systems.
- Horizontal migration in groundwater in the direction of groundwater flow.
- Groundwater discharge into local streams.
- Wind erosion and subsequent deposition of windblown dust.

The potential for a contaminant to migrate spatially and persist in environmental media is important in estimating exposure.

Current and Future Scenarios

Current receptors are base housing residents (adult and child) located near Site 89. These housing units are located to the south of Edwards Creek and occupied by enlisted personnel and their families. It is estimated that the duration of residence is approximately two years. However, to maintain a conservative approach the standard tour of duty, or four years, is used as the duration of residence for the current adult and child resident. Due to the proximity of Edwards Creek, current residents were assessed for potential exposure to surface water and sediment. Potential exposure pathways are surface water and sediment incidental ingestion and dermal contact. Since Edwards Creek is too shallow for swimming activities, a wading scenario was considered when evaluating current residents for exposure to these media. Presently, the groundwater at the site is not used for potable purposes. Consequently, exposure to groundwater was not considered to be applicable for current receptors at the site.

A conservative exposure scenario was examined for a future residential population for Sites 89 and 93. It is unlikely that these sites will be developed for residential use in the future. However, to be conservative groundwater exposure to a future residential child and adult 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 of VOCs while showering. The future adult resident only was evaluated for inhalation of VOCs while showering. In addition, surface water and sediment exposure was evaluated for Site 89 future adult and child residents. The potential exposure pathways are ingestion and dermal contact of surface water and sediment.

Finally, surface and subsurface soil exposure resulting from future excavation and construction activities was assessed. A future construction worker was evaluated for subsurface soil ingestion, dermal contact, and inhalation for both Site 89 and Site 93.

6.3.2 Exposure Pathways

This section presents exposure pathways, shown in Figures 6-1 and 6-2, associated with each environmental medium and each human receptor group for Sites 89 and 93, respectively. It then qualitatively evaluates each pathway for further consideration in the quantitative risk analysis. Table 6-9 presents the matrix of human exposure at Sites 89 and 93.

6.3.2.1 Subsurface Soil

Subsurface soil (one to thirteen feet bgs) is available for contact only during excavation activities, so potential exposure to subsurface soil is limited to future construction workers. Exposure pathways involving ingestion, dermal contact, and inhalation of airborne particulates are evaluated for future construction workers only.

6.3.2.2 Groundwater

Currently, shallow groundwater at Sites 89 or 93 is not used as a potable supply for residents or base personnel. However, it will be conservatively assumed that in the future, (albeit unlikely due to poor transmissivity and insufficient flow) shallow groundwater may be tapped for potable water. In this scenario, potential exposure pathways are ingestion, dermal contact and inhalation of volatile contaminants while showering. Groundwater exposure is evaluated for future residential children and adults. The future adult resident only was evaluated for inhalation of VOCs while showering.

6.3.2.3 Surface Water/Sediment

Access to surface water at Site 89 is limited to Edwards Creek. In a current or future scenario, swimming is unlikely due to the shallowness of the water. However, a wading scenario is considered a conservative estimation of potential exposure. Surface water and sediment exposure pathways include ingestion and dermal contact. Exposure is evaluated for current and future residential children and adults. Surface water sediment exposure was not evaluated at Site 93 since there is no surface water body in the vicinity of this site.

6.3.3 Quantification of Exposure

The chemical concentrations used in the estimation of chronic daily intakes (CDIs) for each medium are considered to be representative of the types of potential exposure encountered by each receptor. Exposure can occur discretely or at a number of sampling locations depending on the type of scenario considered for a given receptor. Furthermore, certain environmental media such as groundwater and surface water are migratory and chemical concentrations detected in these media change frequently over time. Soil and sediment are, by nature, less transitory. The manner in which environmental data are represented also depends on the number of samples and sampling locations available for a given area and a given medium.

To quantify exposure, analytical data must be evaluated to determine its distributional nature. In general, two types of distributions are applied to environmental data; these are the normal and log-normal distributions. The arithmetic mean describes a normal distribution, while a geometric mean describes lognormal distribution. Most large data sets from soil sampling are log-normally distributed rather than normally distributed. While the geometric mean is a convenient parameter for describing central tendencies of log-normal data sets, it bears no logical connection to the cumulative intake that would result from long-term contact with site contaminants (USEPA, 1992c). The geometric mean of a set of sampling results may not adequately represent random exposure and therefore, is not an appropriate basis for estimating the concentration term. Most Agency health criteria are based on the long-term (arithmetic) average exposure which is expressed as the sum of all daily intakes divided by the total number of days in the averaging period. The choice of the arithmetic mean concentration is a more appropriate measure for estimating exposure (USEPA, 1992c).

Potential exposure to subsurface soil at Site 89 and 93 and surface water and sediment at Site 89, regardless of location, is considered as having an equal probability of occurrence as an individual moves randomly across the site. Therefore, for these media, the exposure point concentration for a constituent in the intake equation can be reasonably estimated as the arithmetic average concentration of site sampling data. USEPA supplemental risk assessment guidance (USEPA, 1992c) states that the average concentration is an appropriate estimator of the exposure concentration for two reasons: 1) carcinogenic and chronic noncarcinogenic toxicity criteria are based on lifetime average exposures; and 2) the average concentration is most representative of the concentration that would be contacted over time. However, uncertainty is inherent in the estimation of the true average constituent concentration at the site.

In order to account for this 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.

Assuming all data sets originate from a skewed underlying distribution, lognormal distribution is used to represent all relevant media. The 95 percent UCL for lognormal distribution is used for each contaminant (i.e., as the RME concentration) 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 measured concentration; therefore, in cases where the 95 percent UCL for a contaminant exceeds the maximum detected value in a given data set, the maximum result was used in the estimate of exposure. However, the true mean may still be higher than this maximum value (i.e., the 95 percent UCL indicates a higher mean is possible), especially if the most contaminated portion of the site has not been sampled (USEPA, 1992c). Statistical summaries are presented in Appendix M.

The 95 percent UCL of the lognormal distribution was calculated using the following equation (USEPA, 1992c):

$$\textit{Lognormal } 95\% \ UCL = e^{(\bar{x} + 0.5s^2 + sH/\sqrt{n-1})}$$

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 residents. 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.

The human health risk assessment for future groundwater use incorporates groundwater data collected from all monitoring wells at a given site. In this BRA, the groundwater RME exposure scenario presents the maximum groundwater exposure and used the maximum detected concentrations of the COPCs in the CDI calculations. In this manner, a worst case, as well as a point source, scenario is presented.

6.3.4 Calculation of Chronic Daily Intakes (CDI)

In order to numerically calculate risks for current and future human receptors at Sites 89 and 93, a CDI must be computed for each COPC, in each relevant exposure pathway. Appendix N contains CDI equations for specific exposure scenarios (USEPA, 1989a).

The following paragraphs present the general equations and input parameters used to calculate CDIs. 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 receptors. Furthermore, when USEPA exposure factors are not available, best professional judgement and site-specific information are used to derive a conservative and defensible value. Tables 6-10 through 6-12 present the exposure factors used in the estimation of potential CDIs for COPCs retained for each receptor. The following paragraphs present the rationale for the RME assumptions for each receptor group evaluated in the baseline RA. The CT assumptions, though not discussed below, are presented in Table 6-11 in parentheses.

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).

Assessing the potential for adverse noncarcinogenic health effects, 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, the potential for adverse noncarcinogenic health effects 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.

Current and future residential exposure scenarios address 1 to 6-year old children weighing 15 kg and adults weighing 70 kg, on average. An exposure duration of four years is used to estimate duration of residence for the current residential exposure scenario. A one year duration is used for future construction workers.

6.3.4.1 Incidental Ingestion of Soil

The equation for CDI, calculated for all human receptors potentially experiencing incidental soil ingestion, is as follows:

$$CDI = \frac{C \ x \ IR \ x \ CF \ x \ Fi \ x \ EF \ x \ ED}{BW \ x \ AT_c \ or \ AT_{nc}}$$

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_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 incidental soil ingestion. In each exposure scenario, the Fi value indicates the portion of ingested soils that originated from either Site 89 or 93 versus other sources.

Future Construction Worker

Construction workers may be exposed to COPCs through incidental ingestion of subsurface soil, during the course of excavation activities.

An IR of 480 mg/day is assigned to future construction workers. A 250-day per year EF is used in conjunction with a 1-year ED, representing the estimated length of a typical construction job (USEPA, 1991b). AT_{nc} is 365 days (USEPA, 1989a). The fraction ingested (Fi) is assumed to be

1.0. The BW used for an adult is 70 kilograms (kg). Finally, the AT_c is 25,550 days (USEPA, 1989a). A summary of these values is presented in Table 6-12.

6.3.4.2 Dermal Contact with Soil

The equation for CDI, calculated for all human receptors potentially experiencing dermal contact with soil, is as follows:

$$CDI = \frac{C \ x \ CF \ x \ SA \ x \ AF \ x \ ABS \ x \ EF \ x \ ED}{BW \ x \ AT_c \ or \ AT_{nc}}$$

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_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 soil.

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. However, the potential exists for dust particles to migrate under the clothes so that more of the skin is exposed to soils than that not covered by clothes (USEPA, 1992a). Therefore, the total SA for the construction worker is 25 percent of the total body surface area for an adult, or 5,800 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 Region IV default values of 0.01 for organics and 0.001 for metals were used for the ABS. A summary of these values is presented in Table 6-12.

6.3.4.3 Ingestion of Groundwater

Currently at Sites 89 and 93, 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 twelve supply wells within a one mile radius of these sites. 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:

$$CDI = \frac{C \ x \ IR \ x \ EF \ x \ ED}{BW \ x \ AT_c \ or \ AT_{nc}}$$

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_c = Averaging time, carcinogen (days)
AT_{nc} = Averaging time, noncarcinogen (days)

The following paragraphs explain the exposure assumptions used to calculate the impact of COPCs in groundwater ingestion.

Future On-Site Residents

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

A 6-year-old child weighing 15kg has an IR of 1.0 L/day. This rate provides a conservative exposure estimate, in terms of systemic health effects. This value assumes that children obtain all the tap water they drink from the same source, for 350 days/year (EF). AT is 2,190 days (6 years x 365 days/year) for noncarcinogenic compound exposure.

The IR for adults is 2 L/day (USEPA 1989a). The ED is 30 years, the national upper-bound (90th percentile) time spent at one residence (USEPA 1989b). The 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 6-11.

6.3.4.4 Dermal Contact with Groundwater

The equation for CDI, calculated for all human receptors potentially experiencing dermal contact with groundwater, is as follows:

$$CDI = \frac{C \ x \ SA \ x \ PC \ x \ ET \ x \ EF \ x \ ED \ x \ CF}{BW \ x \ AT_c \ or \ AT_{nc}}$$

Where:

C = Contaminant concentration is groundwater (mg/L)
SA = Surface area available for contact (cm^2)
PC = Dermal permeability constant (cm/hr)

ET = Exposure time (hour/day)
EF = Exposure frequency (days/year)
ED = Exposure duration (years)
CF = Conversion factor (1 L/1000 cm^3)
BW = Body weight (kg)
AT_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 groundwater.

Future On-Site Residents

Children and adults may be exposed to COPCs through dermal contact with groundwater while bathing or showering. It is assumed that bathing takes place 350 days/year (EF). The SA available for dermal absorption is estimated at 10,000 cm^2 for children and 23,000 cm^2 for adults (USEPA, 1992c). The ET for bathing or showering is 0.25 hours/day (USEPA, 1989a), a conservative estimate. The ED, BW and AT values are the same as those used in the groundwater ingestion scenario.

The 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 constants for these compounds are calculated according to USEPA guidance (USEPA, 1992a). A summary of dermal contact with groundwater exposure assessment input parameters is presented in Table 6-11.

6.3.4.5 Inhalation of Volatile Organics

The Foster and Chrostowski (Foster et al., 1987) inhalation model is applied in a quantitative assessment of inhaling volatile organics released from shower water. Contaminant (VOC) concentrations in air while showering are estimated by determining the following: the rate of chemical releases into air, (generation rate) the buildup of VOCs in the shower room air when the shower is on, the decay of VOCs in the shower room after the shower is turned off and the quantity of airborne VOCs inhaled while the shower is on and off.

The equation for CDI, calculated for all human receptors potentially inhaling volatile organics while showering, is as follows:

$$CDI = \frac{C \ x \ IR \ x \ ET \ x \ EF \ x \ ED}{BW \ x \ AT_c \ or \ AT_{nc}}$$

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 adults only. Based on professional opinion, it is considered unlikely that children under the age of six take showers. It is assumed that showering takes place 350 days/year (EF). IR for adults is 0.6 m^3/hr. The ET is 0.25 hrs/day (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 6-11.

6.3.4.6 Incidental Ingestion of Surface Water

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

$$CDI = \frac{C \ x \ IR \ x \ ET \ x \ EF \ x \ ED}{BW \ x \ AT_c \ or \ AT_{nc}}$$

Where:
C = Contaminant concentration in surface water (mg/L)
IR = Ingestion rate (L/hr)
ET = Exposure time (hrs/event)
EF = Exposure frequency (events/year)
ED = Exposure duration (years)
BW = Body weight (kg)
AT_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 surface water ingestion.

Current On-Site Residents

Current residents were evaluated for Site 89 only due to the presence of base housing in the area. The IR, ET and EF values used for future residents apply to both children and adults. The IR is 0.05 L/hr (USEPA, 1989a). The ET is 2.6 hr/day (USEPA, 1992a). The EF is 100 days/yr. This value represents a conservative approximation of time spent in the vicinity of Edwards Creek.

Although the average duration of residence in the base housing at Site 89 is two years, ED values represent a standard military tour of duty duration, or four years. An ED of four years was used to maintain a conservative approach. BW and AT values are the same as those used in groundwater exposure scenarios. These values are presented in Table 6-10.

Future On-Site Residents

The IR, ET and EF values used for future residents apply to both children and adults. The IR is 0.05 L/hr (USEPA, 1989a). The ET is 2.6 hr/day (USEPA, 1992a). The EF is 100 days/yr. This value represents a conservative approximation of time spent in the vicinity of Edwards Creek.

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. These values are presented in Table 6-11.

6.3.4.7 Dermal Contact with Surface Water

The equation for CDI, for all residents potentially experiencing dermal contact with surface water, is as follows:

$$CDI = \frac{C \ x \ CF \ x \ SA \ x \ PC \ x \ EF \ x \ ED \ x \ ET}{BW \ x \ AT_c \ or \ AT_{nc}}$$

Where:
C = Contaminant concentration in surface water (mg/L)
CF = Conversion factor (L/cm^3)
PC = Permeability constant (cm/hour)
EF = Exposure frequency (days/year)
ED = Exposure duration (years)
ET = Exposure time (hours/day)
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.

Current On-Site Residents

SA values represent dermal surface area of hands, forearms and lower extremities exposed for contact with surface water. SA is 2,300 cm^2 for children and 5,800 cm^2 for adults (USEPA, 1992a).

ET, EF, ED, BW and AT values are the same as those used for current children and adult residents in the surface water ingestion exposure scenario. These values are presented in Table 6-10.

Future On-Site Residents

SA values represent dermal surface area of hands, forearms and lower extremities exposed for contact with surface water. SA is 2,300 cm^2 for children and 5,800 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. These values are presented in Table 6-11.

6.3.4.8 Incidental Ingestion of Sediment

The equation for CDI, for all receptors potentially experiencing incidental ingestion of sediment, is as follows:

$$CDI = \frac{C \ x \ IR \ x \ CF \ X \ EF \ x \ ED}{BW \ x \ AT_c \ or \ AT_{nc}}$$

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_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 sediment ingestion.

Current On-Site Residents

The 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 current children and adult residents in the surface water exposure scenarios. These values are presented in Table 6-10.

Future On-Site Residents

The 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. These values are presented in Table 6-11.

6.3.4.9 Dermal Contact with Sediment

The equation for CDI, for all receptors potentially experiencing dermal contact with sediment, is as follows:

$$CDI = \frac{C \ x \ CF \ x \ SA \ x \ AF \ x \ ABS \ x \ EF \ x \ ED}{BW \ x \ AT_c \ or \ AT_{nc}}$$

Where:

C = Concentration of contaminant in sediment (mg/kg)
CF = Conversion factor (kg/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_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 sediment.

Current On-Site Residents

The SA values are the same as those used for current residential children and adults in the dermal contact with surface water exposure scenario. The AF is 1.0 mg/cm^2. It is used to evaluate dermal contact with sediment for both children and adults. The ABS is 1.0 percent for organics and 0.1 percent for inorganics (USEPA, 1991c). The EF, ED, BW, AT and CF values are the same as those used in the current resident sediment ingestion exposure scenario. These values are presented in Table 6-10.

Future On-Site Residents

The SA values are the same as those used for future residential children and adults in the dermal contact with surface water exposure scenario. The AF is 1.0 mg/cm^2. It is used to evaluate dermal contact with sediment for both children and adults. The ABS is 1.0 percent for organics and 0.1 percent for inorganics (USEPA, 1991c). The EF, ED, BW, AT and CF values are the same as those used in the future resident sediment ingestion exposure scenario. These values are presented in Table 6-11.

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

6.4 Toxicity Assessment

This section reviews toxicological information available for COPCs identified in Section 6.2.

6.4.1 Toxicological Evaluation

Toxicological evaluation addresses the inherent toxicity of chemical compounds. It consists of the review of scientific data to determine the nature and extent of the potential human health and environmental effects associated with exposure to various contaminants. Toxicity factors for the COPCs retained for Sites 89 and 93 are presented on Table 6-13.

Because of uncertainties in exposure estimates and inherent difficulties in determining causal relationships established by epidemiological studies, human data from occupational exposures are often insufficient for determining quantitative indices of toxicity. For this reason, animal bioassays are conducted under controlled conditions, and results are extrapolated to humans. There are several stages in this extrapolation. First, to account for species differences, conversion factors are used to apply test animal data to human studies. Second, high dosage administered to test animals must be translated into lower dosage, more typical of human exposure. When developing acceptable human doses of noncarcinogenic contaminants, safety factors and modifying factors are applied to animal test results. When studying carcinogens, mathematical models are used to convert high dosage effects to effects at lower dosages. Epidemiological data can then be used to determine credibility of these experimentally derived indices.

An RfD is an experimentally derived exposure index for noncarcinogenic contaminants, and a 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 (WOE) classifications accompany CSFs. They provide the WOE 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 WOE 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 based on epidemiological studies; 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

RfDs are developed for chronic and/or subchronic chemical exposure and is based solely on noncarcinogenic effects of chemical substances. It is defined as an estimate of the daily exposure level for a human population that is not likely to produce an appreciable risk of adverse effects during a lifetime. The RfD is usually expressed as dose (mg) per unit body weight (kg) per unit time (day). It is generally derived by dividing a no-observed-(adverse)-effect-level (NOAEL or NOEL) or a lowest observed-adverse-effect-level (LOAEL) for the critical toxic effect, by the appropriate "uncertainty factor (UF)". Effect levels are determined by laboratory or epidemiological studies. The UF is based on the availability of toxicity data.

UFs usually consist of multiples of 10, where each factor represents a specific area of uncertainty naturally present in the extrapolation process. These UFs are presented below and were taken from the Risk Assessment Guidance Document for Superfund, Volume I, Human Health Evaluation Manual (Part A) (USEPA, 1989a):

- A UF of 10 is to account for variation in the general population and is intended to protect sensitive populations (e.g., elderly; children).
- A UF of 10 is used when extrapolating from animals to humans. This factor is intended to account for the interspecies variability between humans and other mammals.
- A UF of 10 is used when a NOAEL derived from a subchronic instead of a chronic study is used as the basis for a chronic RfD.
- A UF of 10 is used when a LOAEL is used instead of a NOAEL. This factor is intended to account for the uncertainty associated with extrapolating from LOAELs to NOAELs.

In addition to UFs, a modifying factor (MF) is applied to each reference dose and is defined as:

- An MF ranging from >0 to 10 is included to reflect a qualitative professional assessment of additional uncertainties in the critical study and in the entire data base for the chemical not explicitly addressed by the preceding uncertainty factors. The default for the MF is 1.

Thus, the RfD incorporates the uncertainty of the evidence for chronic human health effects. Even if applicable human data exist, the RfD still maintains a margin of safety so that chronic human health effects are not underestimated.

Toxicity factors and the USEPA WOE classifications are presented in Table 6-13. 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 Office (EPA-NCEA)

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 Crave 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 $1x10^{-6}$, 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 total 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 [$(\text{mg/kg/day})^{-1}$]. 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 effect 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:

$$HI = HQ_1 + HQ_2 + \ldots HQ_n$$

$$= \sum_{i=1}^{n} HQ_i$$

$$\text{where } HQ_i = CDI_i / RfD_i$$

where HQ_i 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 89 (subsurface soil, groundwater, surface water/sediment) and Site 93 (subsurface soil and groundwater) are presented in Tables 6-14 through 6-18, respectively. Total carcinogenic risks and noncarcinogenic effects, 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).

A cancer risk range of $1\text{x}10^{-6}$ to $1\text{x}10^{-4}$ is used to evaluate calculated ICR levels. Any ICR value within this range is considered "acceptable"; an ICR greater than $1\text{x}10^{-4}$ denotes an existing cancer risk. A ratio of 1.0 is used as an upper limit to which calculated HI values are compared. Any HI exceeding 1.0 indicates the potential for noncarcinogenic adverse health effects to occur subsequent to exposure (USEPA 1989a).

