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Final

Remedial Investigation Report
Operable Unit No. 14
(Site 69)

Marine Corps Base
Camp Lejeune, North Carolina

Text and Figures
Volume 1 of 1

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LIST OF APPENDICES

LIST OF ACRONYMS AND ABBREVIATIONS

AOC	Area of concern
AQUIRE	Aquatic Information Retrieval Database
ARARs	Applicable or Relevant and Appropriate Requirements
ASTM	American Society for Testing and Materials
AT	averaging time
ATV	all terrain vehicle
AWQC	Federal Ambient Water Quality Criteria
Baker	Baker Environmental, Inc.
BCF	bioconcentration factor
bgs	below ground surface
BI	biotoxic index
BOD	biological oxygen demand
BRA	baseline risk assessment
$CaCO_3$	calcium carbonate
CAMA	Coastal Area Management Act
CDI	chronic daily intake
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CH	high plasticity clay
CL	low plasticity clay
CLEAN	Comprehensive Long-Term Environmental Action Navy
CLP	Contract Laboratory Program
CN	chloroacetophene
COE	Corps of Engineers
COPC	contaminant of potential concern
COD	chemical oxygen demand
CRAVE	Carcinogen Risk Assessment Verification Endeavor
CRQL	Contract Required Quantitation Limit
CSA	Chemical Storage Area
CSF	Cancer Slope Factor
CSM	chemical surety material
DON	Department of the Navy
DQOs	data quality objectives
1,2-DCE	1,2-dichloroethene
DEM	Division of Environmental Management
DDE	dichlorodiphenyldichloroethylene
DDT	diphenyltrichloroethane
DS	downslope
ECD	electron capture detector
ED	exposure duration
EF	exposure frequency
Eh	oxidation reduction potential

LIST OF ACRONYMS AND ABBREVIATIONS
(Continued)

EM	electromagnetic
EMD	Environmental Management Department
EPIC	Environmental Photographic Interpretation Center
ERA	ecological risk assessment
ER-L	Effects Range - Low
ER-M	Effects Range-Median
ESE	Environmental Science and Engineering, Inc.
ETC	electromagnetic terrain conductivity
FDA	Former Disposal Area
FFA	Federal Facilities Agreement
FID	flame ionization detector
FPA	Former Pesticide Control Area
FSAP	Field Sampling and Analysis Plan
FWS	Fish and Wildlife Service
FWQSV	Freshwater Water Quality Screening Values
gpd/ft	gallons per day per foot
gpm	gallons per minute
GP	GP Environmental Services
GPR	ground penetrating radar
GW	groundwater well
H'	Diversity Index
HA	health advisory
HEAST	Health Effects Assessment Summary Tables
HHAG	Human Health Assessment Group
HHI	Hardin and Huber, Inc.
HHRA	Human Health Risk Assessment
HI	hazard index
Hoggard-Eure	Hoggard-Eure Associates
HCl	hydrochloric acid
HNO_3	nitric acid
HQ	hazard quotient
HQW	high quality water
HTH	high-test hypochlorite
I	hydraulic gradient
IAS	Initial Assessment Study
ICR	incremental cancer risk
ID	inside diameter
IDW	investigative derived wastes
IR	ingestion rate
IRA	interim remedial action
IRIS	Integrated Risk Information System
IRP	Installation Restoration Program

LIST OF ACRONYMS AND ABBREVIATIONS
(Continued)

K	hydraulic conductivity
K_d	soil sorption coefficient
K_{oc}	organic carbon partition coefficient
K_{ow}	octanol-water partition coefficient
LANTDIV	Naval Facilities Engineering Command, Atlantic Division
LANTNAVFACENGCOM	Naval Facilities Engineering Command, Atlantic Division
LEL	lower explosive limit
LOAEL	lowest observed adverse effect level
MBI	Macroinvertebrate Biotic Index
MCAS	Marine Corps Air Station
MCB	Marine Corps Base
MCL	maximum contaminant level
MEK	methylethyl ketone
MIBK	methyl isobutyl ketone
mg/kg	milligram per kilogram
mg/L	milligram per liter
MF	modifying factor
MH	plastic silt
MI	mobility index
ml	milliliter
ML	low plasticity silt
mL/g	milliliters per gram
mmhos/m	millimohos/meter
msl	mean sea level
MW	monitoring well
NACIP	Navy Assessment and Control of Installation Pollutants Program
NC DEHNR	North Carolina Department of Environment, Health and Natural Resources
NCMFC	North Carolina Marine Fisheries Commission
NCSPCS	North Carolina State Plane Coordinate System
NCWP	Near Coastal Waters Program
NCWQS	North Carolina Water Quality Standards
NCWRC	North Carolina Wildlife Resources Commission
N_e	effective porosity
NEESA	Naval Energy and Environmental Support Activity
NEP	National Estuary Program
NOAA	National Oceanic and Atmospheric Administration
NOAEL or NOEL	No observed adverse effect level
NPL	National Priorities List
NPS	National Park Service
NSW	nutrient sensitive waters
NWI	national wetlands inventory

LIST OF ACRONYMS AND ABBREVIATIONS
(Continued)

OD	outside diameter
OS	on-site
OU	Operable Unit
PAH	polynuclear aromatic hydrocarbon
PA/SI	preliminary assessments/site investigations
PC	permeability constant
PCBs	polychlorinated biphenyls
PCE	tetrachloroethene
PDA	Potential Disposal Area
PEF	particulate emissions factor
PHA	public health assessment
PID	photoionization detector
POL	petroleum, oil, lubricants
ppb	parts per billion
ppm	parts per million
psi	pounds per square inch
PVC	polyvinyl chloride
QA/QC	quality assurance/quality control
QI	quotient index
RA	risk assessment
RBC	risk based concentrations
RCRA	Resource Conservation and Recovery Act
RfD	reference dose
RI/FS	remedial investigation/feasibility study
ROD	record of decision
S, S	storativity, water solubility
SA	site assessment or surface area
SARA	Superfund Amendments and Reauthorization Act
Sj	Jaccard Coefficient
Ss	Sorenson Index
SB	soil boring
SCS	Soil Conservation Service
SD	sediment
SMCL	Secondary Drinking Water Regulations
SQC	sediment quality criteria
SOPs	standard operating procedures
SSV	sediment screening value
STP	sewage treatment plant
SVOCs	semivolatile organic compounds
SW	surface water
SWQSVs	surface water quality screening values

LIST OF ACRONYMS AND ABBREVIATIONS
(Continued)

T	transmissivity
TAL	target analyte list
TBC	to be considered
TCE	trichloroethene
TCL	target compound list
TCLP	toxicity characteristic leaching procedure
TDS	total dissolved solids
TEF	toxicity equivalency factor
TEU	Technical Escort Unit
TICs	tentatively identified compounds
TOC	total organic carbon or top of casing
trans-1,2-DCE	trans-1,2-dichloroethene
TRC	Technical Review Committee
TRVs	terrestrial reference values
TSS	total suspended solids
TVS	total volatile solids
UCL	upper confidence limit
UF	uncertainty factor
µg/g	micrograms per gram
µg/kg	micrograms per kilogram
µg/L	micrograms per liter
USAEC	United States Army Environmental Center
USATHAMA	United States Army Toxic and Hazardous Materials Agency
USDA	United States Department of Agriculture
USDI	United States Department of the Interior
USEPA	United States Environmental Protection Agency
USCS	Unified Soil Classification System
USGS	United States Geological Survey
USMC	United States Marine Corps
UST	underground storage tank
VOCs	volatile organic compounds
VP	vapor pressure
V_x	average seepage velocity
WAR	Water and Air Research, Inc.
Weston	Weston Geophysical Corporation
WOE	weight of evidence
WQS	water quality standards
WQSV	water quality screening values
WS	Wilderness Society

EXECUTIVE SUMMARY

INTRODUCTION

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

This remedial investigation report describes the nature and extent of contamination, and potential human health and environmental impacts for Operable Unit (OU) No. 14. Operable Unit No. 14 is comprised of Site 69, the Rifle Range Chemical Dump.

SITE DESCRIPTION AND HISTORY

Operable Unit No. 14 has a reported history of chemical warfare materiel (CWM) disposal. The CWM suspected at MCB Camp Lejeune are chemical agent identification sets (CAIS). [The following information about CAIS was obtained directly from documents published by the U.S. Army Chemical Material Destruction Agency (USACMDA).] There are various classifications associated with disposal of CWM. Based on a report published by USACMDA, the sites at MCB Camp Lejeune were classified as "Classification 3 - Suspected Burial" (USACMDA, 1993). A classification 3 site is a site at which one or more of the following conditions apply:

- The normal duty activities performed on this site indicate a strong suspicion that buried CWM may still exist even though they are indicated in literature as destroyed. An example would be a burn pit where not all of the munitions may have been consumed even though the period literature indicated that they were.
- Chemical weapons were known to be disposed of on this site, but period literature indicates that the site was cleared. The period definition of cleared, and the technology for clearing such locations at that time, may lead to the conclusion that not everything was removed.
- The site is a known chemical range but the literature is unclear as to whether chemical agent was applied to the site by spraying (such that there would be no buried ordnance) or by range firing/bombing.

Based on information collected during the RI, which may not have been available at the time the USACMDA report was published, Site 69 may actually be classified as a Class 2 site (Likely Burial).

A Class 2 site is a site in which the following conditions apply:

- The burial of CWM has been reported.
- The firing of chemical weapons under range conditions (as opposed to static firing under test conditions) has been reported. (Does not apply to Site 69)
- The disposal of chemical weapons by dumping in shallow water has been reported. (Does not apply to Site 69)

With respect to the criteria for a Class 2 site, a background report has indicated the burial of "gas" at Site 69 (Eakes, 1982). The report also indicated that chemical agents may be buried at the site.

CAIS were produced in large quantities (110,000) and various configurations by the U.S. Army to train soldiers and sailors in the identification of actual chemical warfare agents and in the proper actions upon identification (U.S. Army, 1993). The sets contain vials (ampules) or bottles of agent. The agents used in these sets could contain blister agents [mustard (H) and lewisite (L)], nerve agents (GA, GB and VX), blood agents [hydrogen cyanide (AC) and cyanogen chloride (CK)], and choking agent [phosgene (CG)].

There are several different types of CAIS. One variety of CAIS was an instructional "sniff set" that contained agent impregnated charcoal. It was intended for use indoors to instruct military personnel in recognizing the odors of chemical agent. This type of set contained only small amounts of chemical agent. A second major variety of CAIS, designed for use outdoors, consisted of agent (pure or in solution) in sealed pyrex tubes. The gas tubes would be detonated, creating an agent cloud. Soldiers would then try to identify the agent based on its odor and other characteristics. These typically contained more agent then the instructional "sniff sets" and could produce a much greater hazard. A third major variety of CAIS were those containing bulk mustard. These CAIS were used in decontamination training by purposely contaminating the terrain or equipment with mustard, and then teaching the soldiers how to don the correct protective clothing and decontaminate the area or equipment. These CAIS contained relatively large quantities of pure mustard.

Unfortunately, the types of CAIS used at MCB Camp Lejeune is unknown. However, drums containing calcium hypochlorite, a decontaminant, have been identified at the base. Therefore, it is possible that the third variety of CAIS mentioned above (i.e., CAIS containing pure mustard) may have been used at MCB Camp Lejeune. Based on "best professional judgements" made by personnel at the U.S. Army Chemical Material Destruction Agency (USACMDA), CAIS at MCB Camp Lejeune most likely did not contain nerve agents. However, a memo with a hand drawn sketch of Site 69 identified that "mustard or nerve gas" were disposed of at two locations within the site (Scudder, 1982).

In summary, there is a good likelihood that CWM are present at Site 69. However, there is a lack of information to properly identify the amount, types, or disposal methods associated with CAIS disposal. With respect to disposal, it is not known whether the CWM was destroyed (via burning or detonation) prior to disposal. Existing information, however, does mention that drums were used during disposal.

The following provides a description and history of Site 69.

Site 69, the Rifle Range Chemical Dump, is located west of the New River in the area of MCB Camp Lejeune known as the Rifle Range. The site is approximately 14 acres in size and is situated in a topographic high area. The area is overgrown to the point that the boundary of the former dump is not readily noticeable. Three surface water bodies are located within a quarter mile of the site: the New River to the west, an unnamed tributary of the New River to the North, and Everett Creek to the south. The site area is secluded; however, training exercises are conducted throughout the surrounding area. Currently, a fence surrounds the site to restrict access.

During the period 1950 to 1976, the area was used to dispose chemical wastes including polychlorinated biphenyls (PCBs), solvents, pesticides, calcium hypochlorite, high-test hypochlorite (HTH), and drums of "gas" which possibly contained CWM such as mustard gas.

The site is underlain by silty sands from the ground surface to a depth of approximately 18 feet. Beneath the silty sand is a fairly continuous sandy clay, and sand and clay unit, to a depth of approximately 27 feet. This unit could potentially act as a retarding layer. The upper unit of the Castle Hayne, which was encountered below the sand and clay retarding layer, consists of silty sand with shell and limestone fragments.

The upper portion of the formation is comprised of silty sand with shell and limestone fragments with an average thickness of approximately 40 feet. Below the silty sand is a sand unit with trace to little silt. This unit also exhibits a sandy clay/clayey sand layer, with an approximate thickness of 109 feet, at a depth of 145 feet. The deep borings to the bottom of the Castle Hayne encountered limestone beds in the lower portion, beneath the sand unit. These limestone beds are identified in the literature as "marked beds" for the bottom of the Castle Hayne, and were encountered in the three deep borings performed in March/April 1996 at depths of approximately 207 feet.

Beneath the limestone beds is silty sand with a 4 foot thick silty , sandy clay layer/lenses. At a depth of 245 feet, a silty sand unit was encountered which appeared to be glauconitic. Glauconitic is a descriptive terms which refers to a greenish platy materia which occurs in sediments of marine origin. A glauconitic sand unit is identified as part of the Beaufort formation which lies below the Castle Hayne aquifer and the Beaufort confining unit.

The shallow groundwater is typically encountered within a few feet of ground surface to a depth of approximately 5 feet. Groundwater flow is radial from the site to the low lying areas to the north, south, east, and west. Groundwater flow in the upper portion of the Castle Hayne is towards the south/southeast in the southern portion of the site. There would appear to be some interconnection between the shallow water table aquifer and the Castle Hayne aquifer due to the similar groundwater elevations at some of the monitoring well locations. Groundwater flow in the deep portion of the Castle Hayne aquifer is eastward towards the New River. Recharge for the Castle Hayne aquifer would be from the west, and possibly from the surficial aquifer as the units are separated by a semiconfining layer. The gradient for the deep Castle Hayne aquifer was calculated to be 0.002 ft/ft, which is flat.

Previous investigations conducted under the DoN's IR Program at Site 69 have focused on groundwater, surface water, and sediment. No soil samples were obtained prior to this RI. Shallow groundwater exhibited elevated levels of volatile organics in the southeast portion of the site. The volatiles included 1,2-dichloroethene (DCE) (11,000 μg/L), trichloroethene (TCE) (67 μg/L), and vinyl chloride (36 μg/L). Surface water samples obtained from on-site standing water in low-lying areas of the site revealed the same constituents as were detected in shallow groundwater. These low-lying areas were located in the southeastern portion of the site.

REMEDIAL INVESTIGATIONS

The RI field investigations were initiated in January 1994 and completed in April 1996.

The remedial investigation at Site 69 was initiated by performing a geophysical survey to characterize the site with respect to buried material. Determining the potential areas of buried drums was important since these drums could potentially contain CWM. Contact with CWM was purposely avoided.

Following the geophysical survey, shallow test borings were hand augered and soil samples were obtained to characterize surface soil quality and near subsurface soil quality. A total of 29 shallow test borings was installed, in addition to several test borings to characterize background soil quality. The samples were analyzed for full Target Compound List (TCL) organics, Target Analyte List (TAL) inorganics, and CWM degradation compounds. Surface and subsurface soil samples were also collected during the drilling of monitoring well test borings and analyzed for the same constituents. In March 1995, nine subsurface soil samples were collected within the site area to define subsurface soil quality near a suspected source area. These samples were collected from just above the water table. All soil samples were screened in the field by the U.S. Army Technical Escort Unit so that soil samples containing chemical agents would not be forwarded to the laboratory, and for on-site safety reasons.

During the RI of Site 69, it was necessary to conduct several different investigations in order to characterize the extent of contamination in groundwater. The initial RI groundwater investigation (January 1994) focused on defining the extent of VOC contamination in the shallow aquifer. Four shallow wells (GW09, GW10, GW11, and GW12) were installed to a depth between 12.5 and 20.5 feet below ground surface (bgs). The well locations are shown in Figure ES-1 at the end of this Executive Summary. In addition, two wells were installed to depths of 50 feet bgs (well GW02D) and 58 feet bgs (well GW12DW) in order to determine whether the VOCs were migrating vertically into the upper zone of the Castle Hayne aquifer. The results of the groundwater sampling of the existing wells and newly-installed wells indicated two significant findings. First, the concentrations detected in well GW02 were lower than detected during the Confirmation Study. Second, VOCs were detected in the upper zone of the Castle Hayne aquifer above the North Carolina WQS, but much lower than the concentrations detected in the shallow aquifer during previous sampling rounds.

In order to further characterize the extent of VOC contamination, additional monitoring wells were installed in the shallow aquifer and the Castle Hayne aquifer in May 1994. Well GW13 was installed to the east at a depth of 13 feet bgs to determine offsite groundwater conditions in the shallow aquifer (see Figure ES-1). Well GW02DD was installed adjacent to well GW02 at a depth of 125 feet bgs to determine whether VOCs had migrated from the upper zone to the intermediate zone of the Castle Hayne aquifer. Wells GW03DW and GW13DW were installed east of the suspected source area in the upper zone of the aquifer in order to evaluate vertical and horizontal migration of VOCs from the suspected source area (i.e., the area near well GW02). Both of these wells were installed at a depth of 60 feet bgs.

The four newly-installed wells were sampled in June 1994. The two wells installed in the upper zone of the Castle Hayne aquifer (i.e., wells GW03DW and GW13DW) exhibited low levels of VOCs, indicating that the VOCs have migrated from the suspected source area. Well GW02DD did not exhibit any VOCs, indicating that VOCs have not migrated to the intermediate zone of the aquifer.

In December 1994, a three-well cluster (wells GW14, GW14IW, and GW14DW) was installed south of well cluster GW02 in order to better define the horizontal and vertical extent of contamination. This step was deemed necessary since shallow groundwater flow and VOC migration was believed to be south-southeast, and therefore, contamination in this area was possible. It was determined that the area to the south of the suspected source area needed to be characterized. The cluster of wells consisted of a well in the shallow aquifer (GW14), a well in the upper zone of the Castle Hayne aquifer (GW14IW), and a monitoring well in the intermediate zone (GW14DW). The wells were installed to a depth of 14, 62, and 127 feet bgs, respectively. In February 1995, a round of groundwater samples were collected from all existing and newly-installed monitoring wells and analyzed for VOCs via EPA Method 601/602. No VOCs were detected south of the suspected source area in the GW14 cluster. VOC levels in well GW02 and GW03 were lower than previous sampling rounds for reasons unknown.

At this point of the RI, groundwater remediation was being considered by the DoN. In order to design an effective groundwater collection and treatment system, it was imperative that the source area be better defined. The suspected source area to date was the area near shallow monitoring well GW02, where the highest levels of VOCs had always been detected. The DoN, MCB Camp Lejeune, North Carolina DEHNR, and EPA Region IV agreed that groundwater and soil north of well cluster GW02 should be investigated to better define the source area.

A second geophysical survey was conducted north of well cluster GW02 and GW03 in January 1995. The results of this study indicated a substantial amount of buried metallic debris, just north of well GW02. In addition, nine shallow groundwater samples were collected for VOC analysis via the hydropunching technique in order to establish the "northern" boundary of the shallow aquifer VOC plume. Monitoring wells GW15 and GW15IW were constructed near the area where the highest VOC levels were observed. These two wells were installed at depths of 13 feet and 60 feet bgs in the shallow aquifer and upper zone of the Castle Hayne aquifer, respectively. In March 1995, another round of samples were collected from a selected number of Castle Hayne monitoring wells for VOC analysis. The highest levels of VOCs were now detected in well GW15IW, which represents the upper zone of the Castle Hayne aquifer. VOCs were also detected in shallow wells GW15, GW02, and GW14, as well as in wells GW13D, GW02DW and GW02DD.

The following conclusions were developed following this particular investigation:

1. The source of VOC contamination is likely near the area of well cluster GW15.

2. The extent of shallow groundwater contamination is defined; the source is near well GW15 and extends approximately to the eastern and southern fence line.

3. Groundwater contamination in the upper zone of the Castle Hayne aquifer is also defined; the highest levels were detected in well GW15IW. Offsite contamination in the upper zone of the Castle Hayne is minimal; wells GW14IW and GW13DW exhibited only low levels of VOCs.

4. Groundwater contamination at a depth of approximately 100 feet bgs is not as defined as the shallow aquifer or the upper zone of the Castle Hayne aquifer. Deep groundwater near cluster GW15 may be contaminated (there is no deep well at this location to verify this). To what degree the deeper portion of the Castle Hayne is contaminated is unknown. However, wells GW2DD and GW14, which are downgradient of the suspected source area, did not exhibit significant contamination.

5. Deep groundwater east, north, and west of the suspected source area is not defined. Based on the "pattern" of shallow and intermediate groundwater contamination, deep groundwater contamination north and west of the site is not anticipated. Deep groundwater contamination east and southeast of cluster GW15 may be contaminated, but the degree of contamination is questionable.

6. Deep groundwater quality at the bottom zone of the Castle Hayne (greater than 125 feet to approximately 200 feet bgs) is unknown.

During this stage of the RI, a treatability study (TS) was being implemented to evaluate the effectiveness of a technology known as "in well aeration." The TS focused on remediating the VOCs in-situ as opposed to the more common approach of extracting or collecting groundwater for subsequent physical/chemical treatment and discharge. The TS approach focused on the area near well cluster GW15. During the scoping of the TS, it was determined that the vertical extent of contamination needed to be better defined before completing the final details of the TS. Therefore, as part of the TS, another groundwater investigation was conducted in September 1995. During this investigation, groundwater samples were collected via the hydropunch technique near well cluster GW15 at depths of 50, 60, and 70 feet bgs. From this boring, a well was constructed at a depth of 120 feet bgs (GW15DW) in what is referred to as the intermediate zone. Another well (GW15UW) was installed to a depth of 37 feet bgs to characterize VOC levels in the upper zone of the Castle Hayne, specifically, in the zone just below shallow well GW15.

The results of the September 1995 TS groundwater investigation indicated that elevated VOCs were detected in the upper zone of the Castle Hayne between 37 and 70 feet bgs. Monitoring well GW15 exhibited high levels of contamination, similar to those levels detected during the March 1995 sampling round. VOC levels decreased from the 70 foot to 120 foot depth.

A number of data limitations were identified following the September 1995 study. Specifically, concerns were raised about whether the vertical extent of VOC contamination has been adequately identified. In order to complete the characterization of VOCs in the Castle Hayne aquifer, the following study objectives were established:

- Characterize the vertical and horizontal extent of groundwater contamination in the Castle Hayne aquifer; and
- Determine probable contaminant migration pathways in the Castle Hayne aquifer.

In order to meet the above-mentioned objectives, three deep monitoring wells were constructed during the period March 20 through April 18, 1996. All three wells were constructed to monitor groundwater quality at the bottom zone of the Castle Hayne aquifer. Well GW15BCH was installed near the suspected source area. Monitoring well GW02BCH was installed south of the suspected source area, and well GW03BCH was constructed southeast of the suspected source area. The bottom of the well screens were set at a depth of 230 feet bgs.

One round of samples were collected using dedicated bailers, between April 19 and 20, 1996, from the three newly-installed deep wells and from existing deep wells GW02DD, GW03DW, and GW15DW for analysis of Target Compound List (TCL) volatile organics (CLP protocols, Level IV data quality). No VOCs were detected in the three newly installed wells.

Extensive surface water/sediment and ecological investigations were conducted in 1992 and in 1994. Surface water/sediment samples were collected from on-site standing water (i.e., pools of water formed in low-lying portions of the site), downslope drainage areas, Everett Creek, the New River, and the unnamed tributary to the New River. Fish and shellfish samples were collected from the unnamed tributary, Everett Creek, and the New River. A benthic macroinvertebrate study was also conducted in these surface waters to evaluate environmental stress factors which may be associated with the site or base-wide activities. All samples were analyzed for full TCL organics and TAL inorganics.

NATURE AND EXTENT OF CONTAMINATION

The analytical results for this RI are presented in tables at the end of Section 4 in this report. The results are also illustrated on figures, which can be found at the end of Section 4. These tables and figures may assist the reader of this Executive Summary to better understand the nature and extent of contamination at Site 69.

GROUNDWATER

Groundwater contamination is most prevalent in the shallow aquifer in the area of shallow well GW15. Samples collected from well GW02, which historically exhibited VOC levels in the ppm range, have exhibited much lower levels over the last few years. Based on the most recent rounds of sampling, it appears that the VOC contamination in the shallow aquifer emanates very close to well GW15 and extends horizontally to the south and to the east of the suspected source area. VOC contamination has been detected at low concentrations in well GW14, which is located approximately 300 feet south of well GW15 and in well GW13, which is located about 700 feet east of well GW15). Based on the low levels detected in these wells, it is unlikely that VOCs are significantly elevated offsite beyond wells GW14 and GW13.

VOCs have migrated vertically from the source area (i.e., near well cluster GW15) into the Castle Hayne aquifer. The upper zone of the aquifer has exhibited the most elevated levels of VOCs. The highest levels were detected in wells GW15UW and GW15IW. VOCs have also migrated to the intermediate zone of the aquifer. The extent of contamination in the intermediate zone is believed to be limited since well GW02DD, located to the south, did not exhibit much contamination. VOC levels below 120 feet are likely to be lower in concentration since deep well GW15BCH did not exhibit VOC contamination. In summary, VOC levels near the suspected source area decrease significantly from the shallow aquifer to the intermediate zone of the Castle Hayne.

Shallow groundwater also exhibited total metals including iron, manganese, lead, and chromium above Federal Maximum Contaminant Levels (MCLs) and North Carolina Water Quality Standards (NCWQS). The distribution of these contaminants throughout the site does not suggest a pattern that could be correlated with a plume. The contaminant levels and distribution are very similar to other sites investigated at MCB Camp Lejeune, indicating that the shallow geologic conditions and sampling methods may have elevated the concentration of total metals due to suspended solids, rather than a specific disposal event. Total metals in the deep groundwater were limited to only iron and manganese, at much lower levels than observed in shallow groundwater. Dissolved metals detected above the MCLs or NCWQS were limited to only iron and manganese.

SOIL

Soil samples from monitoring well borings did not exhibit significant concentrations of VOCs. Since no subsurface exploratory trenching was performed to investigate the presence of buried drums (because of the possibility of encountering CWM), the source of shallow groundwater contamination could not be determined. However, geophysical investigations conducted on site revealed buried metallic debris just north of well cluster 69-GW15, which indicated elevated levels of VOCs. It should be noted that the VOC contaminant levels in wells 69-GW02 and 69-GW03 have deceased over time, indicating that the source of the groundwater contamination may have migrated from the vadose zone.

Metal concentrations in soil were not significantly elevated above base-specific background levels. The metal concentrations in soil are similar to those levels detected at other sites within MCB Camp Lejeune. No apparent source or area of concern (AOC) was noticeable which would account for the elevated total metals observed in shallow groundwater. Therefore, this supports the belief that total metals are elevated due to geologic conditions/sampling methods rather than disposal activities.

Pesticides were detected in only a few surface soil samples, but at levels which are typically found throughout MCB Camp Lejeune. The pesticides are likely related to historical pest control activities. Low levels of Aroclor 1260 (94 µg/kg) were detected in one surface soil sample. This contaminant was not detected in subsurface soils. The contaminants acetophenone and hydroxyacetophenone, which are degradation compounds of the ingredient used in tear gas, were detected in low concentrations in two on-site surface soil samples. These contaminants may be present due to the ongoing training exercises involving the use of tear gas in the surrounding area of the site. No other chemical surety degradation compounds were detected. Additionally, no chemical surety agents were detected by the U.S. Army TEU during sample screening.

SURFACE WATER/SEDIMENTS

Surface water samples collected from the on-site standing pools of water exhibited elevated levels of 1,2-DCE (55 µg/L), TCE (4 µg/L), vinyl chloride (8 µg/L), and chloroform (2 µg/L). These same contaminants were also detected in shallow groundwater in the southeast portion of the site. The standing pools are located in this general area of the site, indicating that the source of this contamination is associated with the groundwater. Sediment samples collected from one of the two pools also exhibited 1,2-DCE. Surface water samples collected from the drainage area to the northeast of the site exhibited low levels of toluene (1 µg/L), xylene (10 µg/L), and ethylbenzene (1 µg/L). Groundwater was not contaminated in this area, therefore, the presence of these contaminants may be due to past localized spills of fuel products.

Surface water samples collected from the New River, the unnamed tributary, and Everett Creek did not exhibit organic contamination. Metals were detected, but not at levels indicative of a problem due to disposal activities. Sediment samples collected from the unnamed tributary did exhibit low levels of benzo(a)pyrene, pesticides (DDE and DDD), Aroclor 1260, and metals (arsenic, chromium, and lead) in one sample station. The presence of these constituents are not believed to have migrated from Site 69 due to the distance as well as the limited degree of soil and groundwater contamination exhibiting these contaminants. Sediment samples collected from the New River and Everett Creek exhibited metals. Their presence is not likely associated with Site 69.

HUMAN HEALTH RISK ASSESSMENT

The baseline human health risk assessment was based on possible exposure pathways under current and future potential exposure scenarios. Under current conditions, the exposed population considered base personnel who may be exposed to site contaminants during military training operations (Site 69 is in a remote area of the base where military training occurs). The exposure medium is primarily associated with surface soil. Groundwater was not considered as an exposure medium since the Base is serviced by a public (Base) water supply system. In addition, there are no supply wells which have been impacted by Site 69. Future potential exposure scenarios involved construction personnel and residential. For the residential scenario, groundwater and surface soil were identified as exposure media. It should be noted that the future residential exposure pathway to soil or groundwater is extremely unlikely given that the Site is suspected of containing buried CWM. For the future construction pathway, subsurface soil was identified as the exposure medium.

The total site incremental carcinogenic risk (ICR) and hazard index (HI) values associated with current and future receptors at this site are presented in Table 6-47 (see Section 6.0). Given the absence of chemicals of potential concern (COPCs) in the surface soil, current land use (fenced area with restricted access), and that groundwater in this area is not used for potable purposes, there are no current risks posed to any population from this site. Under the future potential risk exposure scenario, the total site ICR estimated for children (3E-04) and adults (6E-04) exceeded the USEPA's upper bound risk range (1E-04). The total site ICR estimated for construction workers (6E-08) was less than the USEPA's lower bound target risk range (1E-06). Additionally, the total site HI for children (26) and adults (11) exceed unity. The total site HI estimated for the construction worker (<0.01) did not exceed unity. The total site risk under the future potential exposure scenarios was driven by exposure to shallow groundwater. It should be noted that the estimated ICRs and HIs for exposure to subsurface soil do not account for the possibility of exposure to CWM since CWM-related contaminants could not be quantified during the RI.

ECOLOGICAL RISK ASSESSMENT

Overall, metals and pesticides appear to be the most significant site related COPCs that have the potential to affect the integrity of the aquatic ecosystems at OU No. 14. For the terrestrial ecosystems, metals appear to be the most significant site related COPCs that have the potential to affect terrestrial receptors at OU No. 14.

Potential adverse impacts to threatened or endangered species are low due to the absence of critical habitats or noted observations at the site. Biohabitats maps did not indicate a significant impact to ecological resources on or near the Site 69.

Copper and silver exceeded the ARARs/TBCs in surface water and cadmium, mercury, benzo(a)pyrene, 4,4'-DDE, 4,4'-DDT, and PCB-1260 exceeded NOAA sediment screening criteria. The silver quotient ratio was slightly high. However, although silver was above the base-wide and median concentrations, it is not related to the site. In addition, silver was detected in the New River in upstream samples at concentrations similar to those found in Everett Creek. The sediment exceedances indicated concentrations above the base-wide and median concentration for cadmium, mercury, 4,4'-DDE, 4,4'-DDT, and PCB-1260.

The potential risks to aquatic receptors due to the above exceedances in the surface waters around the site was evaluated by conducting biosurveys and fish tissue analysis. Fish populations were sampled and were representative of estuarine and tidal freshwater systems. The predominant fish species were croaker, Easter mosquito, and pinfish. There were no anomalies observed on the fish. The fish community appeared healthy and not impacted due to site contaminants.

Fish tissues were sampled and the following were detected: organics (benzene, toluene, and 2-methylphenol), pesticides (4,4'-DDE and 4,4'-DDD), PCBs (1254 and 1260), and metals (aluminum, beryllium, cadmium, iron, selenium, silver, and zinc). The levels detected in the fish tissue were low when compared to published background values, and did not indicate that these COPCs were site related.

Benthic invertebrates were sampled and were representative of estuarine and tidal freshwater species. The predominant species included capitellids followed by tubificids, spionids, goniadids, and bivalves. Diversity and density were characteristic of salinity ranges of zero to 15 ppt in regional surface waters.

No COPCs exceeded soil toxicity reference levels and based on the comparison of chronic daily intakes and terrestrial reference values, there does not appear to be an impact to terrestrial organisms including rabbits, deer, quail, fox, and raccoon from the site.