6.5.1.1 Site 89

Current Residential Child

The current residential child was evaluated for potential noncarcinogenic and carcinogenic risk from exposure to surface water and sediment. The noncarcinogenic and carcinogenic risks for surface water (i.e., HI=0.12 and ICR=$1.6\text{x}10^{-5}$) and sediment (i.e., HI=0.06 and ICR=$2.9\text{x}10^{-6}$) were within the acceptable risk levels (i.e., HI<1 and $1\text{x}10^{-6}<\text{ICR}<1\text{x}10^{-4}$). These results are presented in Table 6-14.

Current Residential Adult

In the current scenario, a resident adult receptor was evaluated for potential risk from exposure to site surface water and sediment. The potential noncarcinogenic and carcinogenic risks from exposure to the surface water (i.e., HI=0.04 and ICR=$4.7\text{x}10^{-6}$) and sediment (i.e., HI=0.01 and ICR=$5.2\text{x}10^{-7}$) were within acceptable risk levels (i.e., HI<1 and $1\text{x}10^{-6}<\text{ICR}<1\text{x}10^{-4}$). These results are presented in Table 6-14.

Future Residential Child

The future child receptor was evaluated for potential risk from exposure to groundwater, surface water, and sediment in the future scenario. The potential noncarcinogenic and carcinogenic risks from exposure to the surface water (i.e., HI=0.12 and ICR=$2.3\text{x}10^{-5}$) and sediment (i.e., HI=0.06 and ICR=$4.4\text{x}10^{-6}$) were within acceptable risk levels (i.e., HI<1 and $1\text{x}10^{-6}<\text{ICR}<1\text{x}10^{-4}$). The results are summarized in Table 6-15.

In the groundwater exposure scenario, there are potential carcinogenic risks and noncarcinogenic adverse health effects from ingestion for the child receptor. The total groundwater carcinogenic risk level was $1.4\text{x}10^{-3}$. This was due primarily to the groundwater ingestion pathway

(ICR=1.4×10^{-3}). This value exceeded the acceptable risk range of 1×10^{-6} to 1×10^{-4} for carcinogenic risk. Primarily, vinyl chloride (95 percent of the ingestion pathway) in groundwater contributed to this risk.

The total groundwater noncarcinogenic effect level was 28. This was due primarily to the groundwater ingestion pathway (HI=27). This value exceeded the acceptable risk level of one for noncarcinogenic effect. Trichloroethene, 1,2-dichloroethene (total), cis-1,2-dichloroethene, and iron contributed 30, 23, 20, and 16 percent (ingestion pathway), respectively, of this elevated noncarcinogenic effect. The risk results are presented in Table 6-15. It should be noted that trichlorethene and 1,2-dichloroethene (total) target the liver with 1,2-dichloroethene (total) causing lesions as the critical effect. Cis-1,2-dichloroethene targets the blood with decreased hematocrit as the critical effect. Iron may target the hepatic parenchyma, heart, and/or endocrine glands with possible critical effects including fibrosis, cardiac dysfunction and failure, or hypogonadism.

Future Residential Adult

The future adult receptor was evaluated for potential risk from exposure to groundwater, surface water, and sediment in the future scenario. The potential noncarcinogenic and carcinogenic risks from exposure to the surface water (i.e., HI=0.04 and ICR=3.7×10^{-5}) and sediment (i.e., HI=0.01 and ICR=4.0×10^{-6}) were within acceptable risk levels (i.e., HI<1 and $1 \times 10^{-6} < \text{ICR} < 1 \times 10^{-4}$). The results are summarized in Table 6-15.

In the groundwater exposure scenario, there are potential carcinogenic risks and noncarcinogenic adverse health effects from ingestion for the adult receptor. The total groundwater carcinogenic risk level was 3.1×10^{-3}. This was due primarily to the groundwater ingestion pathway (ICR=3.0×10^{-3}). This value exceeded the acceptable risk range of 1×10^{-6} to 1×10^{-4} for carcinogenic risk. Primarily, vinyl chloride (95 percent of the ingestion pathway) in groundwater contributed to this risk.

The total groundwater noncarcinogenic effect level was 12.5. This was due primarily to the groundwater ingestion pathway (HI=12). This value exceeded the acceptable risk level of one for noncarcinogenic effect. Trichloroethene, 1,2-dichloroethene (total), cis-1,2-dichloroethene, and iron contributed 30, 23, 20, and 16 percent (ingestion pathway), respectively, of this elevated noncarcinogenic effect. The risk results are presented in Table 6-15. The target organ analysis for the future residential adult is the same discussion provided for the future child.

Future Construction Worker

The construction worker was evaluated for potential noncarcinogenic and carcinogenic risk from exposure to subsurface soil in the future case. The noncarcinogenic and carcinogenic risks (i.e., HI=0.14 and ICR=1.9×10^{-7}) from exposure to subsurface soil fell below the acceptable risk levels (i.e., HI<1 and $1 \times 10^{-4} < \text{ICR} < 1 \times 10^{-6}$). Table 6-17 presents these results.

6.5.1.2 Site 93

Future Residential Child

The future child receptor was evaluated for potential risk from exposure to groundwater in the future scenario. In the groundwater exposure scenario, there are potential noncarcinogenic adverse health effects from ingestion for the child receptor. The total groundwater noncarcinogenic effect level was 6.4. This was due primarily to the groundwater ingestion pathway (HI=6.2). This value exceeded the acceptable HI level of one. Manganese and cis-1,2-dichloroethene contributed 19 and 18 percent (ingestion pathway), respectively, of this elevated HI. The risk results are presented in Table 6-16. It should be noted that manganese targets the central nervous system. Cis-1,2-dichloroethene targets the blood with decreased hematocrit as the critical effect.

The potential carcinogenic risk from groundwater ($ICR=5.9x10^{-5}$) was within the USEPA acceptable risk range (i.e., $1x10^{-4}<ICR<1x10^{-6}$). Table 6-16 presents these results.

Future Residential Adult

The future adult receptor was evaluated for potential risk from exposure to groundwater in the future scenario. In the groundwater exposure scenario, there are potential carcinogenic risks and noncarcinogenic adverse health effects from ingestion for the adult receptor. The total groundwater carcinogenic risk level was $1.3x10^{-4}$. This was due primarily to the groundwater ingestion pathway ($ICR=1.2x10^{-4}$). This value exceeded the acceptable risk range of $1x10^{-6}$ to $1x10^{-4}$ for carcinogenic risk. Primarily, arsenic and tetrachloroethene (63 and 33 percent of the ingestion pathway, respectively) in groundwater contributed to this risk.

The total groundwater noncarcinogenic effect level was 2.8. This was due primarily to the groundwater ingestion pathway (HI=2.7). This value exceeded the acceptable HI level of one. Manganese and cis-1,2-dichloroethene contributed 19 and 18 percent (ingestion pathway), respectively, of this elevated HI. The risk results are presented in Table 6-16. The target organ analysis for the future residential adult is the same discussion provided for the future child.

Future Construction Worker

The construction worker was evaluated for potential noncarcinogenic and carcinogenic risk from exposure to subsurface soil in the future case. The noncarcinogenic and carcinogenic risks (i.e., HI=0.2 and $ICR=3.3x10^{-7}$) from exposure to subsurface soil fell below the acceptable risk levels (i.e., HI<1 and $1x10^{-4}<ICR<1x10^{-6}$). Table 6-18 presents these results.

6.5.2 Lead Uptake/Biokinetic (UBK) Model Results

Lead was detected in Site 93 at a maximum detected concentrations of 164 μg/L. The USEPA lead UBK model was used to determine if exposure to site media would result in unacceptable levels in younger children upon exposure to groundwater at Site 93. Blood lead levels are considered unacceptable when a greater than five percent probability exists that the blood lead levels will exceed 10 μg/dl.

The maximum detected concentration of lead found in the groundwater was used in the model. The remaining model parameters used were the default factors supplied in the model. This maximum concentration resulted in a 69.83 percent probability of the blood lead levels exceeding 10 μg/dl, which exceeds acceptable levels. Figure 6-3 illustrates these results.

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:

- Sampling strategy
- Analytical data
- Exposure Assessment
- Toxicity Assessment
- Iron
- CT-Case Scenarios

6.6.1 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. 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.

6.6.2 Analytical Data

The credibility of the BRA relies on the quality of the analytical data available to the risk assessor. Analytical data are limited by the precision and accuracy of the analytical method of analysis. In addition, the statistical methods used to compile and analyze data (mean concentration, standard deviation, and detection frequencies) are subject to uncertainty in the ability to acquire data.

Data validation serves to reduce some of the inherent uncertainty associated with analytical data by establishing the usability of the data to the risk assessor who may or may not choose to include the data point in risk estimation. Data can be qualified as "J" (estimated) for many reasons, including a slight 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) were not applied to risk analysis. Dismissing data points qualified with "B"did not significantly increase uncertainty in the risk assessment.

6.6.3 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.

Groundwater samples were collected using a low-flow purge sampling technique and were analyzed for total (unfiltered) inorganic contaminants. These samples were obtained from wells which were constructed using USEPA Region IV monitoring well design specifications. Groundwater taken from monitoring wells is not truly representative of groundwater that 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 because of the general water quality in the shallow zone and poor flow rates. Current receptors are only exposed to groundwater drawn from the lower reaches of the Castle Hayne aquifer (200 to 300 bgs). 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. For a more detailed description of the study area, refer to Section 3.0.

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.

6.6.4 Toxicity Assessment

In making quantitative estimates about the toxicity of varying chemical doses, uncertainties arise from two sources. First, existing data usually provide insufficient information about toxic exposure and subsequent effects. Human exposure data display inherent temporal variability and often lack adequate concentration estimates. Animal studies are often used to subsidize available human data. In the process of extrapolating animal results to humans; however, more uncertainties can arise. Second, in order to obtain visible toxic effects in experimental animals, high chemical doses are employed over short periods of time. Doses typical of human exposure, however, are much lower, relative to those doses administered to experimental animals. In order to apply animal test results to human exposure assessments, then, data must be adjusted to extrapolate from high dose effects to low dose effects.

In extrapolating effects from animal receptors to human receptors, and from high doses to low doses, scientific judgment and conservative assumptions are employed. In selecting animal studies for use in dose response calculations, the following factors are considered:

- Studies are preferred in which the animal closely mimics human pharmacokinetics

- Studies are preferred in which dose intake most closely mimics intake route and duration for humans

- Studies are preferred in which the most sensitive responses to the compound in question is demonstrated

In order to evaluate compounds that cause threshold effects, (i.e., noncarcinogens) safety factors are taken into account when experimental results are extrapolated from animals to humans, and from high to low doses.

Employing conservative assumptions yields quantitative toxicity indices that are not expected to underestimate potential toxic effects, but may overestimate these effects by some magnitude.

6.6.5 Iron

Recently, the element iron was given a RBC value and toxicity values with which to evaluate potential human health risks. However, iron is still considered an essential nutrient. Also, the studies that prompted the addition of a RBC value for iron are provisional only and have not undergone formal review by the USEPA. Furthermore, the provisional RfD is based on the Recommended Daily Allowance (RDA) and not a toxic effect. The iron RfD is very conservative and may not represent a toxic effect. For these reasons, the selection of iron as a COPC for evaluation in human health risk assessments is associated with some uncertainty. However, by evaluating iron in the risk assessment, a conservative approach is taken and potential toxic effects are not expected to be underestimated.

6.6.6 CT-Case Scenarios

The CT risk descriptor was used for data sets when the RME concentration term showed a potential risk to human health, specifically, to future on-site residents. 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). In addition, USEPA standard default exposure factors for central tendency were used in the CDI calculations. The results of the CT calculations are summarized below.

Site 89

As shown in Table 6-15, under the CT-case scenario there was an unacceptable noncarcinogenic and carcinogenic risk to the future child resident from groundwater (HI=2.8 and ICR=2.1×10^{-4}). This elevated HI value was primarily from the ingestion pathway (HI=2.7). Trichloroethene, 1,2-dichloroethene (total), and iron contributed 30, 17, and 15 percent (ingestion pathway), respectively, of this elevated HI. The elevated ICR calculated under the CT-case scenario was primarily from the ingestion pathway (ICR=2.1×10^{-4}). Vinyl chloride (94 percent of the ingestion pathway) was the main contributor to this risk. As shown in Table 6-15, under the CT-case scenario the total site noncarcinogenic and carcinogenic risks to the future adult resident fell at or below the acceptable risk levels (i.e., HI<1 and 1×10^{-4}<ICR<1×10^{-6}).

Site 93

As shown in Table 6-16, under the CT-case scenario there was an unacceptable noncarcinogenic effect to the future child resident from groundwater (HI=2). This elevated HI value was primarily from the ingestion pathway (HI=2). Iron, manganese, and arsenic contributed 29, 23, and 14 percent (ingestion pathway), respectively, of this elevated HI. The ICR for the child receptor calculated under the CT-case scenario was within the acceptable risk range of $1x10^{-4}$ to $1x10^{-6}$. As shown in Table 6-16, under the CT-case scenario the total site noncarcinogenic and carcinogenic risks to the future adult resident fell below the acceptable risk levels (i.e., HI<1 and $1x10^{-4}$<ICR<$1x10^{-6}$).

6.7 BRA Conclusions

The BRA highlights the media of interest from the human health standpoint at Sites 89 and 93 by identifying areas with risk values greater than acceptable levels. Current and future potential receptors at the site included current adult and child residents (Site 89 only), future adult and child residents (Sites 89 and 93), and future construction workers (Sites 89 and 93). The total risk from the site for these receptors was estimated by logically summing the multiple pathways likely to affect the receptor during a given activity. Exposure to surface water and sediment was assessed for the current receptors. Groundwater, surface water, and sediment exposure were evaluated for the future residents. Subsurface soil exposure was evaluated for the future construction worker. Total site risks for Sites 89 and 93 are summarized in Tables 6-20 and 6-21, respectively.

6.7.1 Current Scenario

In the current case, the following receptors were assessed: adult and child residents. Receptor exposure to surface water and sediment at Site 89 was examined. The risks calculated for all exposure pathways for the current on-site residents were within acceptable risk ranges.

6.7.2 Future Scenario

In the future case, child and adult residents were assessed for potential exposure to groundwater, surface water, and sediment at Site 89 and groundwater at Site 93. a construction worker was evaluated for subsurface soil exposure at both sites. The potential noncarcinogenic and carcinogenic risks for the construction worker receptor at Sites 89 and 93 were within acceptable levels. The site total carcinogenic risk to the future residential child at Site 93 was within the USEPA's acceptable risk range.

In the Site 89 groundwater exposure scenario, there are potential carcinogenic risks and noncarcinogenic adverse health effects from ingestion for the child receptor. The total groundwater carcinogenic risk level for the future child resident at Site 89 was $1.4x10^{-3}$. This was due primarily to the groundwater ingestion pathway (ICR=$1.4x10^{-3}$). Primarily, vinyl chloride (95 percent of the ingestion pathway) in groundwater contributed to this risk. The total groundwater noncarcinogenic effect level was 28. This was due primarily to the groundwater ingestion pathway with trichloroethene, 1,2-dichloroethene (total), cis-1,2-dichloroethene, and iron contributing 30, 23, 20, and 16 percent, respectively, of this elevated HI. It should be noted that trichlorethene and 1,2-dichloroethene (total) target the liver with 1,2-dichloroethene (total) causing lesions as the critical effect. Cis-1,2-dichloroethene targets the blood with decreased hematocrit as the critical effect. Iron may target the hepatic parenchyma, heart, and/or endocrine glands with possible critical effects including fibrosis, cardiac dysfunction and failure, or hypogonadism.

In the Site 89 groundwater exposure scenario, there are potential carcinogenic risks and noncarcinogenic adverse health effects from ingestion for the adult receptor. The total groundwater carcinogenic risk level for the future adult resident at Site 89 was $3.1x10^{-3}$. This was due primarily to the groundwater ingestion pathway (ICR=$3.0x10^{-3}$). Primarily, vinyl chloride (95 percent of the ingestion pathway) in groundwater contributed to this risk. The total groundwater noncarcinogenic effect level was 12.5. This was due primarily to the groundwater ingestion pathway with trichloroethene, 1,2-dichloroethene (total), cis-1,2-dichloroethene, and iron contributing 30, 23, 20, and 16 percent, respectively, of this elevated HI. The target organ analysis for these constituents is discussed in the previous paragraph.

In the Site 93 groundwater exposure scenario, there are potential noncarcinogenic adverse health effects from ingestion for the child receptor. The total groundwater noncarcinogenic effect level was 6.4. This was due primarily to the groundwater ingestion pathway with manganese and cis-1,2-dichloroethene contributed 19 and 18 percent, respectively, of this elevated HI. It should be noted that manganese targets the central nervous system. Cis-1,2-dichloroethene targets the blood with decreased hematocrit as the critical effect.

In the Site 93 groundwater exposure scenario, there are potential carcinogenic risks and noncarcinogenic adverse health effects from ingestion for the adult receptor. The total groundwater carcinogenic risk level was 1.3×10^{-4}. This was due primarily to the groundwater ingestion pathway (ICR=1.2×10^{-4}). Primarily, arsenic and tetrachloroethene (63 and 33 percent of the ingestion pathway, respectively) in groundwater contributed to this risk. The total groundwater noncarcinogenic effect level for the future residential adult at Site 93 was 2.8. This was due primarily to the groundwater ingestion pathway with manganese and cis-1,2-dichloroethene contributing 19 and 18 percent, respectively, of this elevated HI. The target organ analysis for these constituents is discussed in the previous paragraph.

6.8 References

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SECTION 6.0 TABLES

TABLE 6-1

SUMMARY OF ORGANIC BLANK CONTAMINANT RESULTS
RI/FS CTO-0356
OPERABLE UNIT NO. 16 (SITE 89 AND 93)
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)
Site 89					
Volatiles					
Acetone	70	Soil	Rinsate	700	700
Chloroform	12	Soil	Field	60	60
Bromoform	9J	Soil	Field	45	45
Bromodichloromethane	18	Soil	Field	90	90
Dibromochloromethane	24	Soil	Field	120	120
Tetrachloroethene	3J	Soil	Rinsate	15	15
Semivolatiles					
Bis(2-ethylhexyl)phthalate	120	Soil	Field	1,200	39,600(3)
Volatiles					
Bromodichloromethane	18	Groundwater	Field	90	NA
Chloroform	12	Groundwater	Field	60	NA
Bromoform	9J	Groundwater	Field	45	NA
Dibromochloromethane	24	Groundwater	Field	120	NA
Semivolatiles					
Bis(2-ethylhexyl)phthalate	120	Groundwater	Rinsate	1,200	NA
Site 93					
Volatiles					
Bromoform	9J	Soil	Field	10	NA
Chloroform	12	Soil	Field	330	NA
Bromodichloromethane	18	Soil	Field	65	NA
Dibromochloromethane	24	Soil	Field	15	NA
Semivolatiles					
Bis(2-ethylhexyl)phthalate	120	Soil	Field	1,200	39,600(3)
Volatiles					
Chloroform	12	Groundwater	Rinsate	60	60
Bromodichloromethane	18	Groundwater	Rinsate	90	90
Dibromochloromethane	24	Groundwater	Field	120	120
Bromoform	9J	Groundwater	Field	45	45

TABLE 6-1 (Continued)

SUMMARY OF ORGANIC BLANK CONTAMINANT RESULTS
RI/FS CTO-0356
OPERABLE UNIT NO. 16 (SITE 89 AND 93)
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)
Semivolatiles					
Bis(2-ethylhexyl)phthalate	120	Groundwater	Field	1,200	NA

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

SUMMARY OF DATA AND COPC SELECTION
ORGANICS AND INORGANICS IN SUBSURFACE SOIL
PHASE II - FIXED BASE LABORATORY
RI/FS CTO-0356
OPERABLE UNIT NO. 16 (SITE 89)
MCB, CAMP LEJEUNE, NORTH CAROLINA

	Range/Frequency		Comparison to Criteria						
Constituent	Range of Positive Detections	No. of Positive Detects/ No. of Samples	Twice the Average Base Specific Background(1) Concentration	No. of Times Exceeded Twice the Average Background Concentration	Method I, Category S-1 Target Concentrations (2)	Positive Detects Above S-1 Target	USEPA Region III Residential Soil RBC Value(3)	Positive Detects Above Residential RBC Value	COPC Selection(4)
Volatiles (µg/kg):									
1,1,2,2-Tetrachloroethane	20 - 98	4/26	NA	NA	3,200	0	3,200	0	No
1,2-Dichloroethene (total)	9J - 68	7/26	NA	NA	140,000	0	70,000	0	No
2-Butanone	17J	1/26	NA	NA	9,400,000	0	4,700,000	0	No
Acetone	13 - 100	14/26	NA	NA	1,560,000	0	780,000	0	No
Benzene	3J	1/26	NA	NA	22,000	0	22,000	0	No
Carbon Disulfide	4J	1/26	NA	NA	1,560,000	0	780,000	0	No
Tetrachloroethene	4J - 5J	2/26	NA	NA	12,000	0	12,000	0	No
Toluene	110	1/26	NA	NA	3,200,000	0	1,600,000	0	No
Trichloroethene	3J - 110	7/26	NA	NA	58,000	0	58,000	0	No
Semivolatiles (µg/kg):									
Bis(2-ethylhexyl)phthalate	42J - 630	11/26	NA	NA	46,000	0	46,000	0	No
Fluoranthene	43J - 43J	2/26	NA	NA	620,000	0	310,000	0	No
Pyrene	49J - 66J	2/26	NA	NA	469,200	0	230,000	0	No
Pesticides (µg/kg):									
4,4'-DDD	19J	1/5	NA	NA	2,700	0	2,700	0	No
4,4'-DDE	17J	1/5	NA	NA	1,900	0	1,900	0	No
4,4'-DDT	91	1/5	NA	NA	1,900	0	1,900	0	No

TABLE 6-2 (continued)

SUMMARY OF DATA AND COPC SELECTION
ORGANICS AND INORGANICS IN SUBSURFACE SOIL
PHASE II - FIXED BASE LABORATORY
RI/FS CTO-0356
OPERABLE UNIT NO. 16 (SITE 89)
MCB, CAMP LEJEUNE, NORTH CAROLINA

	Range/Frequency		Comparison to Criteria						
Constituent	Range of Positive Detections	No. of Positive Detects/ No. of Samples	Twice the Average Base Specific Background[(1)] Concentration	No. of Times Exceeded Twice the Average Background Concentration	Method I, Category S-1 Target Concentrations [(2)]	Positive Detects Above S-1 Target	USEPA Region III Residential Soil RBC Value[(3)]	Positive Detects Above Residential RBC Value	COPC Selection[(4)]
Inorganics (mg/kg):									
Aluminum	1,380 - 11,200	26/26	7,375.3	6	15,600	0	7,800	6	Yes
Antimony	0.38 - 0.6J	3/26	6.408	0	6.2	0	3.1	0	No
Arsenic	0.42J - 2.3J	13/26	1.968	1	0.43	12	0.43	12	Yes
Barium	3.3 - 29.9	26/26	14.2	6	1,100	0	550	0	No
Beryllium	0.03 - 0.94	19/26	0.19	6	0.15	7	16	0	Yes
Cadmium	0.04J - 0.24J	2/26	0.712	0	7.8	0	7.8	0	No
Calcium	11.6 - 19,100	20/26	391.5	13	NE	NA	NE	NA	No
Chromium	1.4 - 13.2	26/26	12.6	1	78	0	39	0	No
Cobalt	0.05J - 7.7	19/26	1.5	1	940	0	470	0	No
Copper	0.17 - 2.7	19/26	2.4	1	620	0	310	0	No
Iron	497 - 12,100	26/26	7,252.1	4	4,600	**10**	2,300	15	Yes
Lead	1.8 - 12.6J	26/26	8.3	4	400[(5)]	0	400[(5)]	0	No
Magnesium	42.2 - 569	26/26	260.7	7	NE	NA	NE	NA	No
Manganese	0.43 - 13.7	25/26	7.9	10	360	0	160	0	No
Nickel	0.2J - 11.3	13/26	3.7	1	320	0	160	0	No
Potassium	117 - 389J	20/26	347.2	1	NE	NA	NE	NA	No
Selenium	0.42J - 0.66J	10/26	0.8	0	78	0	39	0	No
Silver	0.18 - 3J	2/26	0.866	1	78	0	39	0	No
Sodium	35.6J - 252J	19/26	52.68	11	NE	NA	NE	NA	No

TABLE 6-2 (continued)

SUMMARY OF DATA AND COPC SELECTION
ORGANICS AND INORGANICS IN SUBSURFACE SOIL
PHASE II - FIXED BASE LABORATORY
RI/FS CTO-0356
OPERABLE UNIT NO. 16 (SITE 89)
MCB, CAMP LEJEUNE, NORTH CAROLINA

	Range/Frequency		Comparison to Criteria						
Constituent	Range of Positive Detections	No. of Positive Detects/ No. of Samples	Twice the Average Base Specific Background[1] Concentration	No. of Times Exceeded Twice the Average Background Concentration	Method I, Category S-1 Target Concentrations [2]	Positive Detects Above S-1 Target	USEPA Region III Residential Soil RBC Value[3]	Positive Detects Above Residential RBC Value	COPC Selection[4]
Vanadium	1.2 - 22.1	26/26	13.5	4	110	0	55	0	No
Zinc	0.12J - 111J	24/26	6.7	2	4,600	0	2,300	0	No

Notes:

[1] Soil background concentrations are based on reference background soil samples collected from MCB Camp Lejeune investigations.
[2] North Carolina Risk Analysis Framework (NCDEHNR, 1996).
[3] USEPA Region III RBC Table, April 15, 1998.
[4] COPC = Chemical of Potentail Concern for human health risk assessment (yes/no).
[5] Action Level for residential soils (USEPA, 1994).

NE = Not established
NA = Not applicable
J = Estimated Value

TABLE 6-3

SUMMARY OF DATA AND COPC SELECTION
ORGANICS AND METALS IN GROUNDWATER
PHASE I AND II - MOBILE LABORATORY AND
PHASE II - FIXED BASE LABORATORY
RI/FS CTO-0356
OPERABLE UNIT NO. 16 (SITE 89)
MCB CAMP LEJEUNE, NORTH CAROLINA

	Groundwater Criteria				Frequency/Range		Comparison to Criteria				
Parameter	NCWQS(1)	MCL(2)	USEPA Region III Tap Water RBC Value(3)	Method I, Category G-1 Target Concentrations(4)	No. of Positive Detects/ No. of Samples	Concentration Range	Positive Detects Above NCWQS	Positive Detects Above MCL	Positive Detects Above RBC Value	Positive Detects Above G-1 Target	COPC Selection(5)
Volatiles (µg/L): 1,1,1-Trichloroethane	200	200	54	200	1/55	0.2	0	0	0	0	No
1,1,2,2-Tetrachloroethane	NE	NE	0.053	NE	1/21	4J	NA	NA	1	NA	Yes
1,1,2-Trichloroethane	NE	5	0.19	NE	1/21	3J	0	0	1	NA	Yes
1,1-Dichloroethene	7	7	0.044	7	1/21	2J	0	0	1	0	Yes
1,2-Dichloroethene (total)	NE	NE	5.5	NE	6/21	29 - 880	0	0	6	NA	Yes
Chloroform	0.19	80	0.15	0.19	26/54	0.3 - 8.6	26	0	26	26	No(6)
cis-1,2-Dichloroethene	70	70	6.1	70	19/41	3 - 818	10	10	18	10	Yes
Tetrachloroethene	0.7	5	1.1	0.7	17/55	0.1 - 42.7	12	10	12	12	Yes
Toluene	1,000	1,000	75	1,000	1/21	6	0	0	0	0	No
trans-1,2-Dichloroethene	70	100	12	70	16/34	1 - 451	4	2	9	4	Yes
Trichloroethene	2.8	5	1.6	2.8	28/55	0.2 - 744.3	25	23	25	25	Yes
Vinyl Chloride	0.015	2	0.019	0.015	4/55	6J - 130	4	4	4	4	Yes
Semivolatiles (µg/L): Bis(2-ethylhexyl)phthalate	3	6	4.8	3	4/14	64 - 150	4	4	4	4	No(6)
Metals (µg/L): Antimony	NE	6	1.5	NE	2/14	2 - 2.2	NA	0	2	NA	Yes
Barium	2,000	2,000	260	2,000	14/14	2.5 - 23.1	0	0	0	0	No
Calcium	NE	NE	NE	NE	14/14	33,200 - 92,800	NA	NA	NA	NA	No
Chromium	50	100	18	50	4/14	0.5 - 0.88	0	0	0	0	No
Iron	300	300(7)	1,100	300	13/14	30.7 - 20,000J	7	7	4	7	Yes
Magnesium	NE	NE	NE	NE	14/14	1,280 - 26,400	NA	NA	NA	NA	No

TABLE 6-3 (continued)

CHEMICALS OF POTENTIAL CONCERN
ORGANICS AND METALS IN GROUNDWATER
PHASE I AND PHASE II - MOBILE LABORATORY AND PHASE II - FIXED BASE LABORATORY
RI/FS CTO-0356
OPERABLE UNIT NO. 16 (SITE 89)
MCB, CAMP LEJEUNE, NORTH CAROLINA

	Groundwater Criteria				Frequency/Range		Comparison to Criteria				
Parameter	NCWQS(1)	MCL(2)	USEPA Region III Tap Water RBC Value(3)	Method I, Category G-1 Target Concentrations(4)	No. of Positive Detects/ No. of Samples	Concentration Range	Positive Detects Above NCWQS	Positive Detects Above MCL	Positive Detects Above RBC Value	Positive Detects Above G-1 Target	COPC Selection(5)
Manganese	50	50(7)	73	50	14/14	9.8 - 379	3	3	2	3	Yes
Nickel	100	100(8)	73	100	2/14	0.83 - 1	0	0	0	0	No
Potassium	NE	NE	NE	NE	14/14	1,170J - 25,700	NA	NA	NA	NA	No
Selenium	50	50	18	50	2/14	2.4J - 2.7	0	0	0	0	No
Sodium	NE	NE	NE	NE	11/11	6,300 - 96,400	NA	NA	NA	NA	No
Vanadium	NE	NE	26	NE	7/14	0.75 - 1.1	NA	NA	0	NA	No

Notes:

(1) NCWQS = North Carolina Water Quality Standards for Groundwater (October, 1994).
(2) MCL = Safe Drinking Water Act Maximum Contaminant Level (October, 1996).
(3) USEPA Region III RBC Table, April 15, 1998.
(4) North Carolina Risk Analysis Framework (NCDEHNR, 1996).
(5) COPC = Chemical of potential concern for human health risk assessment (yes/no).
(6) Not retained as a COPC due to blank contamination.
(7) SMCL = Secondary Maximum Contaminant Level.
(8) Value being remanded.
NE - Not established.
NA - Not Applicable.
J - Estimated Value.

TABLE 6-4

SUMMARY OF DATA AND COPC SELECTION
ORGANICS AND METALS IN SURFACE WATER
PHASE 1 - MOBILE LABORATORY AND FIXED BASE LABORATORY
RI/FS CTO-0356
OPERABLE UNIT NO. 16 (SITE 89)
MCB CAMP LEJEUNE, NORTH CAROLINA

	Surface Water Criteria			Contaminant Frequency/Range		Comparison to Criteria			
		Federal Health AWQCs[2]				Positive Detects Above NCWQS	Positive Detects Above AWQC		
Parameter	NCWQS[1]	Water & Organisms	Organisms Only	No. of Positive Detects/ No. of Samples	Contaminant Range		Water & Organisms	Organisms Only	COPC Selection[3]
Volatiles (µg/L):									
1,1,2,2-Tetrachloroethane	11	0.17	11	4/5	72 - 150J	4	4	4	Yes
1,2-Dichloroethene (total)	NE	NE	NE	4/5	78 - 120	NA	NA	NA	Yes[4]
Chloroform	470	5.7	470	3/11	0.4 - 0.4	0	0	0	No
cis-1,2-Dichloroethene	NE	NE	NE	9/11	2 - 52	NA	NA	NA	Yes[4]
Tetrachloroethene	8.85	0.8	8.85	5/11	0.1 - 1.2	0	1	0	Yes[4]
trans-1,2-Dichloroethene	140,000	70	140,000	8/11	14 - 37	0	0	0	Yes[4]
Trichloroethene	81	2.7	81	9/11	3J - 28.5	0	9	0	Yes[4]
Vinyl Chloride	525	2	525	2/11	21 - 25	0	2	0	Yes[4]
Inorganics (µg/L):									
Aluminum	NE	NE	NE	5/5	41.8 - 554	NA	NA	NA	Yes
Antimony	4,300	14	4,300	1/5	18.5	0	1	0	No
Barium	NE	1,000	NE	5/5	17.9 - 25	0	0	NA	No
Calcium	NE	NE	NE	5/5	37,300 - 46,900	NA	NA	NA	No
Chromium	20	170	3,400	1/5	3.6	0	0	0	No
Copper	3	1,300	NE	3/5	2.6 - 4.7	1	0	NA	Yes
Iron	NE	300	NE	5/5	803 - 1,570	5	5	NA	Yes
Lead	25	50	NE	3/5	1.3J - 5.4	0	0	NA	No
Magnesium	NE	NE	NE	5/5	2,200 - 3,560	NA	NA	NA	No
Manganese	100	50	100	5/5	25.7 - 50.4	0	1	0	No
Potassium	NE	NE	NE	5/5	2,240 - 4,270	NA	NA	NA	No
Sodium	NE	NE	NE	5/5	11,500 - 38,500	NA	NA	NA	No

TABLE 6-4 (continued)

SUMMARY OF DATA AND COPC SELECTION
ORGANICS AND METALS IN SURFACE WATER
PHASE 1 - MOBILE LABORATORY AND FIXED BASE LABORATORY
RI/FS CTO-0356
OPERABLE UNIT NO. 16 (SITE 89)
MCB CAMP LEJEUNE, NORTH CAROLINA

	Surface Water Criteria			Contaminant Frequency/Range		Comparison to Criteria			
		Federal Health AWQCs(2)				Positive Detects Above NCWQS	Positive Detects Above AWQC		
Parameter	NCWQS(1)	Water & Organisms	Organisms Only	No. of Positive Detects/ No. of Samples	Contaminant Range		Water & Organisms	Organisms Only	COPC Selection(3)
Vanadium	NE	NE	NE	2/5	2.8 - 4.2	NA	NA	NA	Yes
Zinc	86	NE	NE	5/5	9.2 - 17.7	0	NA	NA	No

Notes:

(1) NCWQS = North Carolina Water Quality Standards for Surface Water (January, 1996).
(2) AWQC = Ambient Water Quality Standard (December, 1992).
(3) COPC = Chemical of Potential Concern for human health risk assessment (yes/no).
(4) Retained as a site related COPC due to toxicity.

NE = Not Established
ND = Not Detected
NA = Not Applicable
J = Estimated value

TABLE 6-5

SUMMARY OF DATA AND COPC SELECTION
ORGANICS AND METALS IN SEDIMENT
PHASE I - MOBILE LABORATORY AND FIXED BASE LABORATORY
RI/FS CTO-0356
OPERABLE UNIT NO. 16 (SITE 89)
MCB CAMP LEJEUNE, NORTH CAROLINA

Parameter	Region III Residential Soil RBC Screening Value(1)	Average Background	Range/Frequency		Positive Detects Above Residential Soil RBC Value	COPC Selection(2)
			Range of Positive Detections	No. of Positive Detects/ No. of Samples		
Volatiles (µg/kg):						
1,1,2,2-Tetrachloroethane	3,200	ND	550 - 1,700	2/10	0	No
1,1,2-Trichloroethane	11,000	ND	13 - 19	2/10	0	No
1,1-Dichloroethene	1,100	ND	37J	1/10	0	No
1,2-Dichloroethene (total)	70,000	ND	1,500 - 1,600	2/10	0	No
cis-1,2-Dichloroethene	78,000	ND	5 - 16	2/6	0	No
Toluene	1,600,000	ND	7J	1/10	0	No
trans-1,2-Dichloroethene	160,000	ND	1 - 5	2/6	0	No
Trichloroethene	58,000	ND	0.3 - 2,400	2/16	0	No
Vinyl Chloride	340	ND	35 - 230	2/16	0	No
***Semivolatiles* (µg/kg):**						
Benzo(a)anthracene	870	ND	48J - 58J	2/10	0	Yes(3)
Benzo(a)pyrene	87	ND	65J - 3,100	3/10	1	Yes
Benzo(b)fluoranthene	870	ND	40J - 140J	5/10	0	Yes(3)
Benzo(g,h,i)perylene	230,000(4)	ND	50J - 55J	2/10	0	No
Benzo(k)fluoranthene	8,700	ND	50J - 51J	2/10	0	Yes(3)
Bis(2-ethylhexyl)phthalate	46,000	ND	88J - 13,000	10/10	0	No
Chrysene	87,000	ND	51J - 120J	3/10	0	Yes(3)
Fluoranthene	310,000	ND	51J - 180J	5/10	0	No
Indeno(1,2,3-cd)pyrene	870	ND	59J	1/10	0	Yes(3)
Phenanthrene	230,000(4)	ND	42J - 100J	4/10	0	No
Pyrene	230,000	ND	50J - 140J	7/10	0	No

TABLE 6-5 (Continued)

SUMMARY OF DATA AND COPC SELECTION
ORGANICS AND METALS IN SEDIMENT
PHASE I - MOBILE LABORATORY AND FIXED BASE LABORATORY
RI/FS CTO-0356
OPERABLE UNIT NO. 16 (SITE 89)
MCB CAMP LEJEUNE, NORTH CAROLINA

Parameter	Region III Residential Soil RBC Screening Value[1]	Average Background	Range/Frequency: Range of Positive Detections	Range/Frequency: No. of Positive Detects/ No. of Samples	Positive Detects Above Residential Soil RBC Value	COPC Selection[2]
Pesticides/PCBs (µg/kg):						
4,4'-DDD	2,700	ND	42J - 79	2/2	0	No
4,4'-DDE	1,900	ND	33J - 44J	2/2	0	No
4,4'-DDT	1,900	3.38	23J - 34	2/2	0	No
Alpha-Chlordane	180	ND	2J - 2.9	2/2	0	No
Gamma-Chlordane	180	ND	1.6J - 4.6J	2/2	0	No
Inorganics (mg/kg):						
Aluminum	7,800	9,864.29	1,010J - 14,000J	10/10	1	Yes
Arsenic	0.43	ND	0.38 - 0.85	6/10	3	Yes
Barium	550	12.44	6 - 30.1	10/10	0	No
Beryllium	16	0.096	0.14 - 0.55	4/10	0	No
Cadmium	7.8	ND	0.77 - 0.82	3/10	0	No
Calcium	NE	2,932.86	8,020 - 48,000	10/10	NA	No
Chromium	39	30.87	2.4 - 7.6	10/10	0	No
Copper	310	ND	5.5 - 38.7	5/10	0	No
Iron	2,300	12,868.57	1,190J - 3,860	10/10	4	Yes
Lead	400[5]	5.75	6.6 - 35.4J	10/10	0	No
Magnesium	NE	5,081.43	219 - 888	10/10	NA	No
Manganese	160	45.66	7.3 - 16.3	10/10	0	No
Mercury	2.3	0.065	0.1	1/10	0	No
Nickel	160	10.21	2.3 - 3.7	2/10	0	No

TABLE 6-5 (Continued)

SUMMARY OF DATA AND COPC SELECTION
ORGANICS AND METALS IN SEDIMENT
PHASE I - MOBILE LABORATORY AND FIXED BASE LABORATORY
RI/FS CTO-0356
OPERABLE UNIT NO. 16 (SITE 89)
MCB CAMP LEJEUNE, NORTH CAROLINA

Parameter	Region III Residential Soil RBC Screening Value(1)	Average Background	Range/Frequency		Positive Detects Above Residential Soil RBC Value	COPC Selection(2)
			Range of Positive Detections	No. of Positive Detects/ No. of Samples		
Sodium	NE	ND	38.5 - 131	10/10	NA	No
Vanadium	55	26.59	4 - 19.7	10/10	0	No
Zinc	2,300	30.66	11.7 - 53.1	10/10	0	No

Notes:

(1) USEPA Region III RBC Table, April 15, 1998.
(2) Chemical of potential concern for human health risk assessment (yes/no).
(3) Chemical re-included based on potential synergistic effects.
(4) Value for pyrene used as a surrogate.
(5) Action level for residential soils (USEPA, 1994).