CONCLUSIONS

1. Shallow groundwater has been impacted with volatile organic compounds by former disposal operations. The VOC contamination, which is dominated by 1,2-DCE, is present in the southern portion of the site, near monitoring wells 69-GW02 and 69-GW15. In this area, VOCs are above State and Federal drinking water standards. VOCs were also detected in offsite shallow wells, but at much lower levels. Off-site contaminant levels are below Federal and State drinking water standards. The horizontal extent of the VOC plume in the shallow aquifer has been defined, and is primarily present under the former disposal area.

2. The vertical extent of VOC contamination (i.e., primarily 1,2-DCE) in groundwater appears to be centered in the upper portion of the Castle Hayne Aquifer. VOC levels in the upper portion of the Castle Hayne appear to decrease rapidly as the plume migrates offsite to the east-southeast. Offsite VOC levels in the upper portion of the Castle Hayne are below State and Federal groundwater standards.

3. Groundwater quality in the intermediate zone of the Castle Hayne Aquifer has been slightly impacted by the VOCs. Low levels of 1,2-DCE were detected in wells GWO3DD and GW15DW at concentrations below State and Federal drinking water standards. No off-site intermediate zone wells exhibited contamination.

4. VOCs have not migrated to the deep zone of the Castle Hayne Aquifer.

5. Although VOCs are present in both the shallow and Castle Hayne Aquifers, the vertical and horizontal extent of contamination is limited in area. Based on existing data, the plume is estimated to cover an area of approximately three to four acres.

6. The source of the VOCs may be associated with buried waste near well cluster 69-W15. This area contains a significant amount of buried metallic debris, based on the results of the geophysical surveys. It is possible that the source of VOCs are within the fill area and may continue to impact groundwater quality; however, VOC levels in wells 69-GW02 and 69-GW03 appear to be decreasing.

7. Elevated total metals in shallow groundwater are not believed to be indicative of past disposal operations. This conclusion is based on the following: metal concentrations in soil are similar to levels typically encountered throughout MCB Camp Lejeune; there is no pattern or plume to suggest that the total metals are elevated due to a source; total metals in groundwater are similar to some of the background wells throughout the base; and dissolved metals in groundwater are not elevated.

8. Onsite ponded water in the southern portion of the site is contaminated with VOCs. The ponded water appears to be hydraulically connected to the shallow aquifer.

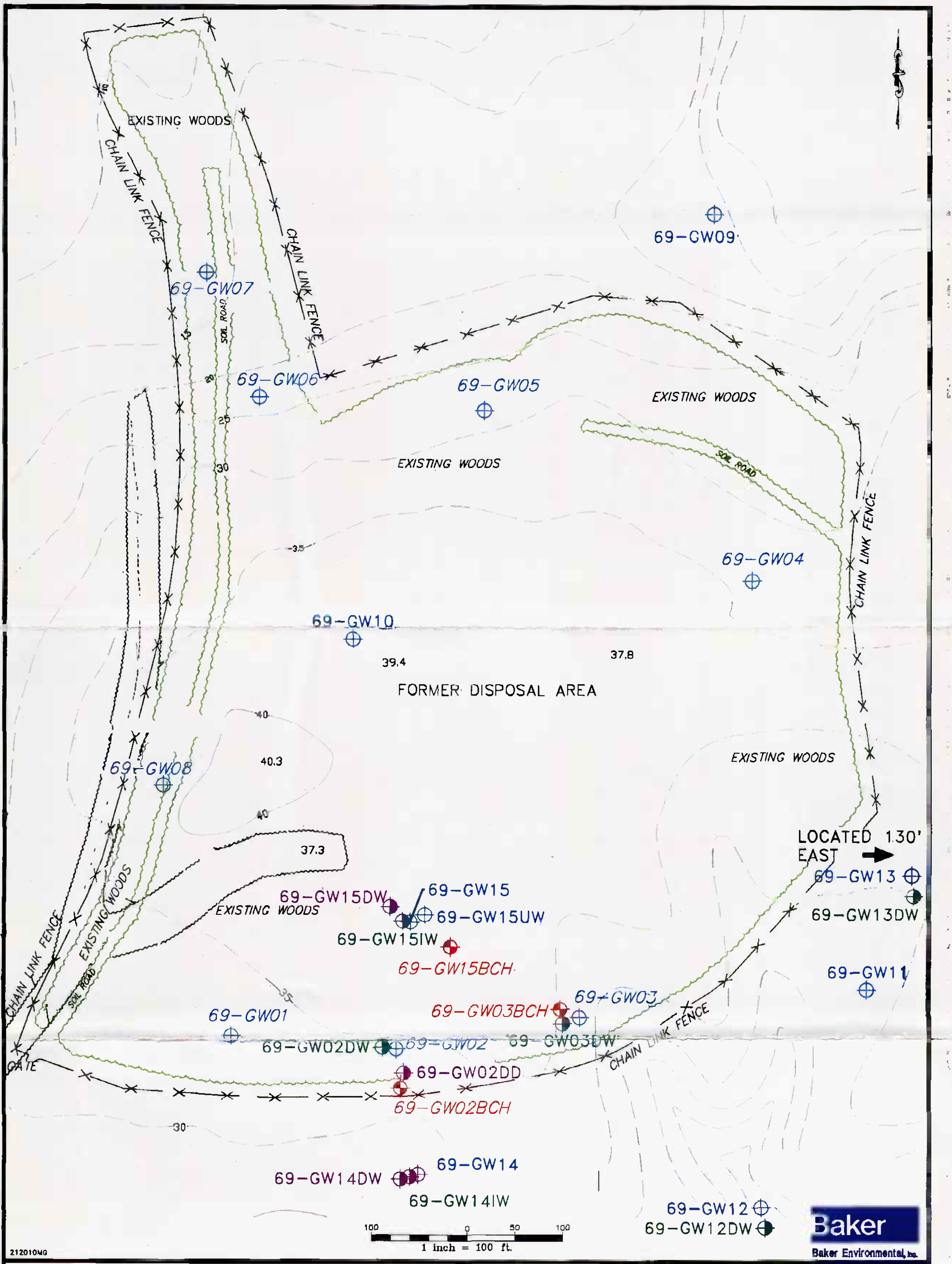
9. Offsite surface water bodies have not been impacted by the site.

10. Under current human health exposure scenarios, there are no adverse human health risks mainly because groundwater in this area is not utilized for potable supply, and because access to the site is restricted.

11. Under future potential human health exposure scenarios involving residential use of the area, adverse human health risks would result due to groundwater exposure. Future residential use of the area is unlikely since the site is suspected of containing buried CWM.

12. There are no significant ecological risks to aquatic or terrestrial receptors associated with Site 69. Although environmental media concentrations exceeded ARARs/TBCs, aquatic biosurveys indicate fish and benthic macroinvertebrate populations that are representative of typical estuarine and tidal freshwater systems that are not adversely impacted by contaminant sources.

13. Based on the human health and ecological risk assessments, groundwater is the only medium of concern at Site 69. Although there is no current groundwater exposure pathway that would result in adverse human health risks, VOCs are migrating into the Castle Hayne Aquifer. The Castle Hayne is utilized extensively throughout MCB Camp Lejeune and the surrounding communities as a source of water.



LEGEND

69GW15BCH ⊕	DEEP ZONE CASTLE HAYNE WELLS
69GW09 ⊕	SHALLOW WELLS
69GW02DW ⊕	UPPER ZONE CASTLE HAYNE WELLS
69-GW02DD ⊕	INTERMEDIATE ZONE CASTLE HAYNE WELLS
30	TOPOGRAPHIC ELEVATION LINES (FEET, MSL)

SOURCE: REVISED FROM LANTDIV, OCT. 1991

FIGURE ES-1
MONITORING WELL LOCATIONS
SITE 69 – RIFLE RANGE CHEMICAL DUMP
REMEDIAL INVESTIGATION CTO-0212

MARINE CORPS BASE, CAMP LEJEUNE
NORTH CAROLINA

01761N01Y

1.0 INTRODUCTION

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

The Fiscal Year 1997 Site Management Plan for MCB Camp Lejeune, a primary document identified in the FFA, identifies 42 sites requiring Remedial Investigation/Feasibility Study (RI/FS) activities. These 27 sites have been divided into 18 operable units to simplify proceeding with RI/FS activities. This report describes the RI conducted at Operable Unit (OU) No. 14, which is comprised of Site 69.

The purpose of this RI is to evaluate the nature and extent of the threat to public health and the environment caused by the release or threatened release of hazardous substances, pollutants, or contaminants. This was accomplished by sampling several media (soil, groundwater, surface water, and sediment) at Operable Unit No. 14, evaluating the analytical data, and performing a human health Risk Assessment (RA) and ecological RA. This RI report contains the results of all field investigations, the human health RA, and the ecological RA. Furthermore, the RI provides information to support the FS and Record of Decision (ROD) for a final remedial action.

Site 69 is the "Rifle Range Chemical Dump." Site 69 is located in the southwest section of MCB, Camp Lejeune. The New River is to the east and State Route 210 to the south of Site 69. Site 69 is identified on Figure 1-1. [Note that all figures are presented at the end of the text section .]

1.1 Report Organization

The following sections are presented in this RI report.

Section 1.0	Introduction
Section 2.0	Study Area Investigation
Section 3.0	Physical Characteristics of the Study Area
Section 4.0	Nature and Extent of Contamination
Section 5.0	Contaminant Fate and Transport
Section 6.0	Baseline Human Health Risk Assessment (BRA)
Section 7.0	Ecological Risk Assessment (ERA)
Section 8.0	Summary and Conclusions
Section 9.0	References

Section 1.0 focuses on the purpose of the RI, and a description of the location, setting and history of Site 69.

Section 2.0 describes the field sampling activities conducted during the RI at Operable Unit No. 14. This section describes the purpose of the sampling procedures, sampling grids, and sampling locations for all media. Figures are included to show sampling locations. Drilling logs and well installation logs are also provided to show site geologic conditions. This section also discusses quality control conducted during the sampling events.

Section 3.0 addresses the physical features of Operable Unit No. 14. This section discusses the surface features, meteorology, surface water hydrology, geology, soils, hydrogeology, demography, land use, the ecology in and around Operable Unit No. 14, and water supply wells identified within the vicinity of OU No. 14.

Section 4.0 presents the nature and extent of the contamination found at Operable Unit No. 14. This section presents the results of the field sampling activities conducted as part of this RI. The results of the sampling activities are presented in the first part of this section. Also included in this section is a discussion of the summary of the contaminants detected, extent of contamination, and a discussion of the potential sources.

Section 5.0 characterizes the fate and transport of contaminants found at Operable Unit No. 14. This characterization includes: potential routes of contaminant migration, contaminant persistence, and contaminant migration.

Section 6.0 contains the Baseline Risk Assessment (BRA) conducted for Site 69. The BRA contains a human health evaluation and an environmental evaluation.

Section 7.0 contains the Ecological Risk Assessment (ERA) conducted for Site 69. The ERA contains an ecological evaluation based on possible impacts related to Site 69.

Section 8.0 includes the Summary and Conclusions. This section summarizes the nature and extent of contamination, contaminant fate and transport and the human health and ecological RA. In addition, the conclusions address any data limitations and recommended remedial action objectives.

Section 9.0 includes references cited in this report.

1.2 Operable Unit Description

Operable units are formed as an incremental step towards addressing individual site problems. There are currently 42 Installation Restoration Program (IRP) sites on MCB Camp Lejeune which have been grouped into 18 operable units to simplify the specific problems associated with a site or a group of sites. Figure 1-2 shows the breakdown of the operable units within MCB Camp Lejeune. Originally, Site 69 was grouped with Sites 41 and 74 in OU No. 4. These sites had been grouped because all three sites had historic documentation of disposal of Chemical Weapons Material (CWM) and industrial wastes. Presently, Site 69 is identified as OU No. 14.

Site 69 is located in the southwestern area of the base and is in the southern portion of the Rifle Range area. The site is situated west of the New River Estuary and is approximately 6 acres in size. The description and history of Site 69 is presented in Section 1.3.

1.3 Site Description and History

This section provides a description of the physical setting of Site 69, which is included under OU No. 14. A detailed history of Site 69 is presented in the subsequent sections.

1.3.1 Site 69 Description

Site 69, the Rifle Range Chemical Dump, is located west of the New River estuary in the area of MCB Camp Lejeune known as the Rifle Range. Figure 1-3 presents a site map of Site 69. Site 69 is a former disposal site (i.e., landfill) and is approximately 6 acres in size. Access is restricted by a 6-foot high chain link fence with a locked entrance gate. The site is heavily wooded with several species of trees including pine, sweetgum, dogwood, and oak. Within the fenced in boundary, the forest type is mostly new growth with a predominance of pine species. Old growth forests (i.e., oak, and sweetgum) dominate the land areas outside the boundaries of the site fence.

The site is located approximately three miles east-southeast of the intersection of Highway 17 and Route 210. The site is situated where a light-duty, unnamed roadway splits to form a "Y". For this report, this road shall be referred to as the "access road."

The New River is located about one-quarter mile east of the site. Everett Creek is located about one-half mile south of the site. An unnamed tributary to the New River is situated about one-quarter mile north of the site. A light-duty road borders the site to the west. Both Everett Creek and the unnamed tributary drain into the New River.

Site 69 is situated at a topographic high. Most of the site within the fence area is flat; however, the topography surrounding the site slopes gently in all directions. During the site field investigation which was conducted from January to March of 1994, portions of the site area exhibited standing/ponding water, which could indicate poor drainage.

Surface water runoff from the northern portion of the site may drain toward the unnamed tributary located to the north; however, the surrounding area is heavily wooded and consists of a dense understory that could inhibit off-site drainage at great distances. Surface runoff from the southeastern portion of the site reportedly drains to unnamed ditches that drain into the New River. Surface runoff from the southwestern portion of the site drains into the Everett Creek basin, which could potentially drain into Everett Creek and the New River. However, as previously mentioned, the surrounding areas are heavily wooded and consist of a thick understory, which could inhibit overland surface runoff at great distances.

1.3.2 Site 69 History

Site 69 was used as a chemical waste dump between 1950 and 1976. The waste materials were reportedly disposed in pits or trenches, 6 to 20 feet deep. Various wastes have been reportedly disposed of at the site including polychlorinated biphenyls (PCBs), fire retardants, pentachlorophenol, dichloro-diphenyltrichloroethane (4,4'-DDT), trichloroethylene (TCE), malathion, diazinon, lindane, calcium hypochlorite, gas cylinders, high-test hypochlorite (HTH), drums of "gas" [possibly training agent containing chloroacetophone (CN)], chemical agent test kits for chemical warfare, and fired and unfired blank rifle cartridges [Water and Air Research, (WAR) 1983].

Based on conversations with personnel from the U.S. Army Environmental Center (USAEC), formerly the U.S. Army Toxic and Hazardous Materials Agency (USATHAMA) and the U.S. Army Technical Escort Unit (TEU), there is a high probability that chemical agent training kits also are buried at the site. PCBs were reportedly sealed in cement septic tanks prior to disposal at the site. The presence of the fired and unfired rifle cartridges indicate that troop training exercises have occurred in this area (WAR, 1983).

In 1970, an explosion reportedly occurred at Site 69 during a disposal operation. Containers of 4,4'-DDT, TCE, and calcium hypochlorite were placed in a pit at the site. While the containers were being covered with earthen, an explosion and fire occurred (WAR, 1983).

The site is inactive at present. Access is restricted by a chain-link fence. No known training activities are presently conducted within the fenced-in area. In addition, conversations with military personnel in charge of the Rifle Range area, which includes Site 69, have indicated that only authorized individuals are permitted in the area of Site 69.

1.4 Previous Investigations

In response to the passage of the CERCLA, the DoN initiated the Navy Assessment and Control of Installation Pollutants (NACIP) program to identify, investigate, and clean up past hazardous waste disposal sites at Navy installations. The NACIP investigations conducted by the DoN consisted of Initial Assessment Studies (IAS), similar to the USEPA's Preliminary Assessments/Site Investigations (PA/SI) and Confirmation Studies, similar to the USEPA's RI/FS. When the Superfund Amendment and Reauthorization Act (SARA) was passed in 1986, the DoN aborted the NACIP program in favor of the Installation Restoration Program (IRP), which adopted the USEPA Superfund procedures.

1.4.1 Initial Assessment Study

An IAS was conducted by WAR in 1983. The IAS identified a number of sites at MCB Camp Lejeune as potential sources of contamination, including the site discussed in this RI. The IAS reviewed historical records and aerial photographs, as well as performing field inspections and personnel interviews to evaluate potential hazards at various sites on MCB Camp Lejeune. The IAS recommended performing confirmation studies at Site 69 to evaluate the necessity of conducting mitigating actions or clean-up operations.

1.4.2 Confirmation Study

A confirmation study was conducted by Environmental Science and Engineering, Inc. (ESE) from 1984 through 1987. The purpose of this investigation was to investigate the potential source areas identified in the IAS. Site 69 was identified in the IAS. The Confirmation Study was divided into two separate reports: a Verification Step done in 1984 and a Characterization Step done in 1986 through 1987. Results from the Confirmation Study for Site 69 are presented in Section 1.4.2.1.

1.4.2.1 Site 69

Previous investigations at Site 69 focused on groundwater, surface water, and sediment. Soil investigations were not conducted at Site 69 as part of the confirmation study.

Groundwater Investigation

As part of the Verification Step conducted in July 1984, eight groundwater monitoring wells (ranging in depths from 20 to 22 feet bgs) were installed and sampled at Site 69. These well locations are provided on Figure 1-4. The samples were analyzed for the following:

- Volatile Organic Compounds (VOCs)
- PCBs

- Pentachlorophenol
- Residual Chlorine
- Organochlorine Pesticides
- Mercury

Groundwater samples collected from monitoring wells installed along the southern and eastern portion of the site (69GW02, 69GW03, and 69GW04) exhibited volatile contamination. Volatile organics detected in the groundwater included benzene, 1,2-dichloroethane (1,2-DCA), trans-1,2-dichloroethane (t-1,2-DCA), TCE, toluene, and vinyl chloride. Volatile organics 1,2-DCA (5.9 µg/L), trans-1,2-DCA (9,700 µg/L) and vinyl chloride (80 µg/L) detected in well 69GW02 exceeded the Federal Maximum Contaminant Level (MCL) and the North Carolina Water Quality Standard (NCWQS) established for these compounds. Additionally, the concentration of TCE (340 µg/L) detected in well 69GW02 exceeded the MCL. Volatile organic concentrations for 1,2-DCA (1.9 µg/L), trans-1,2-DCA (4,000 µg/L), benzene (4 µg/L) and vinyl chloride (2 µg/L) detected in well 69GW03 exceeded either the NCWQS or MCL. Only trans-1,2-DCA exceeded the NCWQS and MCL for groundwater collected from monitoring well 69GW04.

Other contaminants of interest including PCBs, pentachlorophenol, and residual chlorine were not detected. Mercury was detected in one of four groundwater samples (69GW01), however, at a concentration well below the NCWQS and MCL.

In December 1986, a second round of groundwater samples were collected from the eight monitoring wells. This sampling was conducted as part of the Characterization Step. The samples were analyzed for the same compounds as the 1984 round additionally tetrachlorodioxin, methyl ethyl ketone (MEK), methyl isobutyl ketone (MIBK), and ethylene dibromide (EDB). The results from this sampling were similar to those of the 1984 sampling; various VOCs were detected primarily in wells 69GW02, 69GW03, and 69GW04.

Results from the two rounds of groundwater samples are provided on Table 1-1. (Note that all tables are provided at the end of each section.)

As part of the Supplemental Characterization Step, the eight monitoring wells were sampled in January 1991. The samples were analyzed for full target compound list (TCL) organics and target analyte list (TAL) inorganics. Pesticides and semivolatiles were not detected in the samples. Detected volatile organic contaminants and maximum concentrations included 1,2-dichloroethylene (1,2-DCE) (11,000 µg/L maximum), TCE (67 µg/L maximum), vinyl chloride (36 µg/L maximum), and chlorobenzene (40 µg/L maximum). Detected inorganics and concentration ranges included aluminum (2,300 - 43,800 µg/L), antimony (68.5 µg/L), arsenic (2.8 - 11.0 µg/L), barium (36.6 - 153 µg/L), beryllium (0.85 - 3.0 µg/L), calcium (2,500 - 8,330 µg/L), chromium (5.3 - 47 µg/L), cobalt (8.6 - 9.7 µg/L), copper (4.9 -27.5 µg/L), cyanide (11.2 µg/L), iron (7,740 -792,000 µg/L), lead (2.6 - 23.9 µg/L), magnesium (1,970 -4,410 µg/L), manganese (4.6 - 230 µg/L), nickel (5.7 - 27.6 µg/L), potassium (1,450 - 4,190 µg/L), silver (1.6 -6.5 µg/L), sodium (4,880 - 18,900 µg/L), thallium (4.9 - 5.2 µg/L), vanadium (6.1 - 2,240 µg/L), and zinc (51.8 - 10,200 µg/L) (ESE, 1992).

Surface Water Investigation

Surface water samples were collected during various investigations at Site 69. These investigations were conducted in August 1984 (Verification Step), December 1986 (Characterization Step), and January 1991 (Supplemental Characterization Step).

In 1984, two surface water samples were collected from low-lying ponding areas in the vicinity of the former disposal area. No sediment samples were obtained at either location. The surface water samples collected during the Confirmation Study were analyzed for the following:

- VOCs
- Organochloride Pesticides
- Pentachlorophenol
- Mercury

The two surface water sampling locations are shown on Figure 1-5. Several volatile organics were detected in the two surface water samples. Maximum contaminant concentrations for benzene (0.4 µg/L), chlorobenzene (2.1 µg/L), 1,2-DCA (0.9 µg/L), trans-1,2-DCA (410 µg/L), ethylbenzene (3 µg/L), 1,1,2,2-tetrachloroethane (1,1,2,2-PCA) (59 µg/L), 1,1,2-trichloroethane (1,1,2-PCA) (6 µg/L), TCE (55 µg/L), toluene (11 µg/L), and vinyl chloride (15 µg/L). Table 1-2 presented a comparison of surface water contaminant concentrations to Federal Ambient Water Quality Criteria (AWQC).

As part of the Characterization Step, three surface water samples were collected from three small water-filled depressions around Site 69. Depression areas are located along the east and north of the site, and along the southern edge of the site. Surface water sampling locations are depicted on Figure 1-6. The samples were analyzed for the following:

- Organochlorine Pesticides
- PCBs
- Pentachlorophenol
- VOCs
- Mercury
- Residual Chlorine
- Tetrachlorodioxin
- MEK
- MIBK
- EDB

Pentachlorophenol (1.24 µg/L maximum), trans-1,2-DCE (310 µg/L maximum), TCE (63 µg/L maximum), and vinyl chloride (41 µg/L maximum) were detected in the on-site sample 69SW1, and the eastern sample 69SW2. No VOCs were detected in the sample 69SW3 collected north of the site; however, low levels of mercury (0.20 µg/L) were detected at this location.

Surface water sampling locations for the Characterization Step are provided on Figure 1-6. A summary of contaminants detected for surface water is provided in Table 1-2.

Three surface water samples were collected as part of a Supplemental Characterization Study. One sample was collected at the same southern-edge location which was sampled in the Characterization Step. The remaining two samples were collected from two unnamed tributaries that drain from the site into the New River estuary, east-southeast of the site. The surface water sampling locations are depicted on Figure 1-6. The samples were collected near the confluence of the New River and analyzed for full TCL organics and TAL inorganics.

Pesticides and semivolatiles were not detected in any of the samples. Volatile organics were detected in sample 69SW1, only. Inorganics detected in the samples and concentration ranges included aluminum (309 - 622 μg/L), barium (28.2 μg/L), calcium (3,630 - 241,000 μg/L), copper (6.4 μg/L), cyanide (11.2 μg/L), iron (159 - 4,420 μg/L), magnesium (223 μg/L), potassium (710 - 318,000 μg/L), silver (2.4 - 3.1 μg/L), sodium (5,090 μg/L), vanadium (5 μg/L), and zinc (1,960 μg/L) (ESE, 1992). Surface water sampling locations for the 1991 round of sampling are provided on Figure 1-6. A summary of organic contaminants detected in surface water is provided on Table 1-2.

In August 1992, surface water/sediment samples were collected along the New River, Everett Creek, and an unnamed tributary to the river, as part of remedial investigation. These samples were collected in order to conduct the ecological risk assessment. In addition, a benthic, shellfish, and fish population study and fish tissue sampling was conducted. The investigation and results of this study are discussed in Section 2.2.3.6 of this RI report.

Sediment Investigation

As part of the Characterization Step conducted in December 1986, two sediment samples were collected from two unnamed tributaries that drain from Site 69 into the New River estuary. These sediment sampling locations are provided on Figure 1-5. The two tributaries are located east-southeast of the site. The samples were analyzed for the following (ESE, 1991):

- Organochlorine Pesticides
- PCBs
- Pentachlorophenol
- VOCs
- Mercury
- Residual Chlorine
- Tetrachlorodioxin
- MEK
- MIBK
- EDB

Pentachlorophenol (1.190 μg/g) and dichlorodiphenyldichloroethylene (4,4'-DDE) (0.0188 μg/g) were detected in sediment sample 69SE4. Pesticide contaminant dichlorodiphenyldichloroethane (4,4'-DDD) (0.113 μg/g) was detected in sediment sample 69SE5. Table 1-3 provides a summary of contaminants detected in the sediment samples.

Figure 1-6 indicates the three sediment sampling locations for the Characterization Step conducted in January 1991. These samples were analyzed for full TCL organics and TAL inorganics. Organic contaminants were not detected in the samples. Inorganics detected and concentration ranges include aluminum (1,950 - 2,650 mg/kg), antimony (3.4 - 9.70 mg/kg), barium (3.2 - 7.6 mg/kg), chromium (3.5 - 6.4 mg/kg), copper (0.69 - 2.0 mg/kg), iron (1,500 - 2,890 mg/kg), lead (1.7 - 3.1 mg/kg), magnesium (74.2 - 902 mg/kg), manganese (2.0 -12.4 mg/kg), potassium (456 - 582 mg/kg), silver (0.97 mg/kg), sodium (76.1 - 3,290 mg/kg), vanadium (3.0 - 6.90 mg/kg), and zinc (6.10 - 19.5 mg/kg).

In August 1992, surface water/sediment samples were collected along the New River, Everett Creek, and an unnamed tributary to the river, as part of the investigation. These samples were collected in order to conduct the ecological risk assessment. In addition, a benthic, shellfish, and fish population study and fish tissue sampling was conducted. The investigation and results of this study are discussed in Section 2.2.3.6 of this RI report.

SECTION 1.0 TABLES

TABLE 1-1

CONFIRMATION STUDY
DETECTED TARGET CONTAMINANTS IN GROUNDWATER SAMPLES, SITE 69
REMEDIAL INVESTIGATION, CTO-0212
MCB CAMP LEJEUNE, NORTH CAROLINA

Parameter	Federal MCLs	NC Groundwater Standards	Sample No./Date							
			69GW1 7/18/84	69GW1 12/12/86	69GW2 7/18/84	69GW2 12/17/86	69GW3 7/18/84	69GW3 12/17/86	69GW4 7/18/84	69GW4 12/18/86
Mercury	2	1.1	0.2	0.2	<0.2	0.2	<0.2	0.2	<0.2	0.2
beta-BHC	None	None	<0.0001	<0.013	<0.0001	<0.013	<0.0001	0.087	<0.0001	<0.013
delta-BHC	None	None	<0.0003	NR	<0.0003	0.034	<0.0003	2.44	<0.0003	<0.013
1,2-Dibromomethane	None	None	NA	<0.02	NA	4.74	NA	0.363	NA	<0.02
Benzene	5	1	<0.3	<1	0.7	<25	4	4	<0.6	<1
Chlorobenzene	100	300	<0.5	<6	<0.5	<150	49	55	<0.9	<6
Chloroform	None	0.19	<0.7	<1.6	<0.6	<40	<0.6	<1.6	1.3	14
1,2-Dichloroethane	5	0.38	<1	<2.8	5.9	<70	1.9	<2.8	<1.8	<2.8
1,1-Dichloroethylene	7	7	<1.2	<2.8	1.6	<70	2.7	<2.8	<2.4	<2.8
trans-1,2-Dichloroethene	100	70	<1.2	<1.6	9700	37000	4000	830	410	91
Methylene chloride	None	5	10	<2.8	<1	<70	<1	<2.8	<2	<2.8
1,1,2,2-Tetrachloroethane	None	None	<0.9	<4.1	44	<100	<0.8	<4.1	2	5.4
Tetrachloroethene	5	None	<1.7	<3	20	<75	<1.6	<3	<3.3	<3
1,1,2-Trichloroethane	5	None	<1.2	<5	7.9	<130	<1.2	<5	3.1	<5
Trichoroethene	5	None	<1.3	<3	340	710	4.9	<3	<2.5	<3
Toluene	1,000	1,000	0.7	<6	5	<150	14	10	<1	<6
Vinyl chloride	2	0.015	<0.9	<1	80	440	2	1.6	<2	<1

TABLE 1-1 (Continued)

CONFIRMATION STUDY
DETECTED TARGET CONTAMINANTS IN GROUNDWATER SAMPLES
REMEDIAL INVESTIGATION, CTO-0212
MCB CAMP LEJEUNE, NORTH CAROLINA

Parameter	Federal MCLs[(1)]	North Carolina WQS[(2)]	Sample No./Date							
			69GW5 7/18/84	69GW5 12/18/86	69GW6 7/18/84	69GW6 12/18/86	69GW7 7/18/84	69GW7 12/18/86	69GW8 7/18/84	69GW8 12/18/86
Mercury	2	1.1	<0.2	<0.2	<0.2	0.2	<0.2	0.2	<0.2	0.2
beta-BHC	NS	NS	<0.0001	<0.017	<0.0001	<0.013	<0.0001	<0.013	<0.0001	<0.013
delta-BHC	NS	NS	<0.0003	<0.017	<0.0003	<0.013	<0.0003	<0.013	<0.0003	<0.013
1,2-Dibromomethane	NS	NS	NA	<0.02	NA	<0.02	NA	<0.02	NA	<0.02
Benzene	5	1	<0.3	<1	<0.3	<1	<0.3	<1	<0.3	<1
Chlorobenzene	100	300	<0.5	<6	<0.5	<6	<0.5	<6	<0.5	<6
Chloroform	NS	0.19	<0.7	<1.6	<0.6	<1.6	<0.7	<1.6	<0.7	<1.6
1,2-Dichloroethane	5	0.38	<1	<2.8	<0.9	<2.8	<1	<2.8	<1	<2.8
1,1-Dichloroethylene	7	7	<1.2	<2.8	<1.2	<2.8	<1.2	<2.8	<1.3	<2.8
trans-1,2-Dichloroethene	100	70	<1.2	4.2	<1.2	<1.6	<1.2	<1.6	<1.2	<1.6
Methylene chloride	NS	5	<1	<2.8	<1	<2.8	<1	<2.8	<1	<2.8
1,1,2,2-Tetrachloroethane	NS	NS	<0.9	<4.1	<0.8	<4.1	<0.9	<4.1	<0.9	<4.1
Tetrachloroethene	5	NS	<1.7	<3	<1.6	<3	<1.7	<3	<1.7	<3
1,1,2-Trichloroethane	5	NS	<1.2	<5	<1.2	<5	<1.2	<5	<1.2	<5
Trichoroethene	5	NS	<1.3	<3	<1.3	<3	<1.3	<3	<1.3	<3
Toluene	1,000	1,000	<0.6	<6	<0.6	<6	<0.6	<6	<0.6	<6
Vinyl chloride	2	0.015	<1	<1	<0.9	<1	<1	<1	<0.9	<1

NS = No Standard Established　　NA = Not Analyzed

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

Source: ESE, 1992.

[(1)] Federal maximum contaminant levels (MCLs) established under the Safe Drinking Water Act of 1986.

[(2)] NCWQS - North Carolina administrative code, Title 15, N.C. DEHNR, Subchapter 2L, Section .0202 - Water Quality Standards (WQS) for groundwater, August 4,
). Class GA Standards.

TABLE 1-2

CONFIRMATION STUDY
DETECTED TARGET CONTAMINANTS IN SURFACE WATER SAMPLES, SITE 69
REMEDIAL INVESTIGATION, CTO-0212
MCB CAMP LEJEUNE, NORTH CAROLINA

Parameter	Federal Ambient Water Quality Criteria		Sample No./Date							
			Verification Step		Characterization Step			Supplemental Characterization		
	Organisms[1]	Health[2]	69SW1 8/4/84	69SW2 8/4/84	69SW1 12/12/86	69SW2 12/12/86	69SW3 12/12/86	69SW1 1/14/91	69SW4 1/14/91	69DW5 1/14/91
alpha-BHC	NS	NS	<0.001	<0.001	0.043	0.056	<0.035	<0.05	<0.05	<0.05
beta-BHC	NS	NS	0.03	0.005	0.043	0.18	<0.013	<0.05	<0.05	<0.05
delta-BHC	NS	NS	0.2	0.02	NR	NR	NR	<0.05	<0.05	<0.05
Pentachlorophenol	13	1,000	10	<0.9	<0.89	1.24	<0.89	<50	<100	<50
Benzene	NS	0.66	0.4	<0.2	<1	<1	<1	<5	<5	<5
Chlorobenzene	NS	488	2.1	<0.3	<6	<6	<6	<5	<5	<5
Chloroform	1,240	0.19	6	<0.5	<1.6	<1.6	<1.6	3J	<5	<5
1,2-Dichloroethane	20,000	0.94	0.9	<0.8	<2.8	<2.8	<2.8	<5	<5	<5
trans-1,2-Dichloroethene	NS	NS	410	10	310	170	<1.6	190	<5	<5
Ethylbenzene	NS	1,400	3	<0.6	<7.2	<7.2	<7.2	<5	<5	<5
Methylene chloride	NS	NS	<0.6	8	<2.8	<2.8	<2.8	<5	1BJ	<5
1,1,2,2-Tetrachloroethane	2,400	0.17	59	<0.5	<4.1	<4.1	<4.1	5	<5	<5
1,1,2-Trichloroethane	9,400	0.6	6	<0.8	<5	<5	<5	<5	<5	<5
Trichoroethene	21,000	2.7	55	1.3	63	12	<3	7	<5	<5
Toluene	NS	14,000	11	<0.4	<6	<6	<6	2J	<5	<5
Vinyl chloride	NS	2	15	<0.6	41	<1	<1	15	<5	<5
Mercury	0.012	0.144	<0.2	<0.2	<0.2	<0.2	0.2	<0.10	<0.10	<0.10

NA = Not Analyzed
NS = No Standard Established

[1] Freshwater Chronic Criteria.