NE = Not Established
ND = Not Detected
NA = Not Applicable
J = Estimated value

TABLE 6-6

SUMMARY OF DATA AND COPC SELECTION
ORGANICS AND INORGANICS IN SUBSURFACE SOIL
PHASE II - FIXED BASE LABORATORY
RI/FS CTO-0356
OPERABLE UNIT NO. 16 (SITE 93)
MCB, CAMP LEJEUNE, NORTH CAROLINA

	Range/Frequency		Comparison to Criteria						
Constituent	Range of Positive Detections	No. of Positive Detects/ No. of Samples	Twice the Average Base Specific Background(1) Concentration	No. of Times Exceeded Twice the Average Background Concentration	Method I, Category S-1 Target Concentrations(2)	Positive Detects Above S-1 Target	USEPA Region III Residential Soil RBC Value(3)	Positive Detects Above Residential RBC Value	COPC Selection(4)
Volatiles (µg/kg):									
2-Butanone	13J	1/22	NA	NA	9,400,000	0	4,700,000	0	No
Acetone	19J - 340	13/22	NA	NA	1,560,000	0	780,000	0	No
Semivolatiles (µg/kg):									
Benzo(a)pyrene	400J	1/22	NA	NA	88	1	88	1	Yes
Bis(2-ethylhexyl)phthalate	43J - 420J	5/22	NA	NA	46,000	0	46,000	0	No
Pesticides (µg/kg):									
4,4'-DDD	55	1/3	NA	NA	2,700	0	2,700	0	No
4,4'-DDE	22	1/3	NA	NA	1,900	0	1,900	0	No
4,4'-DDT	33	1/3	NA	NA	1,900	0	1,900	0	No
Inorganics (mg/kg):									
Aluminum	624 - 20,500J	21/22	7,375.3	5	15,600	**1**	7,800	5	Yes
Antimony	0.27 - 0.43	3/22	6.408	0	6.2	0	3.1	0	No
Arsenic	0.64 - 3.4J	8/22	1.968	2	0.43	8	0.43	8	Yes
Barium	2.5 - 40.6	22/22	14.2	6	1,100	0	550	0	No
Beryllium	0.02 - 0.5	19/22	0.19	2	0.15	5	16	0	Yes
Cadmium	0.04J - 0.09	4/22	0.712	0	7.8	0	3.9	0	No
Calcium	26 - 2,610J	22/22	391.5	8	NE	NA	NE	NA	No
Chromium	1.3 - 28.1J	22/22	12.6	3	78	0	39	0	No
Cobalt	0.06J - 1.6J	15/22	1.5	1	470	0	470	0	No
Copper	0.16J - 13.6	15/22	2.4	3	620	0	310	0	No
Iron	387 - 14,900	22/22	7,252.1	2	4,600	**10**	2,300	12	Yes
Lead	1.9 - 10.6J	22/22	8.3	3	400(5)	0	400(5)	0	No

TABLE 6-6 (continued)

SUMMARY OF DATA AND COPC SELECTION
ORGANICS AND INORGANICS IN SUBSURFACE SOIL
PHASE II - FIXED BASE LABORATORY
RI/FS CTO-0356
OPERABLE UNIT NO. 16 (SITE 93)
MCB, CAMP LEJEUNE, NORTH CAROLINA

	Range/Frequency		Comparison to Criteria						
Constituent	Range of Positive Detections	No. of Positive Detects/ No. of Samples	Twice the Average Base Specific Background[1] Concentration	No. of Times Exceeded Twice the Average Background Concentration	Method I, Category S-1 Target Concentrations[2]	Positive Detects Above S-1 Target	USEPA Region III Residential Soil RBC Value[3]	Positive Detects Above Residential RBC Value	COPC Selection[4]
Magnesium	29.2J - 594	22/22	260.7	4	NE	NA	NE	NA	No
Manganese	1.3 - 24.6	22/22	7.9	5	360	0	180	0	No
Nickel	0.15J - 3.1J	11/22	3.7	0	320	0	160	0	No
Potassium	105 - 887J	14/22	347.2	3	NE	NA	NE	NA	No
Selenium	0.42 - 1.6	6/22	0.8	1	78	0	39	0	No
Silver	0.04J	1/22	0.866	0	78	0	39	0	No
Sodium	41.7J - 156	15/22	52.68	12	NE	NA	NE	NA	No
Vanadium	1 - 64.9	22/22	13.5	4	110	0	55	1	Yes
Zinc	0.14J - 11.8	21/22	6.7	2	4,600	0	2,300	0	No

Notes:

(1) Soil background concentrations are based on reference background soil samples collected from MCB Camp Lejeune investigations.
(2) North Carolina Risk Analysis Framework (NCDEHNR, 1996)
(3) USEPA Region III RBC Table, April 15, 1998.
(4) COPC = Chemical of Potentail Concern for human health risk assessment (yes/no).
(5) Action Level for residential soils (USEPA, 1994).

NE = Not established
NA = Not applicable
J = Estimated Value

TABLE 6-7

SUMMARY OF DATA AND COPC SELECTION
ORGANICS AND METALS IN GROUNDWATER
PHASE I AND II - MOBILE LABORATORY AND
PHASE II - FIXED BASE LABORATORY
RI/FS CTO-0356
OPERABLE UNIT NO. 16 (SITE 93)
MCB CAMP LEJEUNE, NORTH CAROLINA

	Groundwater Criteria				Frequency/Range		Comparison to Criteria				
Parameter	NCWQS(1)	MCL(2)	USEPA Region III Tap Water RBC Value(3)	Method I, Category G-1 Target Concentrations(4)	No. of Positive Detects/ No. of Samples	Concentration Range	Positive Detects Above NCWQS	Positive Detects Above MCL	Positive Detects Above RBC Value	Positive Detects Above G-1 Target	COPC Selection(5)
Volatiles (µg/L):											
1,2-Dichloroethene (total)	NE	NE	5.5	NE	1/11	92	NA	NA	1	NA	Yes
Chloroform	0.19	80	0.15	0.19	7/26	0.3 - 2.3	7	0	7	7	No (6)
cis-1,2-Dichloroethene	70	70	6.1	70	3/15	4 - 175	1	1	2	1	Yes
Tetrachloroethene	0.7	5	1.1	0.7	7/26	0.1 - 65.1	5	3	4	5	Yes
trans-1,2-Dichloroethene	70	100	12	70	2/15	5 - 57	0	0	1	0	Yes
Trichloroethene	2.8	5	1.6	2.8	8/26	0.1 - 39.4	3	3	3	3	Yes
Semivolatiles (µg/L):											
Bis(2-ethylhexyl)phthalate	3	6	4.8	3	4/11	1J - 130	1	1	1	1	No(6)
Naphthalene	21	NE	150	21	1/11	6J	0	0	0	0	No
Metals (µg/L):											
Aluminum	NE	50(7)	3,700	NA	2/11	270 - 2,540	0	2	0	NA	No
Antimony	NE	6	1.5	NE	1/11	2.3	NA	0	1	NA	Yes
Arsenic	50	50	0.045	50	1/11	4.3	0	0	1	0	Yes
Barium	2,000	2,000	260	2,000	11/11	4.2 - 73.9	0	0	0	0	No
Cadmium	5	5	1.8	5	1/11	1.6	0	0	0	0	No
Calcium	NE	NE	NE	NE	11/11	4,760 - 106,000	NA	NA	NA	NA	No
Chromium	50	100	18	50	6/11	0.57 - 17	0	0	0	0	No
Cobalt	NE	NE	220	NE	3/11	1 - 10.3	0	0	0	NA	No
Copper	1,000	1,300(9)	150	1,000	1/11	32.1	0	0	0	0	No
Iron	300	300(7)	1,100	300	11/11	577 - 4,330	11	11	9	11	Yes
Lead	15	15(9)	NE	15	1/11	164	1	1	NA	1	Yes

TABLE 6-7 (continued)

CHEMICALS OF POTENTIAL CONCERN
ORGANICS AND METALS IN GROUNDWATER
PHASE I AND PHASE II - MOBILE LABORATORY AND PHASE II - FIXED BASE LABORATORY
RI/FS CTO-0356
OPERABLE UNIT NO. 16 (SITE 93)
MCB, CAMP LEJEUNE, NORTH CAROLINA

	Groundwater Criteria				Frequency/Range		Comparison to Criteria				
Parameter	NCWQS(1)	MCL(2)	USEPA Region III Tap Water RBC Value(3)	Method I, Category G-1 Target Concentrations(4)	No. of Positive Detects/ No. of Samples	Concentration Range	Positive Detects Above NCWQS	Positive Detects Above MCL	Positive Detects Above RBC Value	Positive Detects Above G-1 Target	COPC Selection(5)
Magnesium	NE	NE	NE	NE	11/11	457 - 5,220	NA	NA	NA	NA	No
Manganese	50	50(7)	73	50	11/11	9.2 - 432	2	2	2	2	Yes
Nickel	100	100(8)	73	100	3/11	3.7 - 14.8	0	0	0	0	No
Potassium	NE	NE	NE	NA	11/11	892 - 24,500	NA	NA	NA	0	No
Selenium	50	50	18	50	1/11	2.9	0	0	0	0	No
Sodium	NE	NE	NE	NA	10/11	6,510 - 39,700	NA	NA	NA	NA	No
Vanadium	NE	NE	26	NA	4/11	0.71 - 6.4	NA	NA	0	NA	No
Zinc	2,100	5,000(7)	1,100	2,100	4/11	2.7J - 316	0	0	0	0	No

Notes:

(1) NCWQS = North Carolina Water Quality Standards for Groundwater (October, 1994).
(2) MCL = Safe Drinking Water Act Maximum Contaminant Level (October, 1996).
(3) USEPA Region III RBC Table, April 15, 1998.
(4) North Carolina Risk Analysis Framework (NCDEHNR, 1996).
(5) COPC = Chemical of potential concern for human health risk assessment (yes/no).
(6) Not retained as a COPC due to blank contamination.
(7) SMCL = Secondary Maximum Contaminant Level.
(8) Value being remanded.
(9) Value is an action level.
NE - Not established.
NA - Not Applicable.
J - Estimated Value.

TABLE 6-8

SUMMARY OF COPCs IN ENVIRONMENTAL MEDIA OF CONCERN
RI/FS CTO-0356
OPERABLE UNIT NO. 16 (SITES 89 AND 93)
MCB, CAMP LEJEUNE, NORTH CAROLINA

Contaminant	Site 89								Site 93			
	Subsurface Soil		Groundwater		Surface Water		Sediment		Subsurface Soil		Groundwater	
Volatiles												
Acetone	●								●			
Carbon disulfide	●											
Chloroform			●		●						●	
1,1-Dichloroethene			●	X			●					
cis-1,2-Dichloroethene			●	X	●	X	●				●	X
trans-1,2-Dichloroethene			●	X	●	X	●				●	X
1,2-Dichloroethene (total)	●		●	X	●	X	●				●	X
2-Butanone	●								●			
Vinyl Chloride			●	X	●	X	●					
1,1,2-Trichloroethane			●	X			●					
Trichloroethene	●		●	X	●	X	●				●	X
1,1,2,2-Tetrachloroethane	●		●	X	●	X	●					
Tetrachloroethene	●		●	X	●	X					●	X
Toluene	●		●				●					
Benzene	●											
1,1,1-Trichloroethane			●									
Semivolatiles												
Naphthalene											●	
Phenanthrene							●					
Fluoranthene	●						●					
Pyrene	●						●					
Benzo(a)anthracene							●	X				
Chrysene							●	X				

TABLE 6-8 (Continued)

SUMMARY OF COPCs IN ENVIRONMENTAL MEDIA OF CONCERN
RI/FS CTO-0356
OPERABLE UNIT NO. 16 (SITES 89 AND 93)
MCB CAMP LEJEUNE, NORTH CAROLINA

Contaminant	Site 89								Site 93			
	Subsurface Soil		Groundwater		Surface Water		Sediment		Subsurface Soil		Groundwater	
bis(2-Ethylhexyl)phthalate	●		●				●		●		●	
Benzo(b)fluoranthene							●	X				
Benzo(k)fluoranthene							●	X				
Benzo(a)pyrene							●	X	●	X		
Benzo(g,h,i)perylene							●					
Indeno(1,2,3-cd)pyrene							●	X				
Pesticides/PCBs												
4,4'-DDE	●						●		●			
4,4'-DDD	●						●		●			
4,4'-DDT	●						●		●			
Alpha Chlordane							●					
Gamma Chlordane							●					
Metals												
Aluminum	●	X			●	X	●	X	●	X	●	
Antimony	●		●	X	●				●		●	X
Arsenic	●	X					●	X	●	X	●	X
Barium	●		●		●		●		●		●	
Beryllium	●	X					●		●	X		
Cadmium	●						●		●		●	
Calcium	●		●		●		●		●		●	
Chromium	●		●		●		●		●		●	
Cobalt	●								●		●	
Copper	●				●	X	●		●		●	
Iron	●	X	●	X	●	X	●	X	●	X	●	X

TABLE 6-8 (Continued)

SUMMARY OF COPCs IN ENVIRONMENTAL MEDIA OF CONCERN
RI/FS CTO-0356
OPERABLE UNIT NO. 16 (SITES 89 AND 93)
MCB CAMP LEJEUNE, NORTH CAROLINA

	Site 89								Site 93			
Contaminant	Subsurface Soil		Groundwater		Surface Water		Sediment		Subsurface Soil		Groundwater	
Lead	●				●		●		●		●	X
Magnesium	●		●		●		●		●		●	
Manganese	●		●	X	●		●		●		●	X
Mercury							●					
Nickel	●		●				●		●		●	
Potassium	●		●		●				●		●	
Selenium	●		●						●		●	
Silver	●								●			
Sodium	●		●		●		●		●		●	
Vanadium	●		●		●	X	●		●	X	●	
Zinc	●				●		●		●		●	

Notes:

● = Detected in media; compared to relevant criteria and standards.
X = Selected as a COPC for human health risk assessment.

TABLE 6-9

MATRIX OF POTENTIAL HUMAN EXPOSURE
RI/FS CTO-0356
OPERABLE UNIT NO. 16 (SITES 89 AND 93)
MCB, CAMP LEJEUNE, NORTH CAROLINA

Exposure Medium Exposure Route	Site 89			Site 93	
	Current Residential Population	Future Residential Population	Future Construction Worker	Future Residential Population	Future Construction Worker
Subsurface Soil					
Incidental Ingestion	NA	NA	W	NA	W
Dermal Contact	NA	NA	W	NA	W
Groundwater					
Ingestion	NA	A,C	NA	A,C	NA
Dermal Contact	NA	A,C	NA	A,C	NA
Surface Water					
Ingestion	A,C	A,C	NA	NA	NA
Dermal Contact	A,C	A,C	NA	NA	NA
Sediment					
Incidental Ingestion	A,C	A,C	NA	NA	NA
Dermal Contact	A,C	A,C	NA	NA	NA
Air					
Inhalation of Vapor Phase Chemicals Indoor	NA	A	NA	A	NA
Inhalation of Particulates Outdoor	NA	NA	W	NA	W

Notes:

A = Exposure - adults
C = Exposure - children
W = Construction duration exposure
NA = Not applicable to receptor group

TABLE 6-10

EXPOSURE INPUT PARAMETERS
CURRENT RESIDENTIAL CHILDREN AND ADULTS
RI/FS CTO-0356
OPERABLE UNIT NO. 16 (SITES 89 AND 93)
MCB, CAMP LEJEUNE, NORTH CAROLINA

Input Parameter	Media	Units	Future Receptor		Comments/ References
			Child (1 to 6 years)	Adult	
Exposure Duration, ED	All media	years	4	4	Professional Judgement
Exposure Frequency, EF	Sediment/ Surface Water	days/year	100	100	Professional Judgement
Exposure Time, ET	Surface Water	hrs/day	2.6	2.6	USEPA, 1989a
Ingestion Rate, IR	Sediment	mg/day	200	100	USEPA, 1989a
	Surface Water	L/hr	0.05	0.05	USEPA, 1989a
Surface Area, SA	Sediment/ Surface Water	cm^2	2,300(1)	5,800(1)	USEPA, 1992a
Fraction Ingested, FI	Sediment	unitless	1.0	1.0	Professional Judgement
Absorbance Factor, ABS	Sediment	unitless	Chemical Specific(2)	Chemical Specific(2)	USEPA, 1995
Adherence Factor, AF	Sediment	mg/cm^2	1	1	USEPA, 1992b
Body Weight, BW	All Media	kg	15	70	USEPA, 1989a
Permeability Constant, PC	Surface Water	cm/hr	Chemical-Specific	Chemical-Specific	USEPA, 1992a
Averaging Time, AT noncarcinogens, AT_{nc}	All Media	day	1,460	1,460	USEPA, 1989a
carcinogens, AT_c	All Media	day	25,550	25,550	USEPA, 1989a

Notes:

(1) Represents an individual wearing shirt, shorts, and shoes (or exposing approximately 25% of total body surface area).

(2) The following absorbance factors will be applied to estimate dermal intake of COPCs:

USEPA Region IV Defaults (USEPA, 1995): organics - 0.01
inorganics - 0.001

NA = Not applicable

TABLE 6-11

REASONABLE MAXIMUM (RME) AND CENTRAL TENDENCY (CT)
EXPOSURE INPUT PARAMETERS
FUTURE RESIDENTIAL CHILDREN AND ADULTS
RI/FS CTO-0356
OPERABLE UNIT NO. 16 (SITES 89 AND 93)
MCB, CAMP LEJEUNE, NORTH CAROLINA

Input Parameter[(1)]	Media	Units	Future Receptor Child (1 to 6 years)	Future Receptor Adult	Comments/ References
Exposure Duration, ED	All media	years	6 (NA)	30 (9)	USEPA, 1991a (USEPA, 1993)
Exposure Frequency, EF	Soil/Groundwater	days/year	350 (234)	350 (234)	USEPA, 1991a (USEPA, 1993)
	Sediment/ Surface Water	days/year	100 (NA)	100 (NA)	Professional Judgment
Exposure Time, ET	Surface Water	hrs/day	2.6 (NA)	2.6 (NA)	USEPA, 1989a
	Groundwater	hrs/day	0.25 (NA)	0.25 (NA)	USEPA, 1989a
Ingestion Rate, IR	Groundwater	L/day	1 (NA)	2 (1.4)	USEPA, 1991a
	Soil/Sediment	mg/day	200 (100)	100 (50)	USEPA, 1989a (USEPA, 1993)
	Surface Water	L/day	0.05 (NA)	0.05 (NA)	USEPA, 1989a
Surface Area, SA	Groundwater	cm^2	10,000 (7,930)	23,000 (20,000)	USEPA, 1992a (USEPA, 1992a)
	Soil/Sediment/ Surface Water	cm^2	2,300[(2)] (2,000)	5,800[(2)] (5,000)	USEPA, 1992a (USEPA, 1992a)
Inhalation Rate, IR	Groundwater	m^3/hr	NA (NA)	0.6 (NA)	USEPA 1989a
Fraction Ingested, FI	Soil/Sediment	unitless	1.0 (NA)	1.0 (NA)	Professional Judgment
Absorbance Factor, ABS	Soil/Sediment	unitless	Chemical Specific[(3)]	Chemical Specific[(3)]	USEPA, 1995
Adherence Factor, AF	Soil/Sediment	mg/cm^2	1 (0.2)	1 (0.2)	USEPA, 1992b (USEPA, 1992a)
Body Weight, BW	All Media	kg	15 (NA)	70 (NA)	USEPA, 1989a
Permeability Constant, PC	Groundwater/ Surface Water	cm/hr	Chemical-Specific	Chemical-Specific	USEPA, 1992a

TABLE 6-11

REASONABLE MAXIMUM (RME) AND CENTRAL TENDENCY (CT)
EXPOSURE INPUT PARAMETERS
FUTURE RESIDENTIAL CHILDREN AND ADULTS
RI/FS CTO-0356
OPERABLE UNIT NO. 16 (SITES 89 AND 93)
MCB, CAMP LEJEUNE, NORTH CAROLINA

Input Parameter[1]	Media	Units	Future Receptor Child (1 to 6 years)	Future Receptor Adult	Comments/ References
Averaging Time, AT noncarcinogens, AT_{nc}	All Media	day	2,190 (NA)	10,950 (3,285)	USEPA, 1989a (USEPA, 1993)
carcinogens, AT_c	All Media	day	25,550	25,550	USEPA, 1989a

Notes:

(1) CT exposure input parameters are presented in parentheses.

(2) Represents an individual wearing shirt, shorts, and shoes (or exposing approximately 25% of total body surface area).