[2] Protection of Human Health - Water and Organisms

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

Source: ESE, 1992.

TABLE 1-3

CONFIRMATION STUDY
DETECTED TARGET CONTAMINANTS FOR SEDIMENT SAMPLES, SITE 69
REMEDIAL INVESTIGATION, CTO-0212
MCB CAMP LEJEUNE, NORTH CAROLINA

Parameter	Verification Step	
	69SE4 12/12/86	69SE5 12/12/86
DDD, 4,4'	<0.0129	0.113
DDE, 4,4'	0.0188	<0.0224
Pentachlorophenol	1.190	<0.0513

Values reported are concentrations in micrograms per gram (μg/g); this approximates parts per million (ppm).

Note: There are no NC sediment standards.

Source: ESE, 1990.

SECTION 1.0 FIGURES

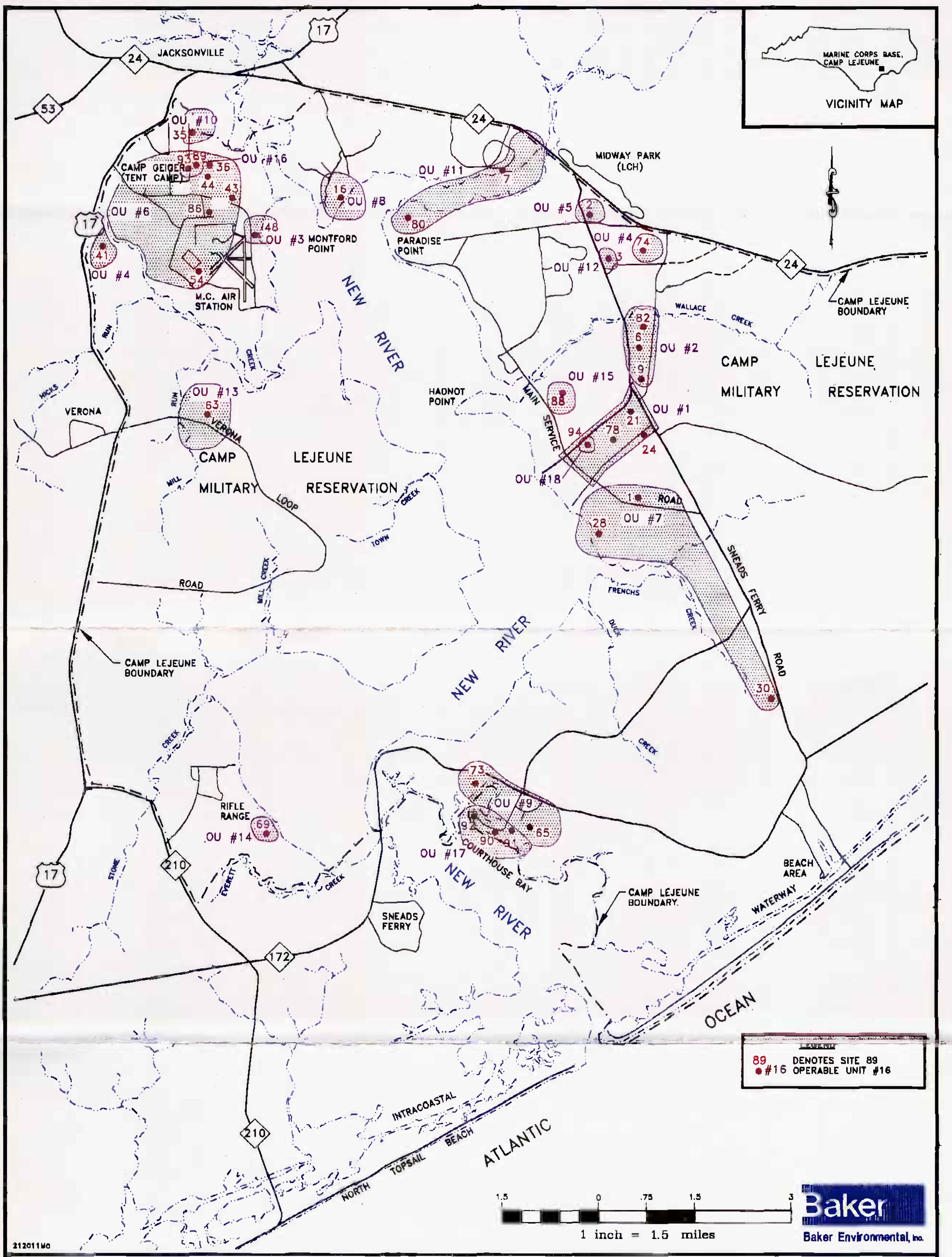


FIGURE 1-1
OPERABLE UNITS AND SITE LOCATIONS AT
MARINE CORPS BASE CAMP LEJEUNE
REMEDIAL INVESTIGATION CTO-0212

MARINE CORPS BASE, CAMP LEJEUNE
NORTH CAROLINA

01761N02Y

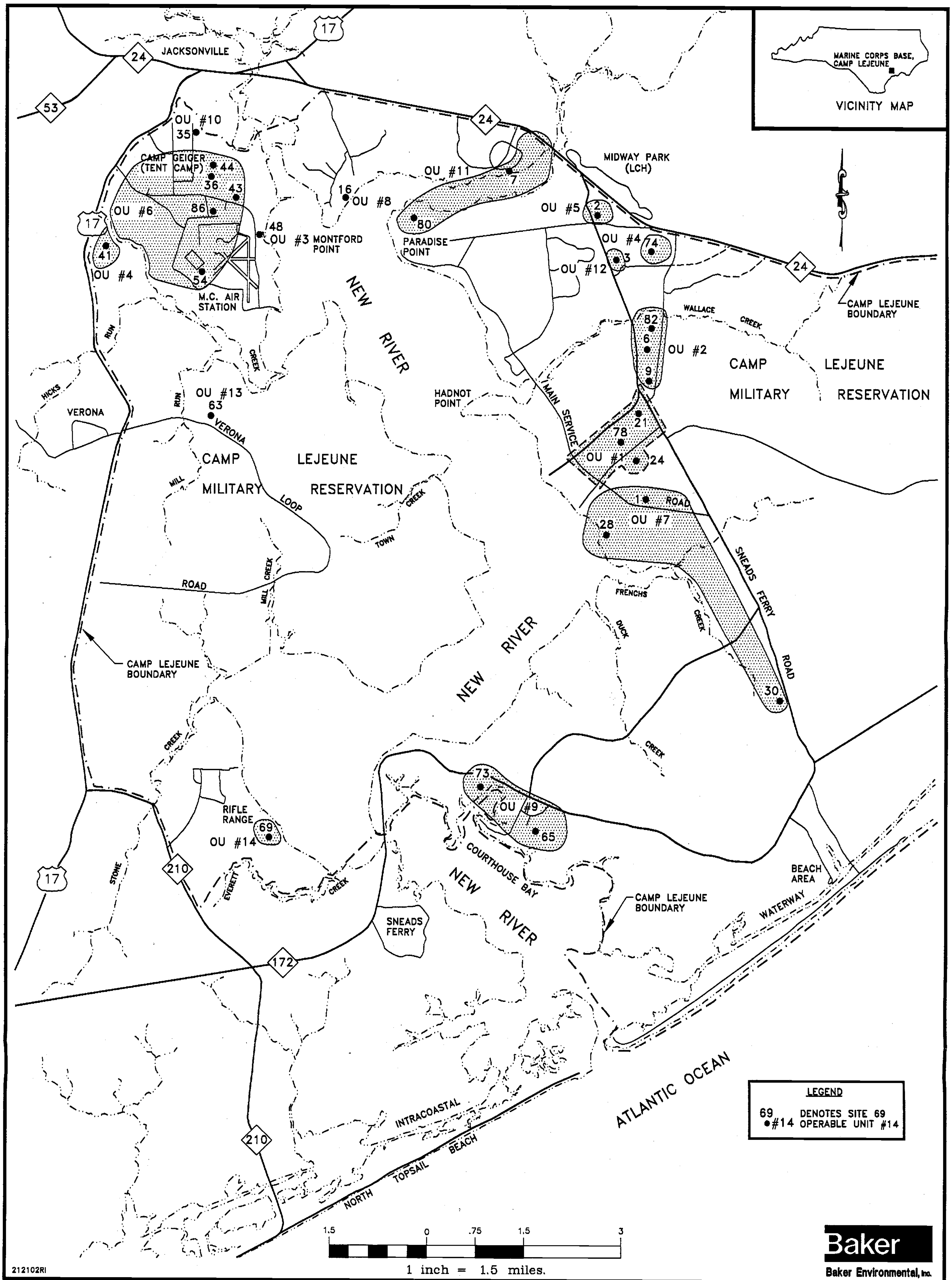
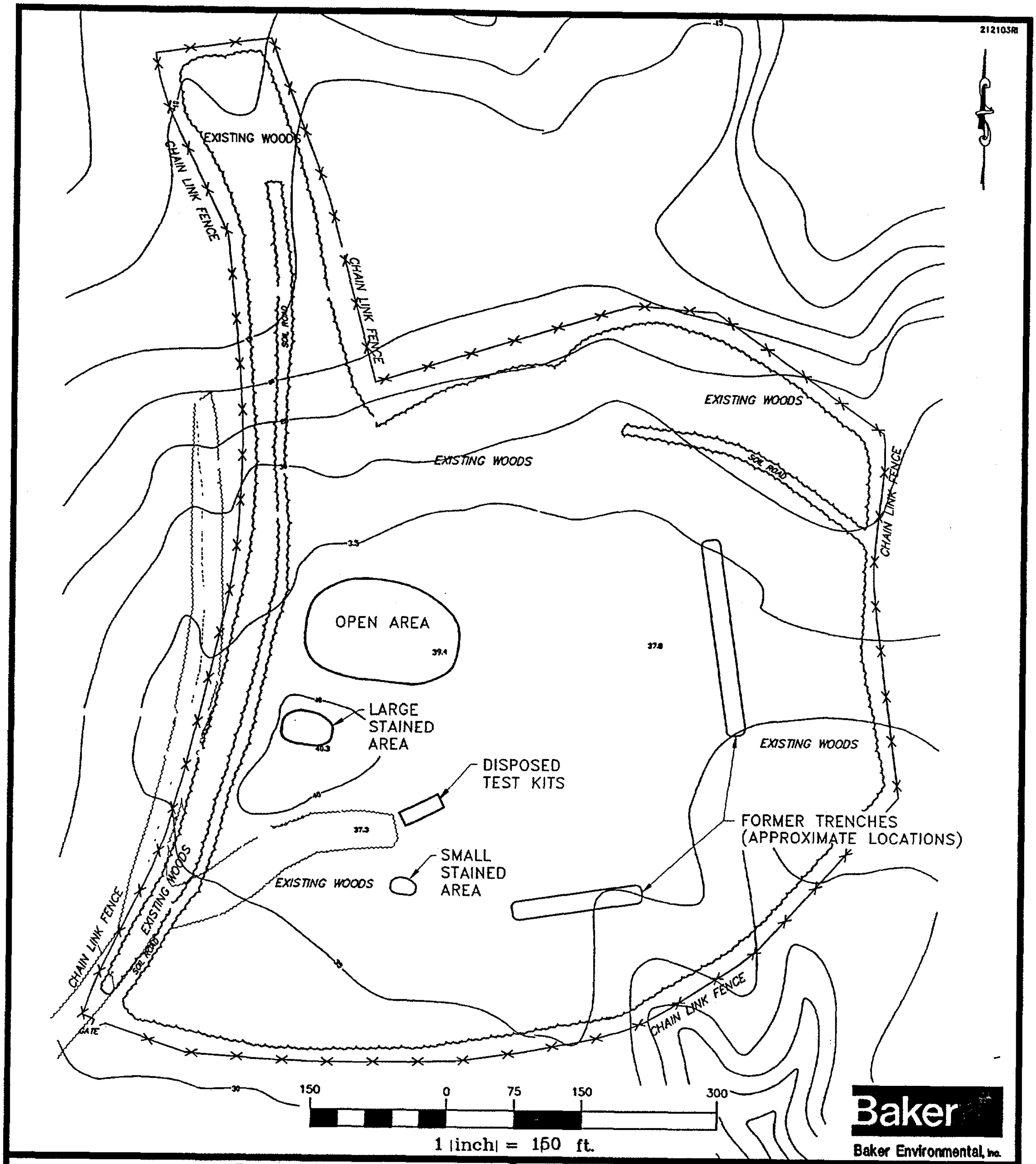


FIGURE 1-2
OPERABLE UNITS AND SITE LOCATIONS AT
MARINE CORPS BASE CAMP LEJEUNE
REMEDIAL INVESTIGATION CTO-0212
MARINE CORPS BASE, CAMP LEJEUNE
NORTH CAROLINA

01761N032



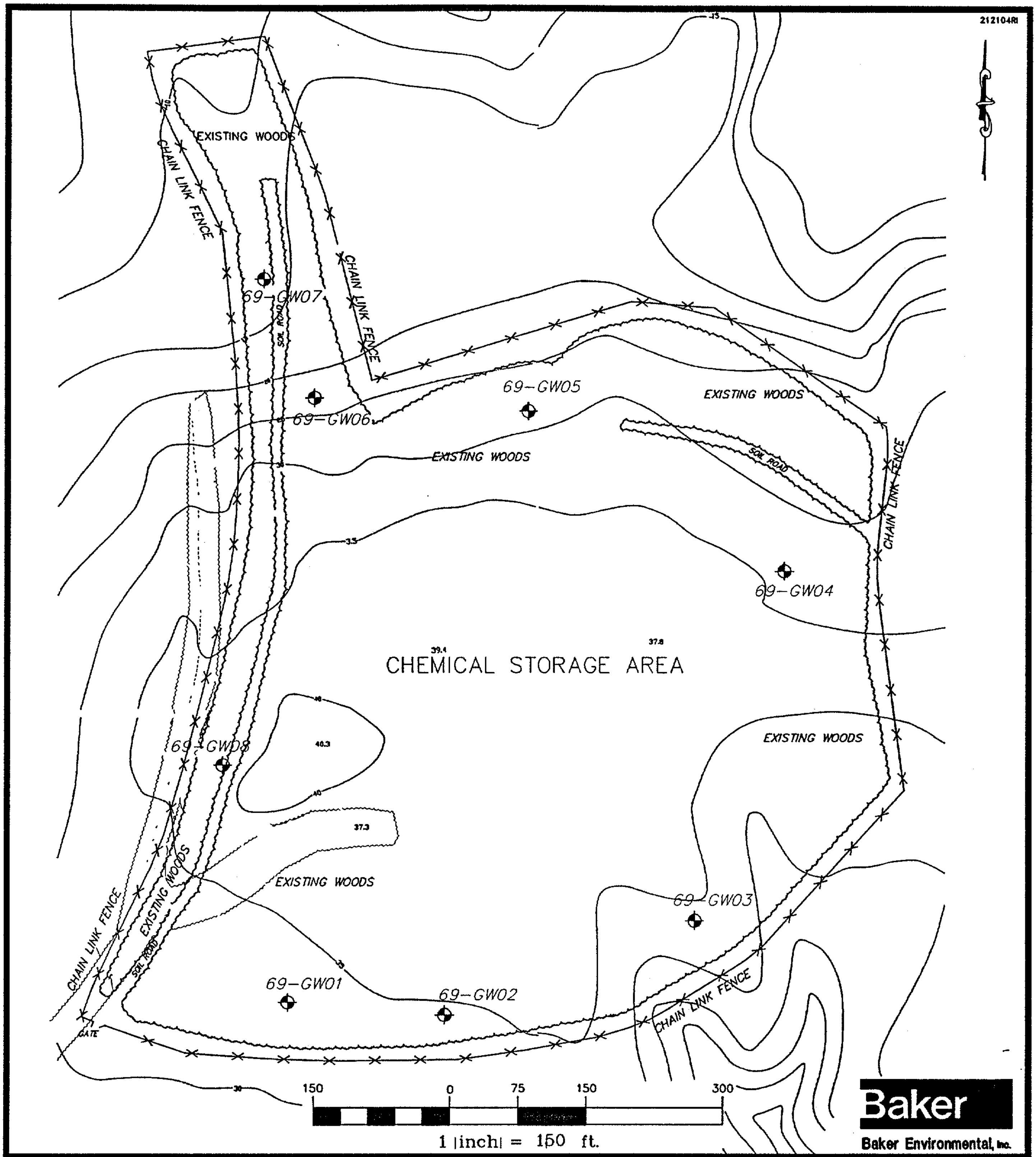
Baker Environmental, Inc.

LEGEND

- FENCE
- VEGETATION
- TOPOGRAPHIC ELEVATION LINES (FEET, MSL)

SOURCE: REVISED FROM LANTDIV, OCT. 1991

FIGURE 1-3
SITE MAP
SITE 69 – RIFLE
RANGE CHEMICAL DUMP
REMEDIAL INVESTIGATION CTO-0212
MARINE CORPS BASE, CAMP LEJEUNE
NORTH CAROLINA



Baker

Baker Environmental, Inc.

LEGEND

69-GW01

⊕ EXISTING SHALLOW WELL

—×—×— FENCE

VEGETATION

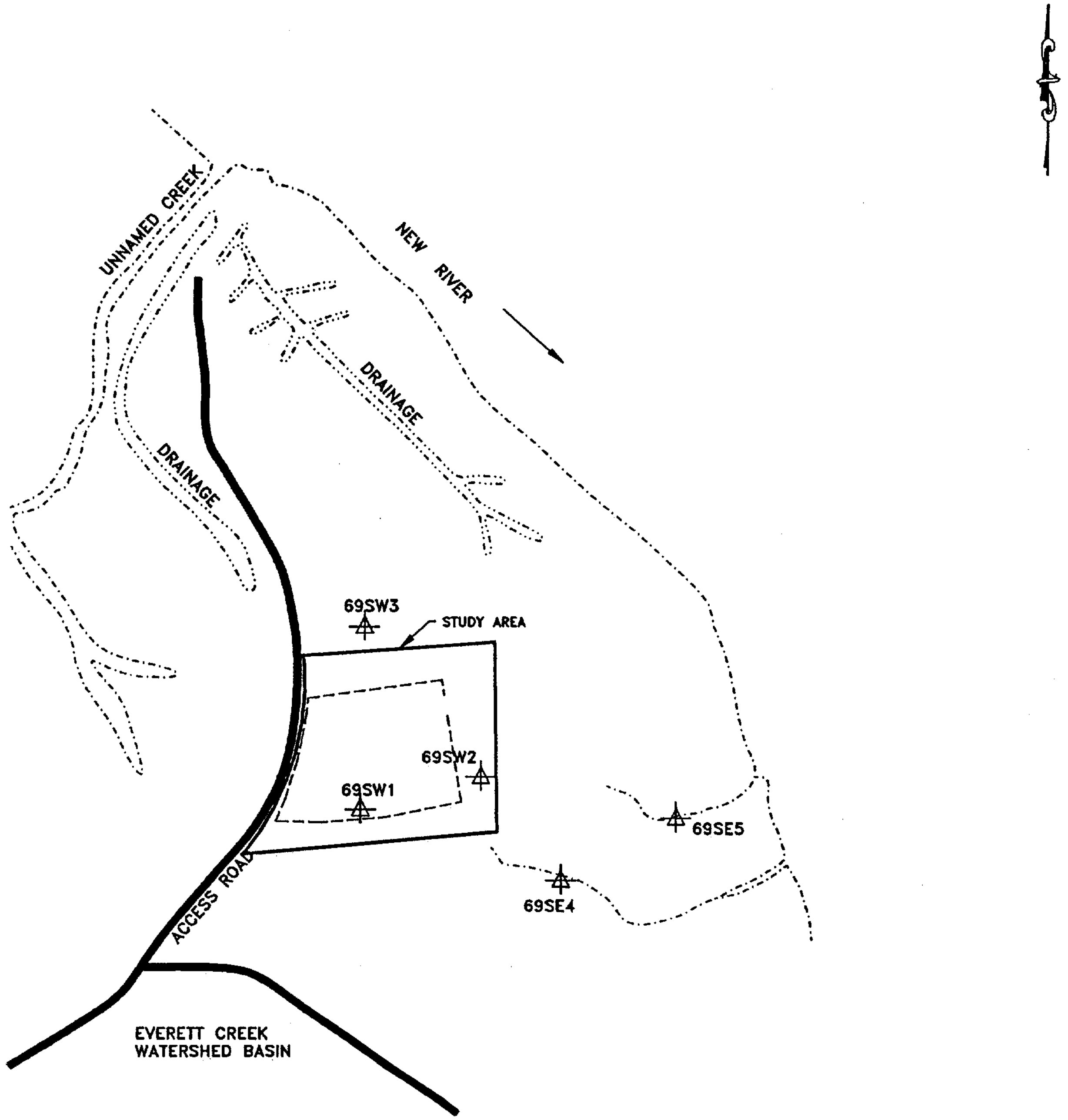
TOPOGRAPHIC ELEVATION LINE (FEET, MSL)

SOURCE: REVISED FROM LANTDIV, OCT. 1991

FIGURE 1-4
CONFIRMATION STUDY
SHALLOW MONITORING WELL
LOCATIONS - SITE 69
REMEDIAL INVESTIGATION CTO-0212

MARINE CORPS BASE, CAMP LEJEUNE
NORTH CAROLINA

212105RI



Baker Environmental, Inc.

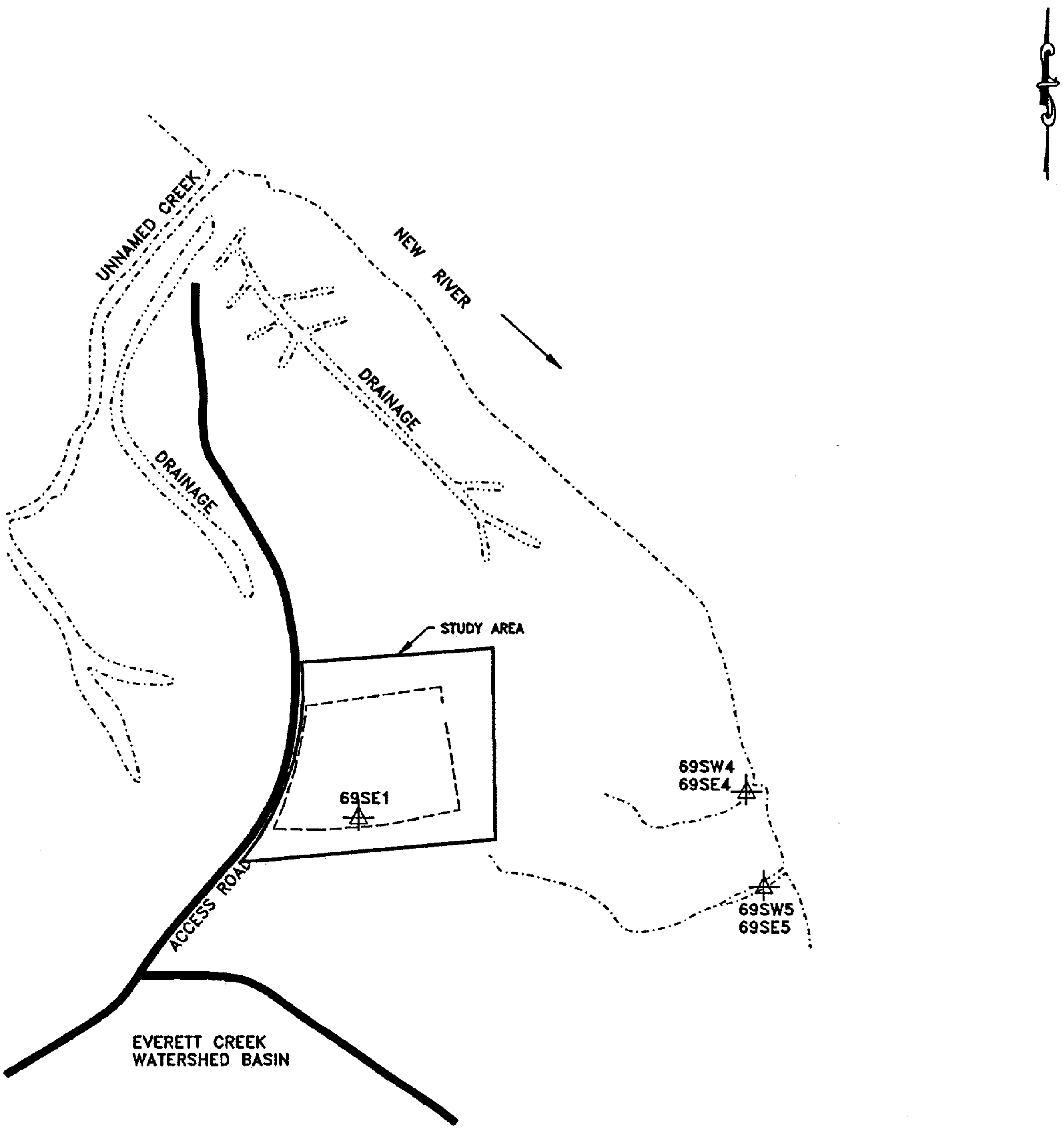
LEGEND

- △ PREVIOUS SURFACE WATER/ SEDIMENT SAMPLE LOCATION
- --- REPORTED LANDFILL BOUNDARY

SOURCE: ESE, 1991

FIGURE 1-5
CONFIRMATION STUDY
SURFACE WATER/SEDIMENT SAMPLING
LOCATIONS (1984/1986) - SITE 69
REMEDIAL INVESTIGATION CTO-0212
MARINE CORPS BASE, CAMP LEJEUNE
NORTH CAROLINA

212106RI



N.T.S.

Baker

Baker Environmental, Inc.

LEGEND

⊕	PREVIOUS SURFACE WATER/ SEDIMENT SAMPLE LOCATION
---	REPORTED LANDFILL BOUNDARY

SOURCE: ESE, 1991

FIGURE 1-6
CONFIRMATION STUDY
SURFACE WATER/SEDIMENT SAMPLING
LOCATIONS (1991) - SITE 69
REMEDIAL INVESTIGATION CTO-0212
MARINE CORPS BASE, CAMP LEJEUNE
NORTH CAROLINA

2.0 STUDY AREA INVESTIGATION

The field programs at Operable Unit No. 14, (Site 69) were initiated to characterize potential disposal related impacts and threats to human health and the environment resulting from previous operations, and disposal activities. This section discusses the site-specific RI objectives for Site 69 (Section 2.1), along with the preliminary RI field activities and the RI field activities conducted to fulfill those objectives.

2.1 Remedial Investigation Objectives

The purpose of this section is to define the site-specific RI objectives aimed at characterizing the problems at each site, assessing potential impacts to the public health and environment, and providing feasible alternatives for consideration in the preparation of the ROD. The site-specific remedial objectives presented in this section have been identified based on review and evaluation of existing background information, assessment of potential risks to the public health and environment, and the consideration of potential feasible technologies/alternatives.

For each site-specific objective identified, the criteria necessary to meet that objective is identified, along with a general description of the study or investigation efforts required to obtain information. Table 2-1 presents this information in tabular form for Site 69, the Rifle Range Chemical Dump.

2.2 Site 69 - Rifle Range Chemical Dump

2.2.1 Aerial Photograph Investigation

In August of 1992, an interim aerial photographic investigation report was completed by the USEPA's Environmental Photographic Interpretation Center (EPIC) in Warrenton, Virginia, of the Advanced Monitoring Systems Division in Las Vegas, Nevada. The investigation was performed at the request of the Superfund Support Section of USEPA Region IV. The aerial photographs detail operations at Site 69 during the period from 1949 to 1980. Investigation results were employed to locate and assess potential sources of contamination, and to document past waste disposal activities within the study areas.

Information supplied by USEPA Region IV identified Areas of Concern (AOCs) within Site 69, and verified the occurrence of waste disposal activities. Where possible, such activities were noted in the EPIC report (and annotated on the photographs from years 1956, 1964, and 1970).

Black-and-white aerial photographs from 1949, 1956, 1958, 1964, 1970, 1974, 1975, and 1980 were used for the analysis of Site 69. The 1938 round of photographs established a basis of comparison, prior to development of the Camp Lejeune Military Reservation.

The analysis was performed by viewing backlit transparencies of aerial photographs through a stereoscope. Stereoscopic viewing of aerial photographs creates a perceived three-dimensional effect which enables the analyst to identify visible characteristics (e.g., color, tone, shadow, texture, size, shape, and pattern). These visible characteristics permit a specific object or condition to be recognized on aerial photographs (EPIC, 1992).

2.2.1.1 Aerial Photograph - February 1956

Activity is first noted at this site in this year of photography. The site consists of a partially revegetated and disturbed ground area. According to collateral information, the site was used at some point as a rifle range. Two trenches are visible along the southeastern borders of the disturbed ground area. Trench No. 1 (TR1) contains dark-toned liquid. Note that any potential overflow of liquid from TR1 would flow south into the drainage pathway which eventually leads east into the New River (EPIC, 1992).

Two sections of Trench No. 2 (TR2) have been excavated. A dark-toned area of material (possibly vegetation) is visible adjacent to TR2. Several mounds of light-toned material (presumably excavated from the trenches) are present next to TR1 and TR2. A small linear mound of material is also visible along the north edge of the site (EPIC, 1992).

This year of aerial photography has been reproduced, and is provided on Figure 2-1.

2.2.1.2 Aerial Photograph - November 1958

Photography from 1958 was not reproduced for the EPIC report, and was unattainable for this RI report. However, photography features from 1958 will be annotated on the 1964 photography.

In 1958, a small drainage channel was visible for the first time, leading away from the southeast corner of Site 69. By 1958, TR1 and TR2 have become enlarged. Trench No. 3 (TR3) is now visible and appears to be connected to the south edge of TR2. Note that the approximate southern half of the range (between the trenches and the road/trail) has been cleared. The northern half of the disturbed ground area visible in 1956 continues to revegetate (EPIC, 1992).

2.2.1.3 Aerial Photograph - February 1964

The northern half of Site 69 continues to revegetate. TR1 through TR3 remain visible. TR1 contains probable medium-toned liquid. The vehicle pathway and associated cleared area visible in 1958 have revegetated. TR2 and TR3 are revegetating (not annotated). A small cleared area is visible within the wooded areas south of Site 69. Farther south, an even larger area, which appears to be in the process of being cleared, is visible (EPIC, 1992).

This year of aerial photography has been reproduced, and is provided on Figure 2-2.

2.2.1.4 Aerial Photograph - October 1970

TR1 through TR3 have been filled. Most of the former rifle range has revegetated, except for a graded area visible at the location of the disturbed ground area seen in 1958 and two additional graded areas noted at the former locations of TR2 and TR3. A solitary pool of probable liquid is seen within the northern graded area. Note also that the cleared areas visible south of Site 69 in 1964 have since revegetated (EPIC, 1992).

This year of aerial photography has been reproduced, and is provided on Figure 2-3.

2.2.2 Preliminary RI Field Investigation

Geophysical Investigation

A geophysical survey was conducted by Baker at Site 69 from August 24 to September 3, then again from December 14 to 18 of 1992. The survey objectives were to characterize subsurface conditions present at the site by delineating areas of suspected disposal and by identifying locations of buried metal. The firm of Weston Geophysical Corporation (Weston) was retained to perform the survey.

Due to heavy vegetation and understory at Site 69, geophysical traverses were referenced to an old road crossing the site and located by compass bearing and taped distance measurements. These east-west oriented traverses were subsequently located and stationed at 50-foot intervals by Hoggard/Eure Associates. A second phase geophysical investigation at Site 69 was then conducted to further define areas of suspected burial.

Two geophysical techniques were employed during the survey including electromagnetic terrain conductivity (EM), and magnetometry. EM profiling was performed to measure lateral variations in subsurface conductivity, indicative of previous disposal and backfilling, and to identify buried metallic objects and debris. Magnetic profiling was performed to complement the EM interpretation of subsurface objects and debris.

EM conductivity and magnetic intensity measurements were obtained along orthogonal traverses extending across the site. Results from the EM measurements showed background conductivity levels at 10 mmhos/m. A distinct increase in conductivity above 10 mmhos/m, representative of a lateral change in conductivity due to buried waste and fill material, was measured across two broad areas as shown on Figure 2-4. Within these two areas, EM in-phase and magnetic measurements indicated buried metallic and ferrous metallic objects.