(3) The following absorbance factors will be applied to estimate dermal intake of COPCs:

USEPA Region IV Defaults (USEPA, 1995a): organics - 0.01
inorganics - 0.001

NA = Not applicable

TABLE 6-12

EXPOSURE INPUT PARAMETERS
FUTURE ADULT CONSTRUCTION WORKERS
RI/FS CTO-0356
OPERABLE UNIT NO. 16 (SITES 89 AND 93)
MCB, CAMP LEJEUNE, NORTH CAROLINA

		Future Receptor	
Input Parameter	Units	Adult Construction Worker	Comments/ References
Exposure Duration, ED	years	1	USEPA, 1991a
Exposure Frequency, EF	days/year	250	USEPA, 1991a
Exposure Time, ET	hrs/day	8	USEPA, 1993
Ingestion Rate, IR	mg/day	480	USEPA, 1991a
Exposed Surface Area, SA	cm^2/day	5,800	USEPA, 1992a
Fraction Ingested, FI	unitless	1.0	Professional Judgment
Dermal Absorption Factor, ABS	unitless	Chemical-specific	USEPA, 1995a
Adherence Factor, AF	mg/cm^2	1	USEPA, 1992a
Body Weight, BW	kg	70	USEPA, 1989a
Averaging Times, AT noncarcinogens, AT_{nc}	days	365	USEPA, 1989a
carcinogens, AT_c	days	25,550	USEPA, 1989a

Notes:

(1) The following absorbance factors will be applied to estimate dermal intake of COPCs:

USEPA Region IV Defaults (USEPA, 1995): organics - 0.01
inorganics - 0.001

TABLE 6-13

TOXICITY FACTORS
RI/FS CTO-0356
OPERABLE UNIT NO. 16 (SITES 89 AND 93)
MCB, CAMP LEJEUNE, NORTH CAROLINA

	RfD	Dermally Adjusted* RfD	RfDi	CSF	Dermally Adjusted* CSF	CSFi	Oral Absorption Factors(1)	WOE	Reference
Volatiles:									
1,1-Dichloroethene	9.0E-03	7.2E-03	NE	6.0E-01	7.5E-01	1.75E-01	80%	D	IRIS
1,2-Dichloroethene (total)	9.0E-03	7.2E-03	NE	NE	NE	NE	80%	C	HEAST
cis-1,2-Dichloroethene	1.0E-02	8.0E-03	NE	NE	NE	NE	80%	D	HEAST
trans-1,2-Dichloroethene	2.0E-02	1.6E-02	NE	NE	NE	NE	80%	D	IRIS
Vinyl Chloride	NE	NE	NE	1.9E+00	2.4E+00	3.0E-01	80%	A	HEAST, EPA-NCEA
1,1,2-Trichloroethane	4.0E-03	3.2E-03	NE	5.7E-02	7.1E-02	5.6E-02	80%	C	IRIS
1,1,2,2-Tetrachloroethane	NE	NE	NE	2.0E-01	2.5E-01	2.0E-01	80%	C	IRIS
Tetrachloroethene	1.0E-02	8.0E-03	NE	5.2E-02	6.5E-02	2.0E-03	80%	--	IRIS, EPA-NCEA
Trichloroethene	6.0E-03	4.8E-03	NE	1.1E-02	1.4E-02	6.0E-03	80%	B2	EPA-NCEA(2)
Semivolatiles:									
Benzo(a)pyrene	NE	NE	NE	7.3	15	6.1(2)	50%	B2	IRIS
Inorganics:									
Aluminum	1.0E+00	2.0E-01	NE	NE	NE	NE	20%	ND	EPA-NCEA
Antimony	4.0E-04	8.0E-05	NE	NE	NE	NE	20%	D	IRIS
Arsenic	3.0E-04	6.0E-05	NE	1.5	7.5	15.1	20%	A	IRIS
Beryllium	5.0E-03	1.0E-03	NE	4.3	21.5	8.4	20%	B2	IRIS
Chromium (VI)	5.0E-03	1.0E-03	NE	NE	NE	4.2E+01	20%	D	IRIS

TABLE 6-13 (Continued)

TOXICITY FACTORS
RI/FS CTO-0356
OPERABLE UNIT NO. 16 (SITES 89 AND 93)
MCB, CAMP LEJEUNE, NORTH CAROLINA

	RfD	Dermally Adjusted* RfD	RfDi	CSF	Dermally Adjusted* CSF	CSFi	Oral Absorption Factors[1]	WOE	Reference
Iron	3.0E-01	6.0E-2	NE	NE	NE	NE	20%	ND	EPA-NCEA
Manganese	2.3E-02	4.6E-03	1.43E-05	NE	NE	NE	20%	D	IRIS
Vanadium	7.0E-03	1.4E-03	NE	NE	NE	NE	20%	D	HEAST
Zinc	3.0E-01	6.0E-02	NE	NE	NE	NE	20%	D	IRIS

Notes:		
	RfD	Oral Reference Dose (mg/kg - day)
	RfDi	Inhalation Reference Dose (mg/kg - day)
	CSF	Oral Cancer Slope Factor $(mg/kg\text{-}day)^{-1}$
	CSFi	Inhalation Cancer Slope Factor $(mg/kg\text{-}day)^{-1}$
	WOE	Weight of Evidence
	IRIS	Integrated Risk Information System
	HEAST	Health Effects Assessment Summary Tables
	EPA-NCEA	Environmental Protection Agency - National Center for Environmental Assessment
	ND	Not Determined
	A	Human Carcinogen
	B1	Probable Human Carcinogen - Limited Evidence
	B2	Probable Human Carcinogen - Sufficient Evidence
	C	Possible Human Carcinogen
	D	Not Classifiable as to Human Carcinogenicity

* Only oral toxicity values were dermally adjusted; inhalation toxicity values were not adjusted.
Dermally-adjusted RfD = oral RfD*oral absorption factor
Dermally-adjusted CSF = oral CSF/oral absorption factor

(1) Region IV recommended values (i.e., 80% for VOCs, 50% for SVOCs/Pesticides, and 20% for Inorganics).

(2) CSF withdrawn.

TABLE 6-14

INCREMENTAL LIFETIME CANCER RISK (ICR) AND HAZARD INDEX (HI)
CURRENT ADULT AND CHILD RESIDENTS
RI/FS CTO-0356
OPERABLE UNIT NO. 16 (SITE 89)
MCB, CAMP LEJEUNE, NORTH CAROLINA

Pathway	Receptors			
	Adults		Children (1-6 yrs.)	
	ICR	HI	ICR	HI
<u>Surface Water</u>				
Ingestion	2.3×10^{-6}	0.02	1.1×10^{-5}	0.08
Dermal Contact	2.4×10^{-6}	0.02	4.9×10^{-6}	0.04
Subtotal	4.7×10^{-6}	0.04	1.6×10^{-5}	0.12
<u>Sediment</u>				
Ingestion	2.5×10^{-7}	0.01	2.4×10^{-6}	0.06
Dermal Contact	2.7×10^{-7}	<0.01	5.1×10^{-7}	<0.01
Subtotal	5.2×10^{-7}	0.01	2.9×10^{-6}	0.06
TOTAL	5.2×10^{-6}	0.05	1.9×10^{-5}	0.2

TABLE 6-15

INCREMENTAL LIFETIME CANCER RISK (ICR) AND HAZARD INDEX (HI)(1)
FOR FUTURE ADULT AND CHILD ON-SITE RESIDENTS
RME AND CENTRAL TENDENCY VALUES
RI/FS CTO-0356
OPERABLE UNIT NO. 16 (SITE 89)
MCB, CAMP LEJEUNE, NORTH CAROLINA

	Receptors			
	Adults		Children (1-6 yrs.)	
Pathway	ICR	HI	ICR	HI
Groundwater				
Ingestion	3.0×10^{-3} (9.7×10^{-5})	12 (0.8)	1.4×10^{-3} (2.1×10^{-4})	27 (2.7)
Dermal Contact	8.7×10^{-5} (3.4×10^{-6})	0.45 (0.04)	3.5×10^{-5} (4.2×10^{-6})	0.9 (0.07)
Inhalation	6.1×10^{-5} (2.8×10^{-6})	NA	NE	NE
Subtotal	3.1×10^{-3} (1.0×10^{-4})	12.5 (0.84)	1.4×10^{-3} (2.1×10^{-4})	28 (2.8)
Surface Water				
Ingestion	1.7×10^{-5} (3.5×10^{-6})	0.02 (0.01)	1.6×10^{-5} (1.1×10^{-5})	0.08 (0.05)
Dermal	2.0×10^{-5} (3.5×10^{-6})	0.02 (0.01)	7.3×10^{-6} (4.4×10^{-6})	0.04 (0.02)
Subtotal	3.7×10^{-5} (7.0×10^{-6})	0.04 (0.02)	2.3×10^{-5} (1.5×10^{-5})	0.12 (0.07)
Sediment				
Ingestion	1.9×10^{-6} (2.9×10^{-7})	0.01 (<0.01)	3.6×10^{-6} (1.8×10^{-6})	0.06 (0.03)
Dermal Contact	2.1×10^{-6} (1.1×10^{-7})	<0.01 (<0.01)	7.6×10^{-7} (1.3×10^{-7})	<0.01 (<0.01)
Subtotal	4.0×10^{-6} (4.1×10^{-7})	0.01 (<0.01)	4.4×10^{-6} (1.9×10^{-6})	0.06 (0.03)
TOTAL	3.1×10^{-3} (1.0×10^{-4})	12.6 (0.86)	1.4×10^{-3} (2.3×10^{-4})	28 (2.9)

TABLE 6-16

INCREMENTAL LIFETIME CANCER RISK (ICR) AND HAZARD INDEX (HI)
FOR FUTURE ADULT AND CHILD ON-SITE RESIDENTS
RME AND CENTRAL TENDENCY VALUES
RI/FS CTO-0356
OPERABLE UNIT NO. 16 (SITE 93)
MCB, CAMP LEJEUNE, NORTH CAROLINA

	Receptors			
	Adults		Children (1-6 yrs.)	
Pathway	ICR	HI	ICR	HI
<u>Groundwater</u>				
Ingestion	1.2×10^{-4} (6.2×10^{-6})	2.7 (0.6)	5.6×10^{-5} (1.4×10^{-5})	6.2 (2)
Dermal Contact	8.2×10^{-6} (2.4×10^{-7})	0.1 (0.02)	3.3×10^{-6} (3.0×10^{-7})	0.2 (0.04)
Inhalation	3.5×10^{-7} (4.9×10^{-8})	NA	NE	NE
TOTAL	1.3×10^{-4} (6.5×10^{-6})	2.8 (0.6)	5.9×10^{-5} (1.4×10^{-5})	6.4 (2)

TABLE 6-17

INCREMENTAL LIFETIME CANCER RISK (ICR) AND HAZARD INDEX (HI)
FUTURE CONSTRUCTION WORKER
RME AND CENTRAL TENDENCY VALUES
RI/FS CTO-0356
OPERABLE UNIT NO. 16 (SITE 89)
MCB, CAMP LEJEUNE, NORTH CAROLINA

	Receptor	
	Adult Construction Worker	
Pathway	ICR	HI
<u>Subsurface Soil</u>		
Ingestion	1.8×10^{-7}	0.13
Dermal Contact	1.1×10^{-8}	0.01
TOTAL	1.9×10^{-7}	0.14

TABLE 6-18

INCREMENTAL LIFETIME CANCER RISK (ICR) AND HAZARD INDEX (HI)
FUTURE CONSTRUCTION WORKER
RME AND CENTRAL TENDENCY VALUES
RI/FS CTO-0356
OPERABLE UNIT NO. 16 (SITE 93)
MCB, CAMP LEJEUNE, NORTH CAROLINA

	Receptor	
	Adult Construction Worker	
Pathway	ICR	HI
<u>Subsurface Soil</u>		
Ingestion	2.9×10^{-7}	0.2
Dermal Contact	3.7×10^{-8}	0.01
TOTAL	3.3×10^{-7}	0.2

TABLE 6-19

SUMMARY OF UNCERTAINTIES IN THE RESULTS
HUMAN HEALTH RISK ASSESSMENT
RI/FS CTO-0356
OPERABLE UNIT NO. 16 (SITES 89 AND 93)
MCB, CAMP LEJEUNE, NORTH CAROLINA

	Potential Magnitude for Over-Estimation of Risks	Potential Magnitude for Under-Estimation of Risks	Potential Magnitude for Over or Under-Estimation of Risks
Environmental Sampling and Analysis Sufficient samples may not have been taken to characterize the media being evaluated.			Low
Systematic or random errors in the chemical analysis may yield erroneous data.			Low
Selection of COPCs The use of USEPA Region III COPC screening concentrations in selecting COPCs in soil and groundwater.			Low
Exposure Assessment The standard assumptions regarding body weight, exposure period, life expectancy, population characteristics, and lifestyle may not be representative of the actual exposure situations.			Moderate
The use of the 95th percentile upper confidence level data of the lognormal distribution in the estimation of the RME.			Low
Assessing future residential property use when the likelihood of residential development is low.	High		
The amount of media intake is assumed to be constant and representative of any actual exposure.			Low
Toxicological Assessment Toxicological indices derived from high dose animal studies, extrapolated to low dose human exposure.	Moderate		
Lack of promulgated toxicological indices for inhalation pathway.		Low	
Risk Characterization Assumption of additivity in the quantitation of cancer risks without consideration of synergism, antagonism, promotion and initiation.			Moderate
Assumption of additivity in the estimation of systemic health effects without consideration of synergism, antagonism, etc.			Moderate

TABLE 6-19 (Continued)

SUMMARY OF UNCERTAINTIES IN THE RESULTS
HUMAN HEALTH RISK ASSESSMENT
RI/FS CTO-0356
OPERABLE UNIT NO. 16 (SITES 89 AND 93)
MCB, CAMP LEJEUNE, NORTH CAROLINA

	Potential Magnitude for Over-Estimation of Risks	Potential Magnitude for Under-Estimation of Risks	Potential Magnitude for Over or Under-Estimation of Risks
Additivity of risks by individual exposure pathways (dermal and ingestion and inhalation).			Low

Notes:

Low = Assumptions categorized as "low" may effect risk estimates by less than one order of magnitude.

Moderate = Assumptions categorized as "moderate" may effect estimates of risk by between one and two orders of magnitude.

High = Assumptions categorized as "high" may effect estimates of risk by more than two orders of magnitude.

Source: Risk Assessment Guidance for Superfund, Volume 1, Part A: Human Health Evaluation Manual. USEPA, 1989a.

TABLE 6-20

TOTAL SITE RISK
RI/FS CTO-0356
OPERABLE UNIT NO. 16 (SITE 89)
MCB, CAMP LEJEUNE, NORTH CAROLINA

Receptors	Subsurface Soil		Groundwater		Surface Water/Sediment		Total	
	ICR	HI	ICR	HI	ICR	HI	ICR	HI
Current Child Resident	NA	NA	NA	NA	1.9×10^{-5}	0.2	1.9×10^{-5}	0.2
Current Adult Resident	NA	NA	NA	NA	5.2×10^{-6}	0.05	5.2×10^{-6}	0.05
Future Child Resident	NA	NA	1.4×10^{-3}	28	2.7×10^{-5}	0.18	1.4×10^{-3}	28
Future Adult Resident	NA	NA	3.1×10^{-3}	12.5	4.1×10^{-5}	0.05	3.1×10^{-3}	12.6
Future Construction Worker	1.9×10^{-7}	0.14	NA	NA	NA	NA	1.9×10^{-7}	0.14

Notes:

ICR = Incremental Lifetime Cancer Risk
HI = Hazard Index
Total = Soil + Groundwater + Surface Water/Sediment
NA = Not Applicable

TABLE 6-21

TOTAL SITE RISK
RI/FS CTO-0356
OPERABLE UNIT NO. 16 (SITE 93)
MCB, CAMP LEJEUNE, NORTH CAROLINA

Receptors	Subsurface Soil		Groundwater		Total	
	ICR	HI	ICR	HI	ICR	HI
Future Child Resident	NA	NA	5.9×10^{-5}	6.4	5.9×10^{-5}	6.4
Future Adult Resident	NA	NA	1.3×10^{-4}	2.8	1.3×10^{-4}	2.8
Future Construction Worker	3.3×10^{-7}	0.2	NA	NA	3.3×10^{-7}	0.2

Notes:

ICR = Incremental Lifetime Cancer Risk
HI = Hazard Index
Total = Soil + Groundwater
NA = Not Applicable

SECTION 6.0 FIGURES

FIGURE 6-1

FLOWCHART OF POTENTIAL EXPOSURE PATHWAYS AND RECEPTORS OU NO. 16 (SITE 89)

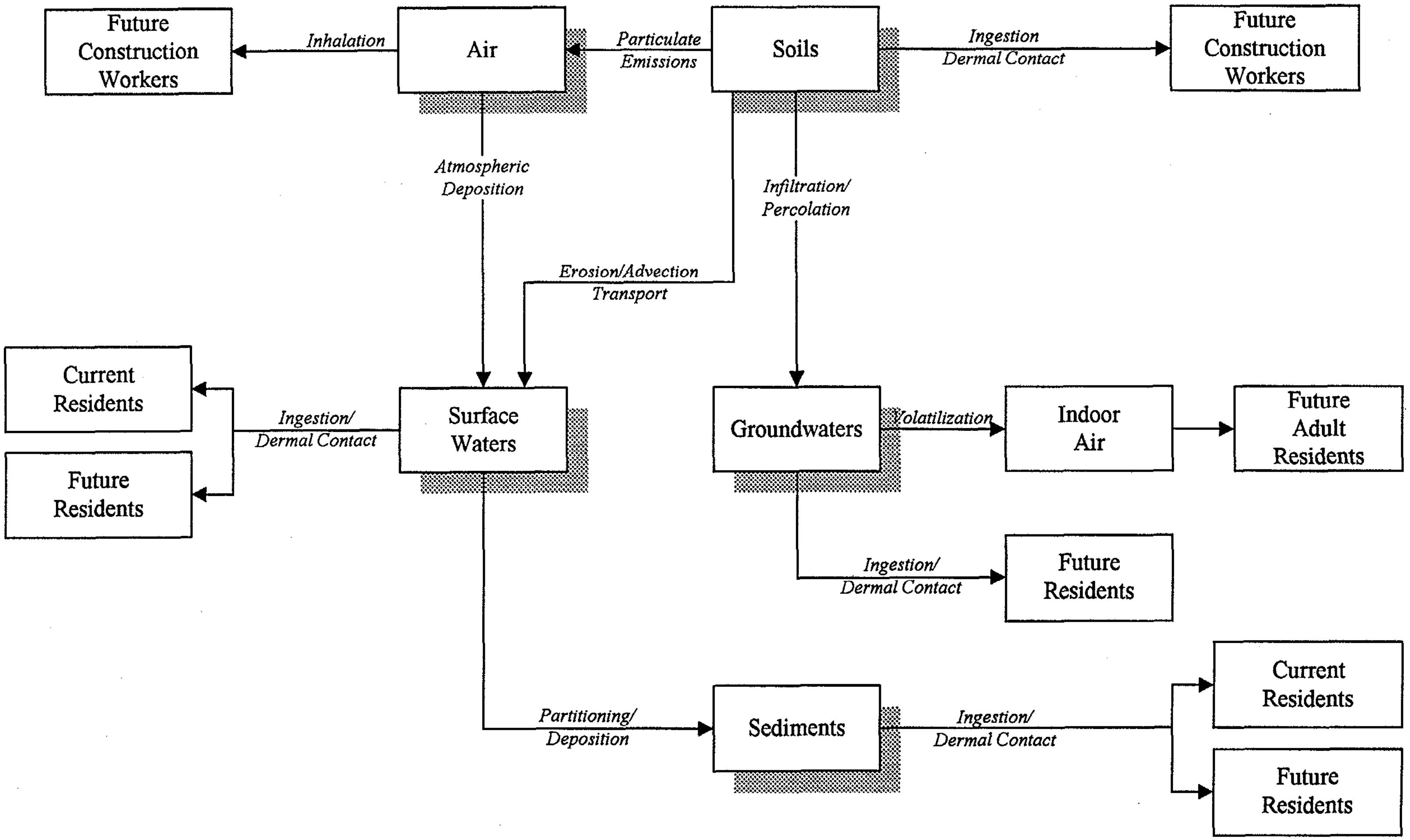
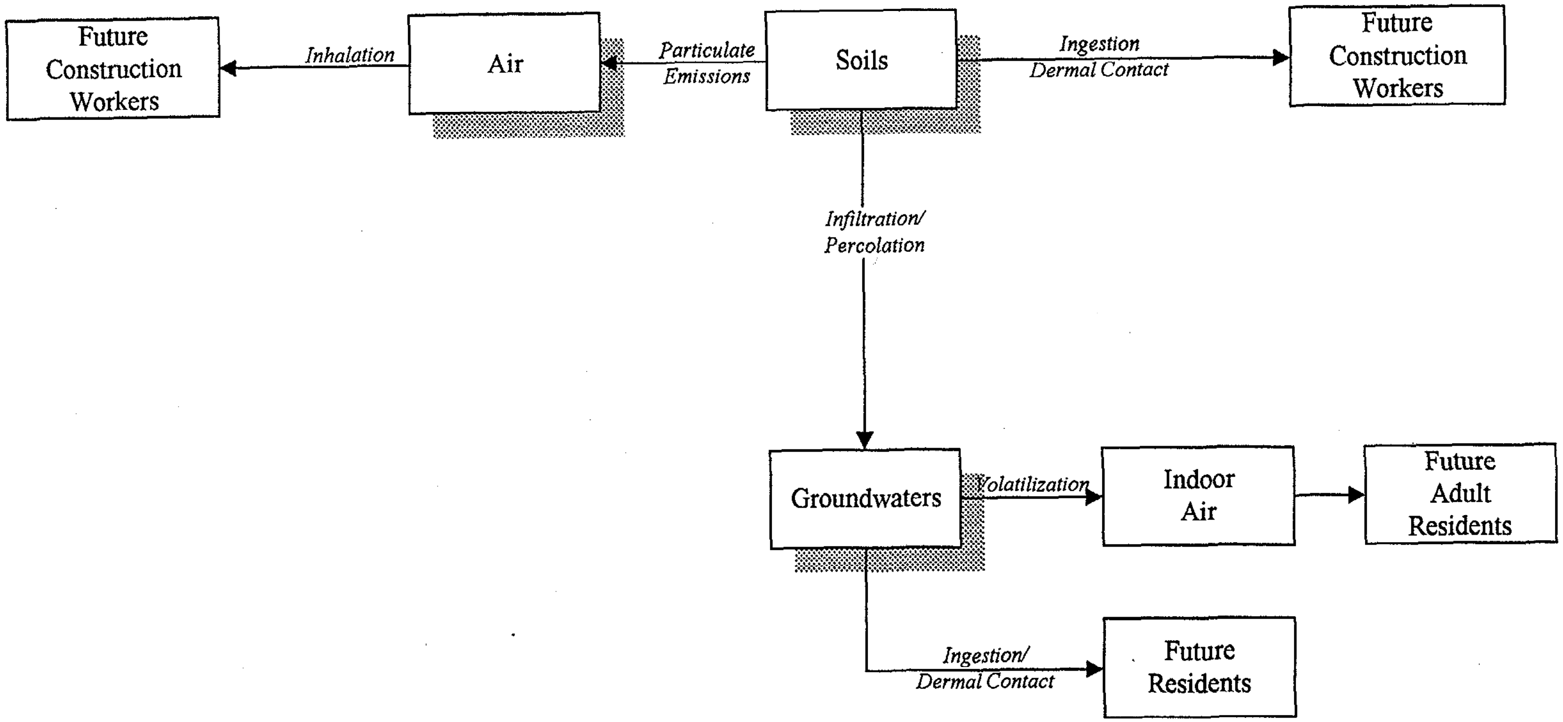


FIGURE 6-2

FLOWCHART OF POTENTIAL EXPOSURE PATHWAYS AND RECEPTORS
OU NO. 16 (SITE 93)



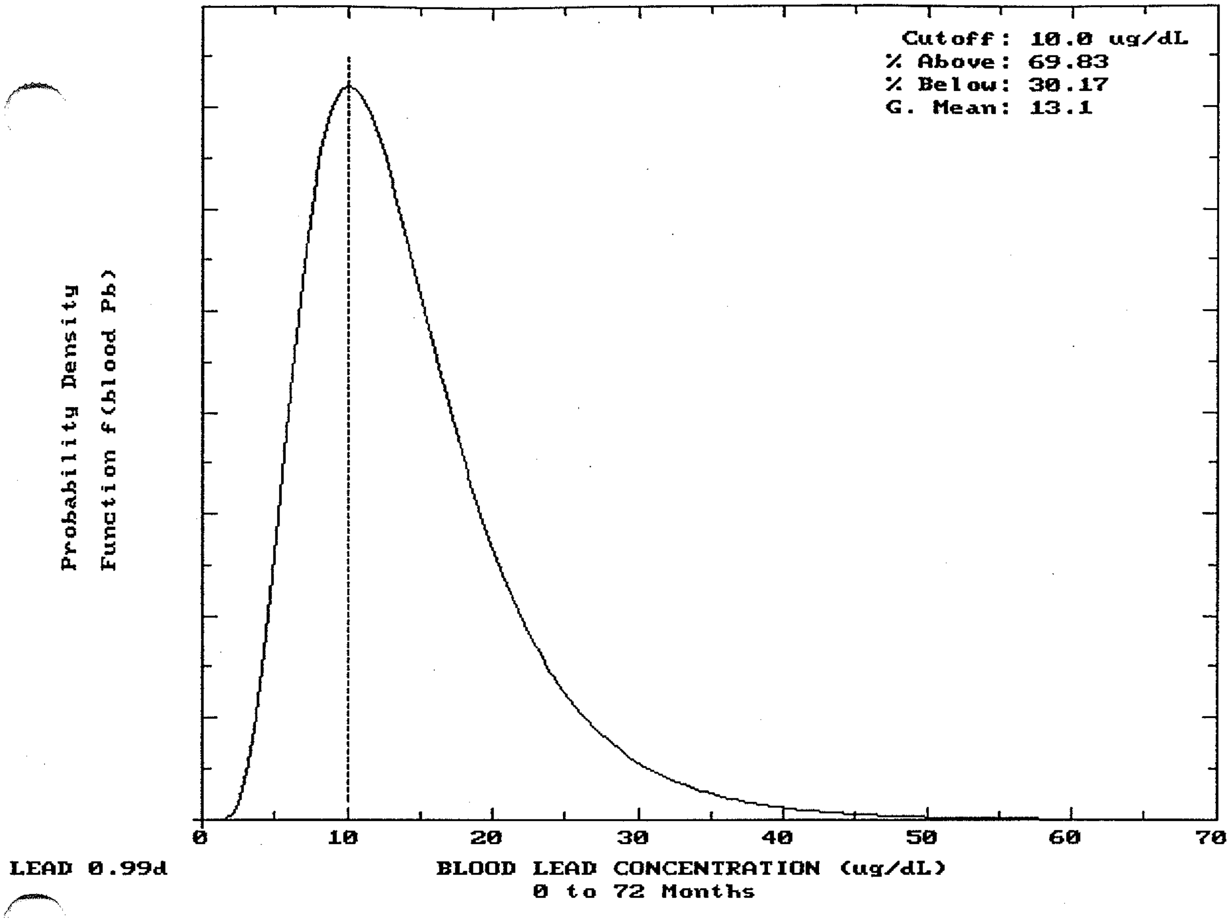


FIGURE 6-3
LEAD UBK MODEL - PROBABILITY DENSITY FUNCTION
SITE 93 GROUNDWATER

7.0 ECOLOGICAL RISK SCREENING

This section presents a focused ecological risk screening conducted on the aquatic environment at Operable Unit No. 16 (Site 89) at the Marine Corps Base (MCB) Camp Lejeune. The objective of this ecological screening is to 1) to determine whether past site operations at Site 89 have caused unacceptable risks to aquatic receptors inhabiting the site, and 2) to determine whether additional ecological studies are warranted at this site. The risk assessment methodologies used in this evaluation were consistent with those outlined in the Ecological Risk Assessment Guidance for Superfund (USEPA, 1997a, the Proposed Guidelines for Ecological Risk Assessment (USEPA, 1996a), and the Supplemental Guidance to RAGS: Region 4 Bulletins: Ecological Risk Assessment (USEPA, 1995a).

The habitat assessed in this ecological risk screening was the aquatic habitat of Edwards Creek. Edwards Creek is a freshwater headwater to the estuarine New River. Edwards Creek is classified as a nutrient sensitive, high water quality, saltwater (SC HQW NSW) (NC DENR, 1993). However, it is acknowledged that the segment of Edwards Creek sampled for this investigation is a freshwater habitat (chloride ion content ranging from 5.4 mg/L to 31.3 mg/L); therefore, freshwater screening values were used to assess the aquatic habitat.

For this ecological risk screening, surface water and sediment samples collected from Edwards Creek (upstream, downstream, and adjacent to Site 89) were analyzed for target compound list (TCL) organics and target analyte list (TAL) inorganics. The surface water and sediment samples were collected during the Phase I Remedial Investigation (RI) (July 26 through August 21, 1996). Additional surface water samples were collected during the Phase II RI (April 18 through June 2, 1997) and analyzed for chloride ion content.

This screening level assessment was conducted only on the aquatic habitat at Site 89. Surface water and sediment were evaluated to determine potential impacts from groundwater seepage into the surface water body. The terrestrial habitat was not evaluated at the site because Operable Unit 16 is an industirálized area that is predominantly covered with either asphalt or gravel. As a result, there is no direct ecological exposure pathway to surface soil; therefore, the terrestrial habitat was not evaluated.

The following subsection presents a brief site history of Site 89. A complete history of the site is presented in Section 1.0.

Site 89 - History

As displayed on Figure 1-2, Site 89 includes the entire Defense Reauthorization Marketing Office (DRMO) area of Camp Geiger and wooded areas to the south and east of the DRMO. Site 89 originated as an underground storage tank area. In the initial underground storage tank assessment conducted at Site 89, chlorinated solvents were identified as contaminants of concern in the groundwater. Historical records indicate that this area was operated as a base motor pool until approximately 1988.

7.1 Problem Formulation

This ecological risk screening was designed to evaluate potential threats to aquatic receptors from exposure to site contaminants. The problem formulation process included the identification of potential ecological contaminants of concern (ECOCs).

The ECOCs were selected based on a screening of the maximum detected concentrations in the surface water and sediment against screening values. The screening values used were obtained from North Carolina Department of Environment and Natural Resources Division of Environmental Management (NC DENR, 1996), USEPA Region IV Toxic Substance Spreadsheet (USEPA, 1997b), USEPA Region IV Supplemental Guidance to RAGS: Region 4 Bulletins (USEPA, 1995a), and USEPA Ecotox Thresholds (USEPA, 1996b). The uncertainties associated with the use of these screening values are presented in Section 7.3. Exceedance of a screening value was the criterion used to identify potential ECOCs at the site. In addition, constituents with low toxicity characteristics (e.g., calcium, magnesium, potassium, and sodium) were eliminated as potential ECOCs. Once the ECOCs were identified, quotient indices (QIs) were calculated using the maximum detected concentrations of the ECOCs compared to the screening values.

7.1.1 Selection of the Ecological Contaminants of Concern

The first step of this ecological risk screening was to identify the ECOCs at Site 89. The following sections present the selected ECOCs in each media.

7.1.1.1 Surface Water

Eleven surface water samples were collected and analyzed for TCL organics and five surface water samples were collected and analyzed for TAL metals at Site 89. Volatile organic compounds (VOCs) and metals were detected in the surface water collected. Four VOCs [1,2-dichloroethene (DCE) (cis- and total), trichloroethene (TCE), and vinyl chloride] and six metals (aluminum, barium, iron, lead, manganese, and vanadium) were retained as ECOCs. Contaminants were retained if the concentrations detected exceeded surface water screening values (SWSVs) or if there were no SWSVs available to assess the detected concentrations. Table 7-1 summarizes the frequency and range of detections in surface water and the selection criteria.

7.1.1.2 Sediment

Ten sediment samples were collected from five locations at two depths (0-6" and 6-12") and analyzed for TCL organics and TAL metals. Volatile organic compounds, semivolatile organic compounds (SVOCs), and metals were detected in the sediment samples. Of the organics, 1,1-DCE, 1,2-DCE (total, cis-, and trans-) 1,1,2,2-tetrachloroethene, 1,1,2-trichloroethane (TCA), TCE, vinyl chloride, benzo(a)pyrene, benzo(b)fluoranthene, benzo(g,h,i)perylene, benzo(k)fluoranthene, bis(2-ethylhexyl)phthalate, chrysene, fluoranthene, indeno(1,2,3-cd)pyrene, phenanthrene, alpha-chlordane, gamma-chlordane, 4,4'-DDD, 4,4'-DDE, and 4,4'-DDT were retained as ECOCs. Of the metals, aluminum, barium, beryllium, cadmium, copper, iron, lead, manganese, and vanadium were retained. Contaminants were retained as ECOCs if the concentrations detected exceeded sediment screening values (SSVs) or if there were no SSVs available to assess the detected concentrations. Table 7-2 summarizes the frequency and range of detections in sediment and the selection criteria.

A summary of the ECOCs identified at Site 89 is presented on Table 7-3.

7.1.2 Exposure Characterization

The purpose of the exposure assessment is to determine the pathways and media through which ecological receptors may be exposed to site contaminants. Potential exposure assessments are dependent on habitats and receptors at the site, the extent and magnitude of contamination, and the environmental fate and transport of ECOCs.

The western portion of Site 89 is primarily covered by asphalt, paved roads, and gravel parking areas. The eastern portion of the site and the area immediately south of the DRMO are heavily wooded. Edwards Creek is located along the western and eastern portion of Site 89. The creek is approximately 525 feet south of the former underground storage tank location. Site 89 slopes in the direction of Edwards Creek.

Four habitat types are present at Site 89: an open area, deciduous forest, pine forest, and ecotones between the open areas and the forests. Scattered pines were identified within the deciduous forest. Numerous birds and mammals were identified in the area. No protected species were observed at Site 89. The site is not located within any ecologically protected or sensitive areas. Information used to evaluate rare species, natural communities, and critical areas at this site was obtained from the Initial Assessment Study (Water and Air Research, 1983) and a habitat inventory conducted for Camp Lejeune (LeBlond et al., 1994). Specific details on the local ecology at Site 89 are presented in Section 3.

The habitat of concern in this study is the aquatic habitat of Edwards Creek. As identified in previous investigations conducted at Site 89 (Section 1.0), VOCs are the primary constituents of concern. The exposure pathway evaluated in this screening, is the direct exposure of the surface water and sediment at the site to aquatic organisms.

The following section presents a brief summary of the ecological fate of the VOCs detected in the surface water and sediment at Site 89. In addition, the fate of SVOCs and pesticides are also presented because of their presence in the sediment collected from Edwards Creek.

7.1.3 Ecotoxicity Assessment

The objective of the ecotoxicity assessment is to identify the ecological toxicity associated with the contaminants of concern at Site 89. The fate and transport of the contaminants identified at Site 89 are presented in Section 4. The ecotoxicity assessment also determines the environmental fate and transport of the ECOCs in the media of concern. The bioconcentration factors (BCFs) for each ECOC identified at the site are presented on Table 7-4. The following subsections present brief ecotoxicological profiles for VOCs (the primary contaminants of concern at the site). In addition, SVOCs and pesticides are also mentioned due to the concentrations detected in the sediment collected at Site 89.

1,1-Dichloroethene

Although 1,1-DCE does not absorb readily to sediment (Howard, 1990 and ATSDR, 1989), concentrations were detected in the sediment collected from Site 89. The BCF for 1,1-DCE (5.6) indicates that this chemical is not expected to bioaccumulate in the aquatic food chain.

1,2-Dichloroethene

Dichloroethene was detected in the surface water and sediment collected at Site 89. BCF values for DCE have been estimated ranging from 15 (for cis-) to 22 (for trans-) (USEPA, 1995b). The BCFs suggest that DCE does not bioconcentrate significantly in aquatic species.

1,1,2,2-Tetrachloroethane

Although 1,1,2,2-tetrachloroethene is not expected to absorb to sediment, concentrations were detected in the sediment collected from Site 89. There is conflicting evidence on the bioconcentration of 1,1,2,2-tetrachloroethane in aquatic species. Based on the BCF developed by Region IV of 5, 1,1,2,2-tetrachloroethane is not expected to bioconcentrate in the aquatic food chain.

1,1,2-Trichloroethane

1,1,2-Trichloroethane was detected in the sediment collected from Site 89. As indicated by a BCF of 5, 1,1,2-TCA is not expected to bioconcentrate in the aquatic food chain (USEPA, 1997b).

Trichloroethene

Trichloroethene was detected in the surface water and sediment collected from Site 89. Trichloroethene, unlike other chlorinated compounds, has a low potential for bioaccumulation in fish [BCF of 10.6 (USEPA, 1997b)], animals, and the human food chain (USEPA, 1987).

Vinyl Chloride

Vinyl chloride was detected in the surface water and sediment collected from Site 89. Vinyl chloride is not expected to bioconcentrate, as suggested by the low BCF value for vinyl chloride of 1.17 (USEPA, 1997b).

Polycyclic Aromatic Hydrocarbons

Polycyclic aromatic hydrocarbons (PAHs) were detected in the sediment collected at Site 89. Although PAHs accumulate in terrestrial and aquatic plants, many organisms can metabolize and eliminate these compounds. Fish and crustaceans readily assimilate PAHs from contaminated food, whereas mollusks and polychaete worms have limited assimilation (Eisler, 1987). Overall, PAHs show little biomagnification in food chains, despite their high lipid solubility (Neff, 1982). Bioconcentration factors for the PAHs detected in the sediment at Site 89 range from 30 to 1,150 (for fluoranthene) (USEPA, 1997b). It is noted that only one station exceeded the lowest SSV for fluoranthene.

Pesticides

Pesticides were detected in sediment samples collected from Site 89. Pesticides are readily bioconcentrated in the aquatic food chain. The BCFs for the pesticides detected at Site 89 ranged from 14,100 (for the chlordane) to 53,600 (for DDD, DDE, and DDT) (USEPA, 1997b). However, the BCF values are based on surface water concentrations and pesticides were not detected in the surface water collected from Site 89.

DDT, DDE, and DDD are highly lipid soluble. This lipophilic property, combined with an extremely long half-life, results in bioaccumulation. When released in ambient water, DDT and its metabolites are concentrated in freshwater and marine plankton, insects, mollusks, and other invertebrates and fish. As these organisms become part of the food chain, a progressive accumulation of residues may result in high levels of residues in organisms at the top of the food chain (ATSDR, 1988).

7.1.4 Assessment Endpoints

Assessment endpoints are explicit expressions of the actual environmental value that is to be protected (USEPA, 1992). The assessment endpoint selected to evaluate the risk of contaminants to the aquatic habitat at Site 89 is the following:

- Protection of benthic macroinvertebrate and fish communities from the direct toxic effects of contaminants in surface water and sediment to maintain species diversity, biomass, and nutrient cycling.

7.1.5 Hypothesis Formulation

Testable hypotheses were developed to determine the potential threat to the endpoints presented. The hypotheses generated for Site 89 are presented below.

- Are the levels of site contaminants in sediment sufficient to cause adverse alterations to the structure and/or function of the benthic community?

- Are levels of site contaminants in surface water and sediment sufficient to cause adverse effects on the fish community at this site?

7.1.6 Measurement Endpoints

Measurement endpoints are measurable ecological characteristics related to the assessment endpoint (USEPA, 1992). This section presents the measurement endpoint selected for the assessment endpoint at Site 89.

Measurement endpoints for assessment endpoint:

- Ecological health of the benthic macroinvertebrate and fish community inhabiting Site 89, specifically in terms of the structure and function.

To evaluate the structure and function of the benthic macroinvertebrate community, each ECOC identified in the sediment collected from Edwards Creek at Site 89 was assessed through a comparison with literature toxicity benchmark values.

- Ecological health of the fish communities that inhabit the water body potentially impacted at Site 89.

The fish communities potentially inhabiting Edwards Creek can be influenced by contaminants in two ways: short-term toxicity to larvae and juveniles using this site; and long-term reproductive effects on organisms exposed to contaminants as larvae or juveniles. A qualitative assessment of the levels of contaminants measured in the surface water and sediment were compared with levels documented to cause adverse impacts to fish. In addition, a qualitative assessment of BCF values associated with contaminants detected will be made in this evaluation.

7.1.7 Exposure Pathway Conceptual Model

An exposure pathway conceptual model for the aquatic habitat at Site 89 is presented in Figure 7-1. The conceptual model identifies critical exposure pathways to the measurement endpoints. At Site 89, VOCs and metals in the surface water may pose risks to the fish community in Edwards Creek. In the sediment, VOCs, SVOCs, pesticides, and metals may pose risks to benthic macroinvertebrates and fish potentially inhabiting Edwards Creek. Higher trophic level receptors may be exposed to contaminants in the surface water and sediment via ingestion of surface water, sediment, and receptors within the creek.

7.2 Risk Characterization

The QI method was used to estimate potential risks to ecological receptors at Site 89. The following equation was used to calculate QIs at Site 89:

$$Quotient\ Index = \frac{Maximum\ Exposure\ Concentration}{Screening\ Value\ or\ Other\ Benchmark\ Value}$$

A QI greater than one indicates that exposure to the contaminant has the potential to cause adverse effects to the species. A QI less than one indicates that the contaminant is not expected to cause adverse effects to the species. The QI for each ECOC was assessed for this ecological risk screening. A total QI per media was calculated to give a general indication of overall site risk. However, it is recognized that total QIs do not represent the synergistic effects of the ECOCs identified at the site. The spreadsheets used to calculate the ecological QIs are presented in Appendix P.

7.3 Uncertainty Analysis

The procedures used in this evaluation to assess risks to ecological receptors, as in all such assessments, are subject to uncertainties. The surface water and sediment analytical samples assessed in this screening were collected in one sampling effort. The results of this sampling will only provide a "snapshot in time" of the ecological environment.

There is uncertainty in the ecological endpoint comparison. The SWSVs are established to be protective of most of the potential receptors. However, some species will not be protected by the values because of their increased sensitivity to the chemicals. Ambient water quality criteria in theory only protect 95 percent of the exposed species, 95 percent of the time. Therefore, there may be some sensitive species present that may not be protected with these criteria. In addition, most of the values are established using laboratory tests, where the concentrations of certain water quality parameters (pH, total organic carbon) that may influence toxicity are most likely at different concentrations than in the site water.

Potential adverse impacts to aquatic receptors from contaminants in the sediment were evaluated by comparing the ECOC concentration in the sediment to SSVs. These SSVs have uncertainty associated with them, since the procedures for developing them are not well established. In addition, sediment type (pH, acid volatile sulfide, total organic carbon) has a significant impact on the bioavailability and toxicity of contaminants. The ecotox values (USEPA, 1996a) used as SSVs represent a measure of direct toxicity to exposed organisms, based on studies reported in the literature. The endpoints of the ecotox studies typically are the reductions of survival, growth, or reproduction based on either laboratory single-species or small-scale studies, or small scale field studies.

The SSVs obtained from Region IV guidance (USEPA, 1995a) were derived from statistical interpretation of effects databases obtained from the literature as reported in publications from the State of Florida, the National Oceanic and Atmospheric Administration, and a joint publication by Long et al (1991 and 1995). These values are primarily based on observations of direct toxicity. In addition, there is uncertainty in the use of the Region IV values for freshwater habitats. These values are primarily based on marine environments.

Several contaminants detected at Site 89 do not have screening values available to evaluate the detected concentrations. In the surface water, 1,2-DCE (cis- and total), TCE, vinyl chloride, barium, manganese, and vanadium did not have North Carolina Water Quality Standards or Region IV SWSVs. In the sediment, 1,1-DCE, 1,2-DCE (cis-, trans-, and total), 1,1,2-TCA, vinyl chloride, benzo(b)anthracene, benzo(g,h,i)perylene, benzo(k)fluoranthene, bis(2-ethylhexyl)phthalate, indeno(1,2,3-cd)pyrene, aluminum, barium, beryllium, iron, manganese, and vanadium did not have Region IV SSVs or USEPA Ecotox values available to assess detected concentrations. The contaminants without screening values were retained as ECOCs, but were not quantitatively evaluated. Nevertheless, these contaminants may be contaminants of concern at the site.

In addition, the toxicity of chemical mixtures is not well understood. All the toxicity information used in this screening 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 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 or underestimate risk.

There is uncertainty associated with the qualitative evaluation of BCF values for the ECOCs identified at Site 89. Bioconcentration factors are based on surface water concentrations; therefore, sediment concentrations are not accounted for in this qualitative comparison. For example, pesticides have a high BCF value indicating a high potential for accumulation up the aquatic food chain. However, in the case of Site 89, pesticides were only detected in the sediment (not the surface water). Therefore, evaluation of BCFs may not represent the actual fate of pesticides in the aquatic food chain.

7.4 Results

This section presents the results of the ecological risk screening conducted on the aquatic habitat at Site 89. The ultimate receptor to contaminants detected in Edwards Creek is the New River.