The greater lateral extent of increased conductivity, to that of detected buried metal, may suggest that previous widespread burial of non-metallic debris on site may have occurred. Furthermore, zones of highest conductivity were not always coincident with the area of buried metal, suggesting widespread disposal on-site. An alternative explanation for the lateral extent of increased conductivity, primarily to the south and north, may be the presence of a conductive contaminant plume.

Appendix A contains the report prepared by Weston for the geophysical survey at Site 69.

2.2.3 RI Field Investigation

The initial RI field investigation performed at Site 69 commenced on January 3 and continued through March 4, 1994. The field program implemented during the investigation consisted of a preliminary site survey; hydropunch investigation; soil investigation including drilling and sampling; a groundwater investigation including monitoring well installation (shallow and deep wells) and sampling; surface water and sediment investigations; and an aquatic and ecological survey.

Additional RI investigations, which focused primarily on characterizing the extent of groundwater contamination, were initiated in May 1994, December 1994, March 1995, September 1995 and March 1996.

2.2.3.1 Preliminary Site Survey

During the week of December 26, 1993, a Baker field crew established a soil sampling grid at Site 69. In addition to the soil grid, proposed well locations were also identified and staked.

The soil sampling grid at Site 69 was established to encircle the large area of possible buried metal, found by the geophysics survey. The grid at Site 69 is referred to as the Chemical Storage Area (CSA). The CSA grid was established on 100 foot by 100 foot spacings at Site 69 and laid out by scaling existing CADD drawings for distance, and then by taping these distances off from existing structures present at the site. Pin flags were then placed at the measured locations with their respective sample identification numbers placed on the pin flag. Provided on Figure 2-5 is the location of the CSA soil sampling grid.

Proposed well locations were also established by utilizing existing CADD drawings for reference. Access to all well locations at Site 69, being that the site is heavily wooded, required a substantial amount of clearing. Heavy equipment (i.e., CASE 38EE front end loader) was utilized to plow roads and make cuts into heavily vegetated areas. Chainsaws were also used to cut down larger trees preventing drill rig access. Proposed well locations were then staked and given their corresponding identification number. Provided on Figure 2-6 are the well locations for the initial set of monitoring wells at Site 69.

2.2.3.2 Hydropunch Investigations

On January 6 and 7, 1994, Baker retained the services of Target Environmental Services, Inc. (Target) to perform hydropunch groundwater sampling at Site 69. A total of 14 groundwater samples were collected at the site. Seven of these samples were collected from the drainage area to the southeast of the site, and the other seven were collected from the drainage area to the northeast. Figure 2-7 depicts the hydropunch locations in both the southeast and northeast drainage areas.

To collect the samples, a van-mounted hydraulic probe was used to advance 3 foot sections of 1-3/8" outside diameter (OD) threaded steel casing to the sampling depth. The steel casing was then removed and a 5 foot section of 1" diameter slotted PVC pipe was connected to one or more 5 foot sections of PVC riser pipe and was inserted to the full depth of the hole. The pipe was allowed to sit from one to two hours to allow groundwater to fill the pipe. A stainless steel bailer was utilized to collect the sample from the PVC slotted riser. Samples were placed in 40 mL, teflon septum sealed glass vials and acidified to pH 2 using a 50% hydrochloric acid solution, sealed, labeled, and shipped to the laboratory. Samples NE-7A and SE-7A, because they were collected from the swampy standing water areas, were collected by submerging clean vials with clean sampling gloves and then preserving the samples as described above.

Prior to the day's field activities and after collection of each sample, the steel casing and the bailer apparatus were decontaminated by washing the equipment with a Alconox soap solution (laboratory detergent), rinsing with distilled water, and drying with filtered ambient air to ensure discrete sampling.

All of the 14 samples collected were prepared for analysis according to EPA Method 3810, and analyzed according to EPA Method 8010 on a gas chromatograph equipped with an electron capture detector (ECD). Four analytes were chosen to be screened during analysis, due to the common usage in industrial solvents. The following chemicals were analyzed for; trans-1,2-DCE, cis-1,2-dichloroethene (cis-1,2-DCE), TCE, and tetrachloroethene (PCE). Target's Report on the

January 1994 investigation is presented in Appendix B of this report. Results of the hydropunch sampling are discussed in Section 4.4.2 of this RI Report.

On March 21, 1995 and March 22,1995, Target performed a second hydropunch investigation within Site 69. A total of nine locations were sampled and are shown on Figure 2-7. This investigation was to further define surficial groundwater contamination north of well location 69-GW02, since elevated levels of volatile organic compounds (VOCs) had been detected in wells in the southern portion of the site (near wells 69-GW02 and 69-GW03).

Surficial groundwater samples from these hydropunch locations were analyzed in the field. Samples were subjected to a dual analyses. One analysis [USEPA Method 8010 (modified)] was performed using a gas chromatograph equipped with an electron capture detector (ECD) and the second analysis [USEPA Method 8020(modified)] was conducted using a gas chromatograph equipped with a flame ionization detector (FID). These analyses were for chlorinated solvents and BTEX constituents, respectively. Results of the sampling and analyses are presented in Section 4.5. Subsurface soil samples were also collected from these sampling locations from just above the groundwater surface. These samples were sent to a contracted laboratory for analysis and are discussed in the soil investigation subsection (Section 2.2.3.3). Target's Report on the March 1995 investigation is presented in Appendix B of this report and the results are discussed in Section 4.5. All locations for this investigation were initially cleared by an unexploded ordnance subcontractor, and sampling activities were monitored by the U.S. Army Technical Escort Unit (TEU) for chemical surety degradation compounds (CSM). TEU also field screened the samples for CSM prior to submittal to the laboratory.

Field QA/QC samples were collected before the hydropunch sampling was initiated, at the end of the first day of survey activities, and at the end of the second day of survey activities. These QA/QC samples were collected by rinsing distilled water through the decontaminated stainless steel bailer into sample vials. These results of the QA/QC samples are presented along with hydropunch samples in Section 4.4.3 of this RI Report.

2.2.3.3 Soil Investigation

The soil investigation performed at Site 69 was intended to assess the nature and extent of contamination which may have resulted from previous disposal practices or site activities. Additionally, the investigation was performed to assess human health, ecological, and environmental risks associated with exposure to surface and subsurface soils. The following describes the sample collection procedures, sample locations, and analytical program.

The soil investigation conducted at Site 69 focused on two main AOCs; the background and on-site surface soil quality of the former disposal area, and the subsurface soil quality from monitoring well boreholes. Monitoring well boreholes were located on-site and to the northeast and southeast of the fenced-in portion of Site 69. Results from subsurface soils that were analyzed were used for correlation to groundwater analyses. The drilling procedures, soil sample locations, sampling procedures, and the analytical program for this soil investigation are summarized below.

Drilling Procedures

Drilling activities at Site 69 commenced on January 6, 1994, and continued through January 12, 1994. Hardin and Huber, Inc. (HHI) was retained to perform the drilling services. The majority of surface soil samples were collected by a hand auger. The boreholes for well installations were advanced by a All Terrain Vehicle (ATV) mounted drill rig using 3-1/4-inch inside diameter (ID) hollow stem augers. Split-spoon samples were collected from inside the augers according to ASTM Method D 1586-84 (ASTM, 1984). Additionally when samples could not be collected with the drill rig due to access or site conditions (i.e., swamp or low areas), samples were obtained by a hand auger. The ID of the hand auger is 3.5 inches, and had a sample depth of 6 inches. For soil borings requiring sample depths of greater than 6 inches, extension poles were affixed to the hand auger to obtain samples from varying depths. Soil cuttings obtained during the drilling program were contained and handled according to the procedures outlined in Section 2.4.

Two types of borings were installed during the investigation: hand auger exploratory borings (i.e., borings installed for sample collection only) and borings advanced for monitoring well installation. The sampling intervals for each type of boring were different because of the analytical requirements for each type. [Note that only selected samples (see Soil Sampling Procedures discussion below) were submitted to the laboratory for analysis.] Soils obtained from hand augers were collected from the surface (ground surface to 1 foot) and then were terminated due to the possibility of CWMs present on site. Soils obtained from borings advanced for monitoring well installation were obtained at continuous two-foot intervals (from the ground surface) to 10 feet below the water table for shallow monitoring wells, then at approximate five-foot intervals thereafter for the deep monitoring wells, until the borings were terminated. In some cases where potential wetting fronts were suspected (i.e., perched water table), an additional split-spoon was driven below the water table to confirm groundwater depth. This sampling scheme was employed because surface soils were not subject to analytical testing from monitoring well borings. A summary of the sample/boring numbers, depths, and intervals for Site 69 is provided in Table 2-2.

Hand auger cuttings and split-spoon soil samples were classified in the field by a geologist. Soils were classified using the Unified Soil Classification System (USCS) by the visual-manual methods described in ASTM D-2487 and D-2488. Lithologic descriptions were recorded in a field logbook and later transposed onto boring log records. Soil classification included characterization of soil type, grain size, color, moisture content, relative density (from "blow counts"), plasticity, and other pertinent information such as indications of contamination. Lithologic descriptions of site soils are provided on the Test Boring Records in Appendix C and the Test Boring and Well Construction Records in Appendix D.

Soil Sampling Locations

The majority of the soil samples were collected within the fenced-in area at Site 69 as depicted on Figure 2-8. The sampling distribution was intended to evaluate the vertical and horizontal extent of contamination at the two AOCs. Selection of sample locations was based on review of historical aerial photographs, geophysical survey results, Camp Lejeune historical records, and previous investigation data. Review of these documents indicated that the trenched areas were used for disposal. A total of 29 hand auger borings were advanced to assess the background and surface soil of the formal disposal area at Site 69. A total of 15 borings were advanced for monitoring well installation to assess subsurface soil quality for correlation to groundwater analysis. Additionally, ten subsurface soil samples were collected from the hydropunch locations and intermediate well location during March 1995.

Soil Sampling Procedures

Surface soil samples [ground surface to 1 foot below ground surface (bgs)] collected from hand augers and subsurface soil samples from monitoring well installations (deeper than 1 foot bgs) were retained for laboratory analysis. Both surface and subsurface samples were collected to evaluate the nature and extent (both horizontal and vertical) of potentially impacted soils. The surface soils, however, were collected for human health and ecological risk assessment evaluation. A summary of the sample/boring numbers, depths, intervals , and parameters analyzed for Site 69 is provided in Table 2-2.

Soil samples were obtained via a drill rig (i.e., split-spoon samples) or a hand auger as described in the section on drilling procedures. Surface samples were collected by slowly advancing the augers to approximately 1 foot bgs so that the soil cuttings could be retained for the grab sample. Deeper subsurface grab samples were collected with a split-spoon sampler in accordance with ASTM Method D 1586-84. The augers, split-spoons samplers, and hand auger buckets were decontaminated prior to sample collection according to the procedures outlined in Section 2.3.

Only one sample from each of the surface soil borehole locations was retained for laboratory analysis. Typically, two samples per monitoring well boreholes were submitted for analysis. In some cases, a third sample from the borehole was also submitted for analysis if indications of contamination (i.e., elevated photoionization detector (PID) readings or visual contamination) were noted or if the encountered groundwater table was deeper than 6 feet. In general, samples retained for laboratory analysis were collected from the surface. Samples were also submitted from just above and below the water table at borings advanced for monitoring well installation so that groundwater results could be correlated with soil conditions. Note that surface soil samples were not submitted from monitoring well borings.

Soil samples retained for analysis were prepared and handled according to USEPA Region IV Standard Operating Procedures (SOPs). Samples collected for volatile organic analysis were extracted with a stainless-steel spoon from different sections of the split-spoon or auger bucket which represented the entire sampling interval. Precautions were taken not to aerate the sample to minimize volatilization. Samples retained for other analytical parameters (e.g., semivolatiles, pesticides/PCBs, and metals) were first thoroughly homogenized and then placed in the appropriate laboratory containers.

During the March 1995 hydropunch investigation, subsurface soil samples were collected from just above the groundwater surface. These samples were collected by Target using a push type sampler which was equipped with a plastic liner. The liners were removed from the sampler and split open to recover the soil sample. As with the initial soil investigation, samples were prepared and handled for analysis according to USEPA Region IV SOPs.

Following sample collection, each sample retained for laboratory analysis was stored on ice in a cooler. Samples remained within the cooler until written documentation from the United States Army Technical Escort Unit (TEU) was provided indicated that the samples had been screened for possible CWMs (i.e., Mustard or blistering agents). Upon Baker receiving written documentation that the samples were absent of any CWMs, the samples were then processed and packaged for shipment to the laboratory. Sample preparation also included documentation of sample number, depth, location, date, time, and analytical parameters in a field logbook. The following information is provided on the Chain-of-Custody documentation, (provided in Appendix E) sample number, date, time of sampling, and sampling personnel, accompanied the samples to the laboratory. Samples were shipped overnight via Federal Express to GP Environmental Services, Inc. (GP) in Gaithersburg, Maryland for analysis.

Analytical Program

The analytical program initiated for the soil investigation at Site 69 focused on the suspected contaminants of concern which were based on previous disposal practices. Soils collected from the background and former disposal area locations were analyzed for the full TCL organics and TAL inorganics, CWM (degradation products), and thiodiglycol. Soil samples obtained from monitoring well installations were analyzed for full TCL organics and TAL inorganics. A summary of the sample/boring numbers, depths, intervals, and parameters analyzed for Site 69 is provided in Table 2-2.

Soil samples collected during the March 1995 investigation were analyzed for VOCs and CSM constituents. These analyses were based on the detected levels of 1,2-dichloroethene (total) (1,2-DCE) and trichlorethene (TCE) in groundwater at well location 69-GW02, and on the potential of chemical warfare materials from past disposal activities. A summary of the sample number, depths and parameters analyzed is provided in Table 2-2.

In addition to analyzing for the contaminants of concern, one boring/well installation was advanced for the collection of soils for analysis of engineering parameters (i.e., particle size, and Atterberg limits). Engineering parameter samples consisted of composites of individual grab samples collected from the ground surface to the water table. Note that the samples were prepared and handled as described in the previous paragraph (i.e., samples were thoroughly homogenized prior to filling the sample jars).

Quality Assurance and Quality Control

Field Quality Assurance/Quality Control (QA/QC) samples were collected during the soil investigation. These samples were obtained to: (1) ensure that decontamination procedures were properly implemented (e.g., equipment rinsate samples); (2) evaluate field methodologies (e.g., duplicate samples); (3) establish field background conditions (e.g., field blanks); and (4) evaluate whether cross-contamination occurred during sampling and/or shipping (e.g., trip blanks). 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 Naval Energy and Environmental Support Agency (NEESA) DQO Level D, as specified in the "Sampling and Chemical Analysis Quality Assurance Requirements for the Navy Installation Restoration Programs" document (1988).

Four types of field QA/QC samples were collected and analyzed including: duplicate samples; equipment rinsate samples; field blanks; and trip blanks. These sampling definitions are listed below (USEPA, 1991):

- Duplicate Sample: Two or more samples collected simultaneously into separate containers from the same source under identical conditions.
- Equipment Blanks: Equipment field blanks are defined as samples which are obtained by running organic free water over/through sample collection equipment after it has been cleaned. These samples are used to determine if cleaning

procedures were adequate. (The equipment could have been cleaned in the field or prior to the field operation.) Equipment blanks were collected daily but only samples collected on every other day were analyzed.

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

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

Table 2-3 summarizes field QA/QC sample types, sample frequencies, the number of QA/QC samples, and parameters analyzed.

Field QA/QC samples were collected at Site 69 (including duplicate samples; field blank samples, equipment rinsate samples; and trip blanks) according to the procedures outlined in the USEPA Region IV SOPs.

Field Screening and Air Monitoring

Several air monitoring and field screening procedures were implemented during the drilling and sampling activities for health and safety and initial contaminant monitoring. During drilling, ambient air monitoring in the vicinity of the borehole was performed with a PID to monitor for airborne contaminants. Moreover, samples (i.e., split-spoon samples) were screened with a PID to measure for volatile organic vapor. Measurements obtained in the field were recorded in a field logbook and later transposed onto the Test Boring Records and the Test Boring Records and Well Construction Records which are provided in Appendices C and D. Field instruments were calibrated and documented on calibration forms prior to the start of field work each day.

2.2.3.4 Groundwater Investigation

The groundwater investigation performed at Site 69 was intended to assess the nature and extent of contamination which may have resulted from previous disposal practices or site activities. Additionally, the investigation was performed to assess human health, ecological, and environmental risks associated with exposure to groundwater. The following describes the sample collection procedures, sample locations, and analytical program.

Four shallow Type II (i.e., wells installed without casing to seal off a confining layer) monitoring wells (69-GW09, 69-GW10, 69-GW11, and 69-GW12) were installed at Site 69 between January 7, and January 12, 1994. In addition to the shallow wells, one Type II well (69-GW12DW), and one

Type III well (69-GW02DW) (i.e., wells installed with casing to seal off a confining unit) were also installed in the upper portion of the Castle Hayne aquifer. Well locations are presented on Figure 2-9. The shallow monitoring wells were installed to collect groundwater from the surficial aquifer for characterizing the nature and horizontal extent of potentially impacted groundwater, and to evaluate shallow groundwater flow patterns at the site. The deeper monitoring wells were installed for the same reasons as above, but to characterize the upper portion of the Castle Hayne aquifer. Selection for the placement of the wells was based on review of historical aerial photographs, Camp Lejeune records, and analytical findings from previous investigations.