7.4.1 Surface Water

The surface water concentrations detected in Edwards Creek were evaluated by a comparison to benchmark screening values for the protection of aquatic species. Table 7-5 presents the QIs calculated per station for the ECOCs identified in the surface water. Quotient indices greater than one were calculated for aluminum (Region IV chronic QI), iron (North Carolina QI), and lead (Region VI chronic QI). All of the QIs were below five.

Table 7-6, a total QI value for Site 89 surface water was calculated at 2 for North Carolina SWSVs, 0.79 for acute Region IV SWSVs, and 9 for chronic Region IV SWSVs. The QI values greater than one were primarily a result of surface water concentrations of aluminum, iron, and lead.

As indicated by the elevated QI values, concentrations of aluminum, iron, and lead pose a slight potential risk to aquatic receptors. In addition, surface water concentrations of 1,2-DCE (cis- and total), TCE, vinyl chloride, antimony, barium, and magnesium also potentially pose a risk to the aquatic environment. There are no screening values available to assess the detected concentrations.

The highest VOC concentrations were detected at the stations adjacent to the site (IR89-EC-SW02 and IR89-EC-SW03). However, the VOCs detected are not likely to bioconcentrate in the aquatic food chain (based on low BCFs).

7.4.2 Sediment

The sediment concentrations detected in Edwards Creek were evaluated by a comparison to benchmark screening values for the protection of aquatic species. As shown on Table 7-7, moderate QIs (10 to 70 times the screening value) were calculated for benzo(a)pyrene, DDD, DDE, and DDT (Region IV QIs). Quotient indices between one and ten were calculated for 1,1,2,2-tetrachloroethane (Ecotox QI), TCE (Ecotox QI), benzo(a)pyrene (Ecotox QI), chrysene (Region IV QI), fluoranthene (Region IV QI), phenanthrene (Region IV QI), alpha-chlordane (Region IV QI), gamma-chlordane (Region IV QI), cadmium (Region IV QI), copper (Region IV), and lead (Region IV).

Table 7-8 presents a sum of the QIs calculated for the sediment. For Region IV values, a total QI of 173 was calculated and for the USEPA ecotox values, a total QI of 34. The elevated Region IV QI was primarily a result of sediment concentrations of the pesticides and benzo(a)pyrene (one sample exceeded screening levels). The elevated Ecotox QI was primarily the result of sediment concentrations of DDT, along with 1,1,2,2-tetrachloroethane, TCE, benzo(a)pyrene, copper, and secondarily from concentrations of fluoranthene, cadmium, and lead.

Concentrations of pesticides, 1,1,2,2-tetrachloroethane, trichloroethene, benzo(a)pyrene, fluoranthene, cadmium, copper, and lead may pose a risk to aquatic receptors. It is noted that sediment concentrations of dichloroethene, 1,1,2-trichloroethane, vinyl chloride, benzofluoranthenes, benzo(g,h,i)perylene, bis(2-ethylhexyl)phthalate, indeno(1,2,3-cd)pyrene, aluminum, barium, beryllium, iron, manganese and vanadium may also adversely impact the aquatic environment. However, these contaminants could not be quantitatively evaluated because of the lack of screening values available.

The VOCs in sediment were primarily detected at one station adjacent to Site 89 (IR89-EC-SD03). The VOC concentrations detected in the shallow sediment were higher than the concentrations detected in the deeper sediments, with the exception of vinyl chloride. There were no VOCs detected in the sediment collected downstream of the site. The VOCs detected are not likely to bioconcentrate in the aquatic food chain.

The SVOCs in the sediment were detected at one station immediately downstream of the railroad tracks (IR89-EC- SD04). Pesticides were only analyzed at one station (two depths) in Edwards Creek (IR89-EC-SD05). The pesticide concentrations were higher in the deeper sediment collected. The majority of the inorganic ECOCs were detected in the deep sediment sample collected immediately downstream of the site (IR89-EC- SD04). It is noted that the highest cadmium concentration was detected in the shallow sediment collected upstream of Site 89 (IR89-EC-SD01).

7.5 References

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SECTION 7.0 TABLES

TABLE 7-1

FREQUENCY AND RANGE OF DETECTION OF SURFACE WATER DATA COMPARED TO FRESHWATER SCREENING VALUES
PHASE I - MOBILE LABORATORY AND FIXED BASE LABORATORY
RI/FS CTO-0356
OPERABLE UNIT NO. 16 (SITE 89)
MCB, CAMP LEJEUNE, NORTH CAROLINA

Constituents	Surface Water Screening Values (SWSVs)			Contaminant Frequency/Range		No. of Positive Detects Above Lowest SWSV	Ecological Contaminant of Concern	Comments
	North Carolina Water Quality Standards (WQS)[(1)]	USEPA Region IV[(2)]		No. of Positive Detects/ No. of Samples	Range of Positive Detection			
		Acute	Chronic					
Volatiles (μg/L)								
Chloroform	NE	2,890	289	3/11	0.4-0.4	0	No	Below SWSV
1,2-Dichloroethene (total)	NE	NE	NE	4/5	78-120	NA	Yes	
cis-1,2-Dichloroethene	NE	NE	NE	9/11	2-52	NA	Yes	
trans-1,2-Dichloroethene	NE	13,500	1,350	8/11	14-37	0	No	Below SWSV
1,1,2,2-Tetrachloroethane	NE	932	240	4/5	72-150J	0	No	Below SWSV
Tetrachloroethene	NE	528	84	5/11	0.1-1.2	0	No	Below SWSV
Trichloroethene	NE	NE	NE	9/11	3J-28.5	NA	Yes	
Vinyl Chloride	NE	NE	NE	2/11	21-25	NA	Yes	
Metals (μg/L)								
Aluminum	NE	750	87	5/5	41.8-554	4	Yes	
Antimony	NE	1,300	160	1/5	18.5	0	No	
Barium	NE	NE	NE	5/5	17.9-25	NA	Yes	

TABLE 7-1

FREQUENCY AND RANGE OF DETECTION OF SURFACE WATER DATA COMPARED TO FRESHWATER SCREENING VALUES
PHASE I - MOBILE LABORATORY AND FIXED BASE LABORATORY
RI/FS CTO-0356
OPERABLE UNIT NO. 16 (SITE 89)
MCB, CAMP LEJEUNE, NORTH CAROLINA

Constituents	Surface Water Screening Values (SWSVs)			Contaminant Frequency/Range		No. of Positive Detects Above Lowest SWSV	Ecological Contaminant of Concern	Comments
	North Carolina Water Quality Standards (WQS)(1)	USEPA Region IV(2)		No. of Positive Detects/ No. of Samples	Range of Positive Detection			
		Acute	Chronic					
Metals (µg/L) (Continued)								
Calcium	NE	NE	NE	5/5	37,300-46,900	NA	No	Low Toxicity
Chromium	50	1,991(3)(4)(5)	237(3)(4)(5)	1/5	3.6	0	No	Below SWSV
Copper	7	21(3)(4)	14(3)(4)	3/5	2.6-4.7	0	No	Below SWSV
Iron	1,000	NE	1,000	5/5	803-1,570	4	Yes	
Lead	25	101(3)(4)	4(3)(4)	3/5	1.3J-5.4	1	Yes	
Magnesium	NE	NE	NE	5/5	2,200-3,560	NA	No	Low Toxicity
Manganese	NE	NE	NE	5/5	25.7-50.4	NA	Yes	
Potassium	NE	NE	NE	5/5	2,240-4,270	NA	No	Low Toxicity
Sodium	NE	NE	NE	5/5	11,500-38,500	NA	No	Low Toxicity

TABLE 7-1

FREQUENCY AND RANGE OF DETECTION OF SURFACE WATER DATA COMPARED TO FRESHWATER SCREENING VALUES
PHASE I - MOBILE LABORATORY AND FIXED BASE LABORATORY
RI/FS CTO-0356
OPERABLE UNIT NO. 16 (SITE 89)
MCB, CAMP LEJEUNE, NORTH CAROLINA

	Surface Water Screening Values (SWSVs)			Contaminant Frequency/Range				
	North Carolina Water Quality Standards (WQS)[1]	USEPA Region IV[2]						
Constituents		Acute	Chronic	No. of Positive Detects/ No. of Samples	Range of Positive Detection	No. of Positive Detects Above Lowest SWSV	Ecological Contaminant of Concern	Comments
Metals (µg/L) (Continued)								
Vanadium	NE	NE	NE	2/5	2.8-4.2	NA	Yes	
Zinc	50	135[3][4]	122[3][4]	5/5	9.2-17.7	0	No	Below SWSV

Notes:

Shaded areas indicate that the constituent was selected as an ecological contaminant of concern.

NE = Not Established
NA = Not Applicable
ND = Not Detected

[1] NC DEHNR, 1996 (North Carolina Water Quality Standards)
[2] USEPA, 1995a (Region IV Surface Water Screening Values)
[3] USEPA, 1997b (Region IV "Toxic Substance Spreadsheet")
[4] Screening value is based on an average site-specific hardness value of 118.18 mg/L.
[5] Chromium III screening value

TABLE 7-2

FREQUENCY AND RANGE OF DETECTION OF SEDIMENT DATA COMPARED TO SEDIMENT SCREENING VALUES
PHASE I - MOBILE LABORATORY AND FIXED BASE LABORATORY
RI/FS CTO-0356
OPERABLE UNIT NO. 16 (SITE 89)
MCB, CAMP LEJEUNE, NORTH CAROLINA

Constituents	Sediment Screening Values (SSV)		Contaminant Frequency/Range		No. of Positive Detects Above Lowest SSV	Ecological Contaminan of Concern	Comments
	Region IV Screening Values$^{(1)}$	USEPA Ecotox Values$^{(2)}$	No. of Positive Detects/ No. of Samples	Range of Positive Detections			
Volatiles (μg/kg)							
1,1-Dichloroethene	NE	NE	1/10	37J	NA	Yes	
1,2-Dichloroethene (total)	NE	NE	2/10	1,500-1,600	NA	Yes	
cis-1,2-Dichloroethene	NE	NE	2/6	5-16	NA	Yes	
trans-1,2-Dichloroethene	NE	NE	2/6	1-5	NA	Yes	
1,1,2,2-Tetrachloroethane	NE	940$^{(3)}$	2/10	550-1,700	1	Yes	
1,1,2-Trichloroethane	NE	NE	2/10	13-19	NA	Yes	
Trichloroethene	NE	1,600$^{(3)}$	7/16	0.3-2,400	1	Yes	
Toluene	NE	670$^{(3)}$	1/10	7J	0	No	Below SSV
Vinyl Chloride	NE	NE	2/16	35-230	NA	Yes	
Semivolatiles (μg/kg)							
Benzo(a)anthracene	74.8	NE	2/10	48J-58J	0	No	Below SSV
Benzo(a)pyrene	88.8	430$^{(4)}$	3/10	65J-3,100	1	Yes	
Benzo(b)fluoranthene	NE	NE	5/10	40J-140J	NA	Yes	
Benzo(g,h,i)perylene	NE	NE	2/10	50J-55J	NA	Yes	
Benzo(k)fluoranthene	NE	NE	2/10	50J-51J	NA	Yes	
Bis(2-ethylhexyl)phthalate	NE	NE	10/10	88J-13,000	NA	Yes	
Chrysene	108	NE	3/10	51J-120J	1	Yes	
Fluoranthene	113	2,900$^{(5)}$	5/10	51J-180J	1	Yes	
Indeno(1,2,3-cd)pyrene	NE	NE	1/10	59J	NA	Yes	

TABLE 7-2 (Continued)

FREQUENCY AND RANGE OF DETECTION OF SEDIMENT DATA COMPARED TO SEDIMENT SCREENING VALUES
PHASE I - MOBILE LABORATORY AND FIXED BASE LABORATORY
RI/FS CTO-0356
OPERABLE UNIT NO. 16 (SITE 89)
MCB, CAMP LEJEUNE, NORTH CAROLINA

Constituents	Sediment Screening Values (SSV)		Contaminant Frequency/Range		No. of Positive Detects Above Lowest SSV	Ecological Contaminan of Concern	Comments
	Region IV Screening Values(1)	USEPA Ecotox Values(2)	No. of Positive Detects/ No. of Samples	Range of Positive Detections			
Semivolatiles (μg/kg)							
Phenanthrene	86.7	NE	4/10	42J-100J	1	Yes	
Pyrene	153	660(4)	7/10	50J-140J	0	No	Below SSV
Pesticides/PCBs (μg/kg)							
alpha-Chlordane	0.5(6)	NE	2/2	2J-2.9	2	Yes	
gamma-Chlordane	0.5(6)	NE	2/2	1.6J-4.6J	2	Yes	
4,4'-DDD	1.22	NE	2/2	42J-79	2	Yes	
4,4'-DDE	2.07	NE	2/2	33J-44J	2	Yes	
4,4'-DDT	1.19	1.6(4)	2/2	23J-34	2	Yes	
Metals (mg/kg)							
Aluminum	NE	NE	10/10	1,010J-14,000J	NA	Yes	
Arsenic	7.24	8.2(4)	6/10	0.38-0.85	0	No	Below SSV
Barium	NE	NE	10/10	6-30.1	NA	Yes	
Beryllium	NE	NE	4/10	0.14-0.55	NA	Yes	
Cadmium	0.676	1.2(4)	3/10	0.77-0.82	3	Yes	
Calcium	NE	NE	10/10	8,020-48,000	NA	No	Low Toxicity
Chromium	52.3	81(4)	10/10	2.4-7.6	0	No	Below SSV
Copper	18.7	34(4)	5/10	5.5-38.7	1	Yes	

TABLE 7-2 (Continued)

FREQUENCY AND RANGE OF DETECTION OF SEDIMENT DATA COMPARED TO SEDIMENT SCREENING VALUES
PHASE I - MOBILE LABORATORY AND FIXED BASE LABORATORY
RI/FS CTO-0356
OPERABLE UNIT NO. 16 (SITE 89)
MCB, CAMP LEJEUNE, NORTH CAROLINA

Constituents	Sediment Screening Values (SSV)		Contaminant Frequency/Range		No. of Positive Detects Above Lowest SSV	Ecological Contaminan of Concern	Comments
	Region IV Screening Values(1)	USEPA Ecotox Values(2)	No. of Positive Detects/ No. of Samples	Range of Positive Detections			
Metals (mg/kg) (continued)							
Iron	NE	NE	10/10	1,190J-3,860	NA	Yes	
Lead	30.2	47(4)	10/10	6.6-35.4J	1	Yes	
Magnesium	NE	NE	10/10	219-888	NA	No	Low Toxicity
Manganese	NE	NE	10/10	7.3-16.3	NA	Yes	
Mercury	0.13	0.15(4)	1/10	0.1	0	No	Below SSV
Nickel	15.9	21(4)	2/10	2.3-3.7	0	No	Below SSV
Sodium	NE	NE	10/10	38.5-131	NA	No	Low Toxicity
Vanadium	NE	NE	10/10	4-19.7	NA	Yes	
Zinc	124	150(4)	10/10	11.7-53.1	0	No	Below SSV

TABLE 7-2 (Continued)

FREQUENCY AND RANGE OF DETECTION OF SEDIMENT DATA COMPARED TO SEDIMENT SCREENING VALUES
PHASE I - MOBILE LABORATORY AND FIXED BASE LABORATORY
RI/FS CTO-0356
OPERABLE UNIT NO. 16 (SITE 89)
MCB, CAMP LEJEUNE, NORTH CAROLINA

Notes:

Shaded areas indicate that the constituent was selected as an ecological contaminant of concern.

NE = Not Established

NA = Not Applicable

(1) USEPA, 1995a (Region IV Sediment Screening Values for Hazardous Waste Sites)
(2) USEPA, 1996b (Ecotox thresholds)
(3) Ecotox threshold value assumes 1% total organic carbon content
(4) Ecotox threshold value is an Effects-Range Low concentration
(5) Ecotox threshold value is based on freshwater sediment quality criteria
(6) Total chlordane value

TABLE 7-3

ECOLOGICAL CONTAMINANTS OF POTENTIAL CONCERN IN EACH MEDIA
RI/FS CTO-0356
OPERABLE UNIT NO. 16 (SITE 89)
MCB, CAMP LEJEUNE, NORTH CAROLINA

Contaminant	Surface Water	Sediment
Volatiles		
1,1-Dichloroethene		X
1,2-Dichloroethene (total)	X	X
cis-1,2-Dichloroethene	X	X
trans-1,2-Dichloroethene		X
1,1,2,2-Tetrachloroethane		X
1,1,2-Trichloroethane		X
Trichloroethene	X	X
Vinyl Chloride	X	X
Semivolatiles		
Benzo(a)pyrene		X
Benzo(b)fluoranthene		X
Benzo(g,h,i)perylene		X
Benzo(k)fluoranthene		X
Bis(2-ethylhexyl)phthalate		X
Chrysene		X
Fluoranthene		X
Indeno(1,2,3-cd)pyrene		X
Phenanthrene		X
Pesticides/PCBs		
alpha-Chlordane		X
gamma-Chlordane		X
4,4'-DDD		X
4,4'-DDE		X
4,4'-DDT		X
Metals		
Aluminum	X	X
Barium	X	X
Beryllium		X
Cadmium		X
Copper		X
Iron	X	X

TABLE 7-3 (Continued)

ECOLOGICAL CONTAMINANTS OF POTENTIAL CONCERN IN EACH MEDIA
RI/FS CTO-0356
OPERABLE UNIT NO. 16 (SITE 89)
MCB, CAMP LEJEUNE, NORTH CAROLINA

Contaminant	Surface Water	Sediment
Metals (continued)		
Lead	X	X
Manganese	X	X
Vanadium	X	X

TABLE 7-4

BIOCONCENTRATION FACTORS FOR THE ECOLOGICAL CONTAMINANTS OF CONCERN
RI/FS CTO-0356
OPERABLE UNIT NO. 16 (SITE 89)
MCB, CAMP LEJEUNE, NORTH CAROLINA

Contaminant	Bioconcentration Factor(1)
Volatiles	
1,1-Dichloroethene	5.6
1,2-Dichloroethene (total)	ND
cis-1,2-Dichloroethene	15(1)
trans-1,2-Dichloroethene	22(1)
1,1,2,2-Tetrachloroethane	5
1,1,2-Trichloroethane	5.6
Trichloroethene	10.6
Vinyl Chloride	1.17
Semivolatiles	
Benzo(a)pyrene	30
Benzo(b)fluoranthene	30
Benzo(g,h,i)perylene	30
Benzo(k)fluoranthene	30
Bis(2-ethylhexyl)phthalate	130
Chrysene	30
Fluoranthene	1,150
Indeno(1,2,3-cd)pyrene	30
Phenanthrene	30
Pesticides/PCBs	
alpha-Chlordane	14,100(3)
gamma-Chlordane	14,100(3)
4,4'-DDD	53,600
4,4'-DDE	53,600
4,4'-DDT	53,600
Metals	
Aluminum	231(2)
Antimony	1
Barium	8(2)
Beryllium	19

TABLE 7-4 (Continued)

BIOCONCENTRATION FACTORS FOR THE ECOLOGICAL CONTAMINANTS OF CONCERN
RI/FS CTO-0356
OPERABLE UNIT NO. 16 (SITE 89)
MCB, CAMP LEJEUNE, NORTH CAROLINA

Contaminant	Bioconcentration Factor(1)
Metals (continued)	
Cadmium	64
Copper	36
Iron	ND
Lead	49
Manganese	35(1)
Vanadium	ND

Notes:

(1) USEPA, 1997b (Region IV "Toxic Substance Spreadsheet")
(2) USEPA, 1995b (Region III)
(3) Bioconcentration factor for total chlordane

TABLE 7-5

SURFACE WATER QUOTIENT INDICES PER STATION
RI/FS CTO-356
OPERABLE UNIT NO. 16 (SITE 89)
MCB, CAMP LEJEUNE, NORTH CAROLINA

Ecological Contaminant of Concern	Sample Identification	Sample Concentration	Quotient Index		
			North Carolina	Region IV Acute	Region IV Chronic
Organics (µg/L)					
1,2-Dichloroethene (total)	IR-89-SW09/10/11-01	NA	NA	NA	NA
cis-1,2-Dichloroethene	IR89-EC-SW04-01	NA	NA	NA	NA
Trichloroethene	IR89-EC-SW09-01	NA	NA	NA	NA
Vinyl Chloride	IR89-EC-SW02-01	NA	NA	NA	NA
Metals (µg/L)					
Aluminum	IR89-EC-SW02-01	189.00	NA	0.25	2.17
	IR89-EC-SW03-01	201.00	NA	0.27	2.31
	IR89-EC-SW04-01	554.00	NA	0.74	6.37
	IR89-EC-SW05-01	275.00	NA	0.37	3.16
Barium	IR89-EC-SW03-01	25.00	NA	NA	NA
Iron	IR89-EC-SW02-01	1500.00	1.50	NA	1.50
	IR89-EC-SW03-01	1510.00	1.51	NA	1.51
	IR89-EC-SW04-01	1570.00	1.57	NA	1.57
	IR89-EC-SW05-01	1220.00	1.22	NA	1.22
Lead	IR89-EC-SW03-01	5.40	0.22	0.05	1.35
Manganese	IR89-EC-SW02-01	50.40	NA	NA	NA

Notes:

Shaded boxes are Quotient Indices that exceed "1"

µg/L - micrograms per liter
NA - Not Applicable (no screening value available)

TABLE 7-6

SURFACE WATER QUOTIENT INDICES PER ECOLOGICAL CONTAMINANT OF CONCERN
RI/FS CTO-356
OPERABLE UNIT NO. 16 (SITE 89)
MCB, CAMP LEJEUNE, NORTH CAROLINA

Ecological Contaminant of Concern	Maximum Concentration	Quotient Index North Carolina	Quotient Index Region IV Acute	Quotient Index Region IV Chronic
Organics (µg/L)				
1,2-Dichloroethene (total)	120	NA	NA	NA
cis-1,2-Dichloroethene	52	NA	NA	NA
Trichloroethene	28.5	NA	NA	NA
Vinyl Chloride	25	NA	NA	NA
Metals (µg/L)				
Aluminum	554	NA	0.74	6.37
Barium	25	NA	NA	NA
Iron	1570	1.57	NA	1.57
Lead	5.4	0.22	0.05	1.35
Manganese	50.4	NA	NA	NA
Total		1.79	0.79	9.29

Notes:

Shaded boxes are Quotient Indices that exceed "1"

µg/L - micrograms per liter
NA - Not Applicable (no screening value available)

TABLE 7-7

SEDIMENT QUOTIENT INDICES PER STATION
RI/FS CTO-356
OPERABLE UNIT NO. 16 (SITE 89)
MCB, CAMP LEJEUNE, NORTH CAROLINA

Ecological Contaminant of Concern	Sample Identification	Maximum Concentration	Sediment Screeening Values		Quotient Index Ratios	
			Region IV Screening Values	USEPA Ecotox Values	Region IV	Ecotox
Organics (µg/kg)						
1,1-Dichloroethene	IR89-EC-SD03-312	37	NE	NE	NA	NA
1,2-Dichloroethene (total)	IR89-EC-SD03-06	1600	NE	NE	NA	NA
cis-1,2-Dichloroethene	IR89-EC-SD10-06	16	NE	NE	NA	NA
trans-1,2-Dichloroethene	IR89-EC-SD10-06	5	NE	NE	NA	NA
1,1,2,2-Tetrachloroethane	IR89-EC-SD03-06	1700	NE	940	NA	1.81
1,1,2-Trichloroethane	IR89-EC-SD03-06	19	NE	NE	NA	NA
Trichloroethene	IR89-EC-SD03-06	2400	NE	1600	NA	1.50
Vinyl Chloride	IR89-EC-SD03-312	230	NE	NE	NA	NA
Benzo(a)pyrene	IR89-EC-SD04-612	3100	88.8	430	34.91	7.21
Benzo(b)fluoranthene	IR89-EC-SD02-612/04-06	140	NE	NE	NA	NA
Benzo(g,h,i)perylene	IR89-EC-SD04-06	55	NE	NE	NA	NA
Benzo(k)fluoranthene	IR89-EC-SD04-06	51	NE	NE	NA	NA
Bis(2-ethylhexyl)phthalate	IR89-EC-SD05-612	13000	NE	NE	NA	NA
Chrysene	IR89-EC-SD04-06	120	108.0	NE	1.11	NA
Fluoranthene	IR89-EC-SD04-06	180	113.0	2900	1.59	0.06
Indeno(1,2,3-cd)pyrene	IR89-EC-SD04-06	59	NE	NE	NA	NA
Phenanthrene	IR89-EC-SD04-06	100	86.7	NE	1.15	NA
alpha-Chlordane	IR-EC-SD05-06	2.0	0.5	NE	4.00	NA
	IR-EC-SD05-612	2.9	0.5	NE	5.80	NA
gamma-Chlordane	IR-EC-SD05-06	1.6	0.5	NE	3.20	NA
	IR-EC-SD05-612	4.6	0.5	NE	9.20	NA
4,4'-DDD	IR-EC-SD05-06	42	1.22	NE	34.43	NA
	IR-EC-SD05-612	79	1.22	NE	64.75	NA
4,4'-DDE	IR-EC-SD05-06	33	2.07	NE	15.94	NA
	IR-EC-SD05-612	43	2.07	NE	20.77	NA
4,4'-DDT	IR-EC-SD05-06	23	1.19	1.6	19.33	14.38
	IR-EC-SD05-612	34	1.19	1.6	28.57	21.25
Metals (mg/kg)						
Aluminum	IR-EC-SD04-612	14000	NE	NE	NA	NA
Barium	IR-EC-SD04-612	30	NE	NE	NA	NA
Beryllium	IR-EC-SD04-612	0.55	NE	NE	NA	NA
Cadmium	IR89-EC-SD01-06	0.82	0.676	1.2	1.21	0.68
	IR89-EC-SD03-06	0.77	0.676	1.2	1.14	0.64
	IR89-EC-SD03-612	0.78	0.676	1.2	1.15	0.65
Copper	IR89-EC-SD02-06	38.7	18.7	34	2.07	1.14
Iron	IR-EC-SD04-612	3860	NE	NE	NA	NA
Lead	IR89-EC-SD05-06	35.4	30	47	1.17	0.75
Manganese	IR-EC-SD04-612	16.3	NE	NE	NA	NA
Vanadium	IR-EC-SD02-612	19.7	NE	NE	NA	NA

Notes:

Shaded boxes are Quotient Indices that exceed "1"

QI - Quotient Index (Maximum Detected Concentration/Screening Value)
µg/kg - micrograms per kilogram
mg/kg - milligrams per kilogram
NA - Not Applicable
NE - Not Established

TABLE 7-8

SEDIMENT QUOTIENT INDICES PER ECOLOGICAL CONTAMINANT OF CONCERN
RI/FS CTO-356
OPERABLE UNIT NO. 16 (SITE 89)
MCB, CAMP LEJEUNE, NORTH CAROLINA

Ecological Contaminant of Concern	Maximum Concentration	Quotient Index	
		Region IV	Ecotox
Organics (µg/kg)			
1,1-Dichloroethene	37.0	NA	NA
1,2-Dichloroethene (total)	1600.0	NA	NA
cis-1,2-Dichloroethene	16.0	NA	NA
trans-1,2-Dichloroethene	5.0	NA	NA
1,1,2,2-Tetrachloroethane	1700.0	NA	1.81
1,1,2-Trichloroethane	19.0	NA	NA
Trichloroethene	2400.0	NA	1.50
Vinyl Chloride	230.0	NA	NA
Benzo(a)pyrene	3100.0	34.91	7.21
Benzo(b)fluoranthene	140.0	NA	NA
Benzo(g,h,i)perylene	55.0	NA	NA
Benzo(k)fluoranthene	51.0	NA	NA
Bis(2-ethylhexyl)phthalate	13000.0	NA	NA
Chrysene	120.0	1.11	NA
Fluoranthene	180.0	1.59	0.06
Indeno(1,2,3-cd)pyrene	59.0	NA	NA
Phenanthrene	100.0	1.15	NA
alpha-Chlordane	2.9	5.80	NA
gamma-Chlordane	4.6	9.20	NA
4,4'-DDD	79.0	64.75	NA
4,4'-DDE	44.0	21.26	NA
4,4'-DDT	34.0	28.57	21.25
Metals (mg/kg)			
Aluminum	14000.0	NA	NA
Barium	30.1	NA	NA
Beryllium	0.6	NA	NA
Cadmium	0.8	1.21	0.68
Copper	38.7	2.07	1.14
Iron	3860.0	NA	NA
Lead	35.4	1.17	0.75
Manganese	16.3	NA	NA
Vanadium	19.7	NA	NA
Total		172.80	34.40

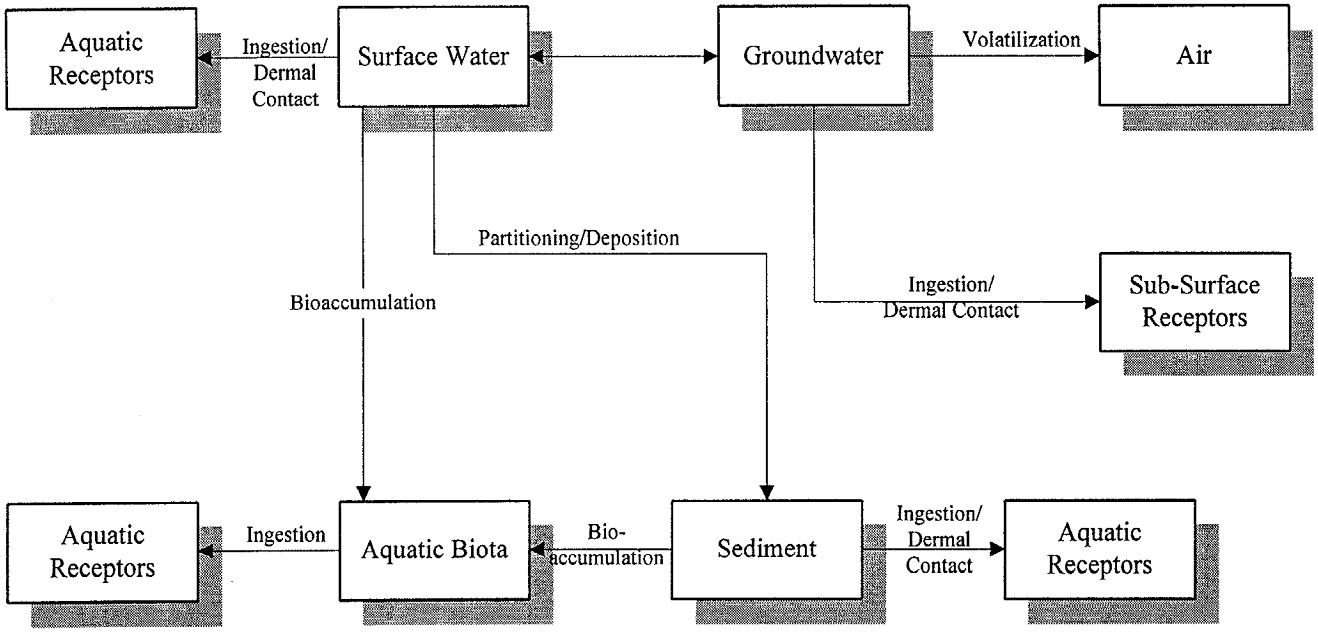
Notes:

Shaded boxes are Quotient Indices that exceed "1"

QI - Quotient Index (Maximum Detected Concentration/Screening Value)
µg/kg - micrograms per kilogram
mg/kg - milligrams per kilogram
NA - Not Applicable (no screening value available)

FIGURE 7-1

SITE 89 - POTENTIAL EXPOSURE PATHWAYS AND AQUATIC RECEPTORS
PHASE I - MOBILE LABORATORY AND FIXED BASE LABORATORY
RI/FS CTO-0356
OPERABLE UNIT NO. 16 (SITE 89)
MCB, CAMP LEJEUNE, NORTH CAROLINA



8.0 CONCLUSIONS

The following conclusions for Operable Unit No. 16 (Sites 89 and 93) are based on the results of the Remedial Investigation, and the human and ecological risk assessment.

1. Soil at Site 89 has been impacted mainly by volatile organics. The majority of the detections of volatile compounds occurred at monitoring well clusters IR89-MW03 and IR89-MW05 both of which are located in the western portion of Site 89. Monitoring well cluster IR89-MW03 is located near the original UST location within the DRMO. This area, inside the DRMO facility, is considered to be one of the potential source areas of site contamination. Impact to the soil is also apparent at monitoring well location IR89-MW05 located just west of the DRMO facility at the end of F Street. Contamination at points other than the area of the former UST suggests various sources, in and near the DRMO have impacted Site 89. Monitoring well IR89-MW04, located in the wooded area, immediately east of White Street Extension, noted one detection of 1,2-dichloroethene (total) at a concentration of 27 µg/kg in a soil sample collected from 9 to 11 feet bgs. There were no significant areas of soil contamination identified in the wooded portion west of the DRMO area.

   In general, the data demonstrate that contaminated soil occurs at depth, and is most likely due to volatile organic compounds which are present in the groundwater affecting the local soil conditions. The majority of the maximum detections occur from the samples collected from approximately 11 to 13 feet bgs, which is within the saturated zone. Impacted soil is primarily concentrated in the area of the DRMO and is in general, present at depths of approximately 10 to 15 feet bgs.

2. Groundwater in the surficial and upper portions of the Castle Hayne aquifers at Site 89 has been impacted by volatile contamination. This includes groundwater to depths of approximately 40 to 50 feet bgs. Groundwater contamination in the surficial aquifer has been defined by the shallow monitoring wells which are screened at approximately 15 to 20 feet bgs. Intermediate wells have detected groundwater contamination at approximately 40 to 50 feet bgs. The intermediate wells are screened in the upper portions of the Castle Hayne Aquifer, immediately above the first semi-confining layer.

   The majority of the volatile contamination detected was in samples collected from the shallow monitoring wells at Site 89 are concentrated in the area of the DRMO facility and to the south in the direction of Edwards Creek. Areas to the west and slightly north (hydraulically upgradient) of the DRMO have also been impacted, but at lower concentrations compared to down gradient locations. Monitoring wells installed at Site 93 help to define the limits of the northwest portions of the contaminant plume The shallow groundwater in the wooded area east of the DRMO and White Street Extension has not been significantly effected. Several volatile compounds were detected in monitoring well IR89-MW04 which exceeded the water quality standards, demonstrating that the contaminant plume has migrated beyond White Street Extension at this portion of the site. However additional sample points east of the road demonstrate that the shallow groundwater plume is mostly limited to the area beneath the DRMO.

   The groundwater sample collected from temporary monitoring well IR89-TW13 which is just north of Edwards Creek detected tetrachloroethene and trichloroethene at concentrations greater than the applicable groundwater standards. This data indicates that volatile contamination have migrated as far south as Edwards Creek. Based upon these results and the presence of volatile contamination in surface water, it appears that Edwards Creek acts as a intercept for contaminants moving with shallow groundwater. Groundwater samples from temporary wells located further south did not detect contaminants which exceeded the water quality standards. In addition, historical analytical data from permanent monitoring wells located in the housing area in the southeast portion of the aired photograph have not detected volatile organics in the groundwater. These analytical results indicate that Edwards Creek is acting as a natural barrier for the majority of volatile contamination migrating south of the DRMO facility.

Permanent deep monitoring wells extending to depths of approximately 70 feet below ground surface (bgs) were installed. Volatile contamination was not detected in any groundwater samples collected from deep monitoring wells. The absence of volatile contamination in the deep monitoring wells establishes the vertical extent of groundwater contamination to the depth of the intermediate wells (i.e., approximately 40 to 50 feet bgs).

3. The detection of volatile compounds in Edwards Creek and the drainage swale which borders the eastern edge of the DRMO, coupled with the detection of a low concentration of only tetrachloroethene in the water discharging into Edwards Creek from the south, suggest that the source of the volatile contamination impacting Edwards Creek is located in the vicinity of the DRMO. It appears that volatile contamination enters the stream by contaminated groundwater which provides base flow to Edwards Creek and by groundwater which is channeled directly to the stream from the drainage swale.

4. In general, the analytical results demonstrate that soil at Site 93 has not been significantly impacted organic compounds. The majority of the detections are reasonably low and are most likely attributable to non-site related activities. In addition, none of the detections exceeded the relative RBCs for residential soils.

5. Impact to the groundwater at Site 93 is concentrated in the shallow aquifer in the area of the former UST near Building TC-942 but was also evident south and west of the site. Although, the former UST appears to have introduced contaminants to the groundwater, based upon the site history it was not considered to be the only potential source area. The investigation at Site 93 was not prepared with the intention of limiting the study area to the former UST, but was completed with emphasis placed on defining the limits of groundwater contamination in the entire area. The presence of contamination south and west of the Building TC-942 may not be a result of the former UST, however, on-site screening and placement of permanent monitoring wells define the limits of groundwater contamination in this portion of Camp Geiger. Analytical findings indicate contaminated groundwater is confined to this area and has not migrated substantially from the original source area. In addition, low concentrations of volatile compounds were detected in groundwater samples collected from the intermediate wells, demonstrating that very little vertical migration of the contaminants has occurred.

6. Although contaminants are similar at both sites, the data indicate that the plumes are a result of two different source areas. One being the DRMO facility at Site 89 and the other being the former UST located near Building TC-942 at Site 93. The contaminant plumes have been defined separately through specific monitoring well installation at both sites.

   In general, the areal extent of the contaminated plume at site 89 is significantly larger. In addition, contaminants at Site 89 have migrated vertically to the upper portions of the Castle Hayne aquifer extending to depths of approximately 40 to 50 feet bgs. Vertical migration of contaminants at Site 93 is insignificant.

7. In the current case, the following receptors were assessed: adult and child residents. Receptor exposure to surface water and sediment at Site 89 was examined. The risks calculated for all exposure pathways for the current on-site residents were within acceptable risk ranges.

8. In the Site 89 groundwater exposure scenario, there are potential carcinogenic and noncarcinogenic risks from ingestion for the future child receptor. The total groundwater carcinogenic risk level for the future child resident at Site 89 was 1.4×10^{-3}. This was due primarily to the groundwater ingestion pathway (ICR=1.4×10^{-3}). Primarily, vinyl chloride (95 percent of the ingestion pathway) in groundwater contributed to this risk. The total groundwater noncarcinogenic risk level was 28. This was due primarily to the groundwater ingestion pathway with trichloroethene, 1,2-dichloroethene (total), cis-1,2-dichloroethene, and iron contributing 30, 23, 20, and 16 percent, respectively, of this elevated noncarcinogenic risk.

   In the Site 89 groundwater exposure scenario, there are potential carcinogenic and noncarcinogenic risks from ingestion for the future adult receptor. The total groundwater carcinogenic risk level for the future adult resident at Site 89 was 3.1×10^{-3}. This was due primarily to the groundwater ingestion pathway (ICR=3.0×10^{-3}). Primarily, vinyl chloride (95 percent of the ingestion pathway) in groundwater contributed to this risk. The total groundwater noncarcinogenic risk level was 12.5. This was due primarily to the groundwater ingestion pathway with trichloroethene, 1,2-dichloroethene (total), cis-1,2-dichloroethene, and iron contributing 30, 23, 20, and 16 percent, respectively, of this elevated noncarcinogenic risk.

9. In the Site 93 groundwater exposure scenario, there are potential noncarcinogenic risks from ingestion for the future child receptor. The total groundwater noncarcinogenic risk level was 6.4. This was due primarily to the groundwater ingestion pathway with manganese and cis-1,2-dichloroethene contributed 19 and 18 percent, respectively, of this elevated noncarcinogenic risk.

   In the Site 93 groundwater exposure scenario, there are potential carcinogenic and noncarcinogenic risks from ingestion for the adult receptor. The total groundwater carcinogenic risk level was 1.3×10^{-4}. This was due primarily to the groundwater ingestion pathway (ICR=1.2×10^{-4}). Primarily, arsenic and tetrachloroethene (63 and 33 percent of the ingestion pathway, respectively) in groundwater contributed to this risk. The total groundwater noncarcinogenic risk level for the future residential adult at Site 93 was 2.8. This was due primarily to the groundwater ingestion pathway with manganese and cis-1,2-dichloroethene contributing 19 and 18 percent, respectively, of this elevated noncarcinogenic risk.

10. The surface water concentrations detected in Edwards Creek were evaluated by a comparison to benchmark screening values for the protection of aquatic species. Quotient indices greater than one were calculated for aluminum (Region IV chronic QI), iron (North Carolina QI), and lead (Region VI chronic QI). All of the QIs were below five. Quotient indices could not be calculated for the VOCs detected in the surface water due to the lack of screening values for these contaminants. However, it is noted that VOCs in surface water do not readily bioconcentration in the aquatic food web. Based on the ecological screening and site QI calculations (acute and NC = 2/chronic = 9) for surface water collected at Site 89, previous site operations do not appear to be significantly impacting the aquatic habitat at Site 89.

11. The sediment concentrations detected in Edwards Creek were evaluated by a comparison to benchmark screening values for the protection of benthic macroinvertebrates. As indicated by the elevated QIs (Region IV = 173 and Ecotox = 34), concentrations of pesticides, 1,1,2,2-tetrachloroethane, trichloroethene, benzo(a)pyrene, fluoranthene, cadmium, copper, and lead may pose a risk to aquatic receptors. It is noted that sediment concentrations of dichloroethene, 1,1,2-trichloroethane, vinyl chloride, benzofluoranthenes, benzo(g,h,i)perylene, bis(2-ethylhexyl)phthalate, indeno(1,2,3-cd)pyrene, aluminum, barium, beryllium, iron, manganese and vanadium may also adversely impact the aquatic environment. However, these contaminants could not be quantitatively evaluated because of the lack of screening values available.

    From an ecological standpoint, pesticides detected in the sediment present the greatest risk to aquatic receptors inhabiting the site. Pesticides were the primary contributors to elevated site QI values. However, it is acknowledged that pesticides are not site-related contaminants. The concentrations detected in the sediment in Edwards Creek are most likely the result of previous station-wide application of pesticides. The potential ecological risk presented from pesticides is based on two sediment samples.

    The volatile contaminants in sediment were primarily detected at one station adjacent to Site 89 (IR89-EC- SD03). The volatile contaminant concentrations detected in the shallow sediment were higher than the concentrations detected in the deeper sediments, with the exception of vinyl chloride. There were no volatile organics detected in the sediment collected downstream of the site. The volatile organics detected are not likely to bioconcentrate in the aquatic food chain.