From May 17 to May 25, 1994, Baker installed four additional wells at Site 69. The purpose of these wells was to delineate the vertical and horizontal extent of volatile contamination that was detected in wells 69-GW02, 69-GW02DW, and 69-GW03. To accomplish this, one well (69-GW02DD) was installed in what is referred to as the intermediate zone of the Castle Hayne aquifer, at a depth of approximately 125 feet bgs. This well was installed to assess potential vertical migration of VOCs. Two wells (69-GW03IW and 69-GW13IW) were installed in the upper zone of the Castle Hayne at depths of approximately 62 feet bgs for purposes of assessing both vertical and horizontal VOC migration. A shallow well (69-GW13) was installed to the east of the suspected source area for purposes of assessing offsite VOC migration. These well locations are depicted on Figure 2-9. Wells 69-GW02DD, 69-GW03IW, and 69-GW13IW were all Type III well construction, with well 69-GW02DD being cased twice (once at 12 feet bgs, and again at 73 feet bgs.). The shallow well (69-GW13) was a Type II construction.

During December 12, 1994 through December 20, 1994, three additional groundwater monitoring wells were installed south of well location 69-GW02 outside the site boundary fence (refer to Figure 2-9) to determine if site VOC contaminants had migrated off-site. This triple nest of wells was installed to monitor the shallow aquifer (69-GW14, 14'), upper Castle Hayne aquifer (69-GW14IW, 62') and the intermediate zone of the Castle Hayne (69-GW14DW, 127'). The shallow well was a Type II construction and the upper Castle Hayne well was a Type III construction with a 6" I.D. steel outer casing installed to a depth of 12 feet in a sandy clay confining layer. The intermediate well was a Type III construction with a 10" I.D. steel outer casing installed to a depth of 12 feet (set in the sandy clay confining layer) and a 6" I.D. steel inner casing installed to a depth of 72 feet. The inner casing was installed to prevent any potential contamination that had been detected in the upper zone of the Castle Hayne at location 69-GW02 from being transported to the intermediate zone during drilling at this new location.

Baker conducted a geophysical survey north of well cluster GW02 and between wells GW02 and GW03 in January 1995. The results of this study indicated a substantial amount of buried metallic debris, especially north of the well GW02. In addition, nine shallow groundwater samples were collected for VOC analysis via the hydropunching technique in order to establish the "northern" boundary of the shallow aquifer VOC plume. The hydropunch locations are depicted on Figure 2-8. The most elevated VOC levels were detected at location HP-02.

Two groundwater monitoring wells were installed during the March 1995 field investigation, based on the results of the hydropunch sampling and analysis. Monitoring wells 69-GW15 (shallow aquifer, 13 feet) and 69-GW15IW (upper zone of the Castle Hayne, 60 feet) were installed north of well location 69-GW02 in the vicinity of hydropunch sample location 69-DA-HP02 which exhibited high levels of 1,2-DCE and TCE. Well 69-GW15 was a Type II construction and well 69-GW15IW was a Type III construction with an 8" I.D. steel outer casing set at 12 feet.

The shallow monitoring wells were installed upon completion of advancing the boreholes. Each borehole was overdrilled with 8-1/4-inch ID hollow stem augers prior to well installation. Well depths ranged from 13.5 to 21 feet bgs. In general, the wells were installed approximately 10 feet below where the water table was encountered during the initial drilling. The wells were installed at depths and with screen interception intervals sufficient to compensate for seasonal variations in the water table (known to fluctuate from 2 to 4 feet). Well construction details for the wells are summarized on Table 2-4, and well construction diagrams are shown on the Well Construction Records provided in Appendix D.

During this stage of the RI, a treatability study (TS) was being implemented to evaluate the effectiveness of a technology known as "in well aeration." The TS focused on remediating the VOCs in-situ as opposed to the more common approach of extracting or collecting groundwater for subsequent physical/chemical treatment and discharge. The TS approach focused on the area near well cluster GW15. During the scoping of the TS, it was determined that the vertical extent of contamination needed to be better defined before completing the final details of the TS. Therefore, as part of the TS, another groundwater investigation was conducted in September 1995. During this investigation, groundwater samples were collected via the hydropunch technique near well cluster GW15 at depths of 50, 60, and 70 feet bgs. From this boring, a well was constructed at a depth of 120 feet bgs (GW15DW) in what is referred to as the intermediate zone. Another well (GW15UW) was installed to a depth of 37 feet bgs to characterize VOC levels in the upper zone of the Castle Hayne, specifically, in the zone just below shallow well GW15. The results of the September 1995 TS groundwater investigation are provided as Appendix X. Well locations are shown on Figure 2-9.

A number of data limitations were identified following the September 1995 study. Specifically, concerns were raised about whether the vertical extent of VOC contamination has been adequately identified. In order to complete the characterization of VOCs in the Castle Hayne aquifer, the following study objectives were established:

- Characterize the vertical and horizontal extent of groundwater contamination in the Castle Hayne aquifer; and
- Determine probable contaminant migration pathways in the Castle Hayne aquifer.

In order to meet the above-mentioned objectives, three deep monitoring wells were constructed during the period March 20 through April 18, 1996. All three wells were constructed to monitor groundwater quality at the bottom zone of the Castle Hayne aquifer. Well GW15BCH was installed near the suspected source area. Monitoring well GW02BCH was installed south of the suspected source area, and well GW03BCH was constructed southeast of the suspected source area. The bottom of the well screens were set at a depth of 230 feet bgs. Figure 2-9 also depicts the locations of all monitoring wells and has been provided in color to differentiate between wells in the shallow aquifer, and in the upper zone, intermediate zone, and deep zone of the Castle Hayne aquifer. The wells were constructed as Type III monitoring wells in accordance with the final RI/FS Project Plans (Baker, 1994).

The upper Castle Hayne monitoring wells were installed upon completion of advancing the boreholes. Each borehole used the drilling method of mud rotary to complete the borehole to the desired depth. Each borehole was drilled with a 8-3/4-inch OD roller bit prior to well installation. All upper Castle Hayne well screen intervals were set in similar geologic material, which best represented the upper portion of the Castle Hayne aquifer. Well construction details are summarized on Table 2-4, and well construction diagrams are shown on the Well Construction Records provided in Appendix D.

The wells were constructed of 2-inch nominal diameter Schedule 40, flush-joint and threaded poly vinyl chloride (PVC) casing with a 10-foot or 15-foot long No. 10 (.01 inch) slotted screen section. A fine-grained sand pack (No. 1 silica sand), extending approximately 2 feet above the top of the screen, was placed in the annulus between the screen and the borehole wall from inside the augers on the shallow wells (note, since augers were not utilized in deep well installation, the sand pack was poured down the borehole manually). A 1 to 2 foot sodium bentonite pellet seal was then placed (by dropping the pellets down the borehole) above the sand pack and hydrated with potable water. The seal was installed to prevent cement or surface run-off from intruding into the sand pack. The remaining annular space was backfilled with a mixture of Portland cement and 5 percent bentonite to ground surface, and then a 6 inch protective casing with cover was placed over the well and into the cement. A protective locking cap was also installed to the top of the PVC well pipe. A 5 foot by 5 foot by 5 inch pad was placed around the protective well casing. Then four protective bollard posts were installed around the corners of the concrete pad. Well tags were installed at the top of each well which contained well construction information. Typical Type II well construction details are shown on Figure 2-10. Figure 2-11 shows the well construction details for a typical intermediate and deep Type III well.

Well Development

Following well construction and curing of the bentonite seal, each newly-installed well was developed to remove fine-grained sediment from the screen and to establish interconnection between the well and the formation. The shallow wells were developed by a combination of surging and pumping (centrifugal pump). The deep wells were developed using a large compressor (equipped with a filter) and "air lifting" the water out of the well. Typically, 50 gallons (approximately 3 to 5 borehole volumes) of water was evacuated from the shallow wells, followed by 10 minutes of surging, then continued pumping. Anywhere from 50 to 150 gallons of water (approximately 3 to 5 borehole volumes) was evacuated from the deep wells. Groundwater recovered during well development was temporarily stored in drums, then transferred into an on-site tanker (refer to Section 2.4 for IDW handling). Pumping hoses (constructed of flexible PVC) were dedicated for each well to minimize the potential for cross contamination.

Measurements of pH, specific conductance, and temperature were recorded at each borehole volume in determining well stabilization. Periodic flow and volume measurements were also recorded during development to evaluate flow rates of the shallow and deeper water-bearing zones. Well Development Forms summarizing this information are provided in Appendix F.

Water Level Measurements

Upon completion of well development activities, static water level measurements were collected from top-of-casing (TOC) reference points (marked on the PVC casing) at each existing and newly-installed well (refer to Section 3 of this RI Report for water level results). Complete rounds of the measurements were collected on the following dates: February 16, March 1, and April 30, 1994; January 25 and February 20, 1995; and May 2, 1996. Groundwater measurements were recorded using an electric measuring tape. Measurements were recorded to the nearest 0.01 foot from TOC. Water level data were collected within a three hour period.

Groundwater Sampling

This section describes the sampling procedures and analytical methods associated with the groundwater sampling program.

Groundwater Sampling Procedures

Groundwater samples were collected to confirm the presence and/or absence of contamination in the shallow and deep aquifers, which may have resulted from previous site disposal practices. At Site 69, the contaminants of concern were: volatiles, pesticides, metals, CWMs, and thiodyglycol based on previous investigative results and historical records. Accordingly, the sampling program initiated at Site 69 focused on these contaminants.

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

Following well volume calculations, a minimum of three to five well volumes were purged from each well prior to sampling. Water was purged from each well using a decontaminated teflon bailer. Measurements of pH, specific conductance, and temperature were made prior to purging and after each well volume was removed to ensure that the groundwater was stabilized before sampling. These measurements were recorded in a field logbook (refer to Section 4 of this RI Report for results). Purge water was contained and handled as described in Section 2.4.

Groundwater samples were collected using decontaminated teflon bailers (i.e., bottom loading bailer). The samples were introduced directly from the bailer into laboratory-prepared, preserved sample containers (where appropriate) and stored on ice. Sample bottles for volatile analysis were filled first, followed by semivolatiles, pesticides/PCBs, CWMs, thiodiglycol, TAL metals (total and dissolved), and cyanide. Volatile samples were collected by slowly pouring water from the bailer into 40 ml vials to minimize volatilization. Samples analyzed for dissolved metals were first collected in laboratory-prepared bottles and filtered in the field prior to placement in bottles [preserved with nitric acid (HNO_3)]. The samples were filtered through a disposable 0.45 micron membrane which was attached to teflon tubing. A peristaltic pump was used for the filtering procedures.

Following the initial sampling at Site 69 in January and June 1994, all subsequent sampling events utilized a "low-flow" purging technique. This technique was implemented to reduce the effects of particulates in groundwater samples on total metal concentrations. The "low-flow" purging and sampling involved the use of a low flow submersible pump set approximately 2-3 feet below the top of the groundwater surface. The flow rate was adjusted to approximately 0.25 gallons per minute (gpm). Water quality measurements for pH, specific conductance, temperature and turbidity were taken to determine when groundwater had reached a state of equilibrium. Samples were collected directly from the pump discharge or with a decontaminated teflon bailer following purging.

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

Analytical Program

One round of groundwater samples were collected in January 1994 from the 8 existing and four newly installed shallow wells. Groundwater samples were collected from the two newly installed upper Castle Hayne wells in February 1994. The groundwater samples were analyzed for volatiles, semivolatiles, pesticides/PCBs, CWMs, thiodiglycol, TAL metals (total and dissolved), and cyanide. The samples were analyzed by Contract Laboratory Program (CLP) protocols. Four additional wells installed in May 1994 were sampled in June 1994 and analyzed for TCL organics and TAL metals (total and dissolved).

Selected wells in the southern and eastern portions of the site were sampled at various times following the initial sampling in January and June 1994 to better define contamination exhibited at well locations 69-GW02 and 69-GW03. These samples were purged and sampled using the "low-flow" purging technique. Samples from the August 1994 sampling event were analyzed for TAL metals (total and dissolved). Selected wells were again sampled in January 1995, following the installation of a three-well cluster at location 69-GW14. These samples were analyzed for VOCs.

A complete round of groundwater samples were collected in February 1995 from the fourteen shallow wells, and seven Castle Hayne wells. These samples were analyzed for VOCs at Microbac Laboratories in Norfolk, Virginia. This sampling round was initiated due to the suspected cross contamination of the January samples from another site at MCB Camp Lejeune.

In March 1995, after the installation of wells 69-GW15 and 69-GW15IW. A total of 5 shallow and 7 Castle Hayne wells were sampled and analyzed for VOCs by Quanterra Laboratories in Pittsburgh, Pennsylvania.

In September 1995, as part of the pre-treatability study groundwater investigation, groundwater samples were collected via hydropunching to better define the extent of groundwater contamination near shallow monitoring well G15. Based on these results, two additional wells were installed in the Castle Hayne aquifer (wells GW15DW and GW15UW). Samples were collected from the two newly-installed wells and from wells GW15 and GW15IW, and analyzed for VOCs.

In April 1996, following the installation of three deep wells in the Castle Hayne aquifer, additional groundwater sampling was performed. Samples were collected from the three newly-installed wells (GW02BCH, GW03BCH, and GW15BCH) and from existing wells GW02D, GW03D, and GW15DW for analysis of VOCs.

Quality Assurance and Quality Control Samples

Field QA/QC samples were also submitted during the groundwater investigation. These samples included trip blanks, equipment rinsates, and duplicates. Equipment rinsates were collected from the sampling bailers prior to usage. Table 2-5 summarizes the QA/QC sampling program employed for the groundwater investigation conducted at Site 69.

Field Screening and Air Monitoring

Several air monitoring and field screening procedures were implemented during the groundwater sampling activities for health and safety and initial contaminant monitoring. Air monitoring and field screening procedures implemented at Site 69 were: screening of the well head, and screening of the actual purged groundwater with a PID to measure for volatile organic vapor. Measurements obtained in the field were recorded in a field logbook. Field instruments were calibrated and documented on calibration forms prior to the start of field work each day.

2.2.3.5 Surface Water and Sediment Investigation

This section discusses the surface water and sediment investigations conducted for Site 69. Included in this section are the sampling methodologies, procedures, locations, analytical requirements, and QA/QC sample types of the surface water and sediment investigations. Site 69 had a full ecological and aquatic survey conducted during the period that RI activities were being performed for OU. No. 2 (August through November 1992). In addition to this survey, a surface water and sediment investigation was also conducted during field activities from January through March 1994. For this report, the ecological and aquatic survey is discussed in Section 2.2.3.6 and the surface water and sediment investigation is discussed below.

Surface Water and Sediment Sampling Locations

Seven surface water and seven sediment samples were collected at Site 69. Three of the samples were obtained from on-site standing water areas. Two samples were collected from the drainage area to the northeast and two samples were collected from the drainage area to the southeast. Figure 2-12 provides the surface water and sediment sampling locations at Site 69. Surface water samples are designated with an SW (i.e., 69-OS-SW01 indicating Site 69, on-site, surface water station 01). Sediment samples are designated with an SD. Sediment locations, depth of sample, sampling interval, and analytical parameters for Site 69 are provided on Table 2-6.

Surface Water and Sediment Sampling Procedures

At all sampling stations, surface water samples were collected by dipping the sample container directly into the water surface. Most samples were collected at the approximate vertical mid-point by dipping the sample bottles directly into the water. Samples analyzed for volatiles were obtained prior to any other sample collection. Care was taken to avoid excessive agitation that could result in loss of volatiles. At all surface water locations, water quality readings were taken (i.e., pH, specific conductance, and temperature).

Sediment samples were collected below an aqueous layer using either a stainless steel spoon or hand auger. The sediment was then placed into the appropriate sample containers, volatiles being collected prior to the remaining analytical parameters. At each station, sediment samples were collected from the surface to 0.5 feet bgs.

All samples were collected in clean containers provided by the laboratory. Bottles for surface water sample collection which contained a preservative (i.e., nitric acid), a transfer bottle was utilized for sample collection.

The majority of the surface water samples were collected from areas where the water appeared stagnant or contained minimal flow. This was the case throughout many of the surface water features due to the small amount of precipitation incurred during the field investigation. In general, samples were collected at surface water features that were either on-site or adjacent to Site 69 to accurately assess any impacts resulting from former disposal operations. Sediment samples were collected following collection of the surface water samples to minimize sediment resuspension. Surface water and sediment sample were collected from downstream stations prior to moving to upstream stations.

All sample locations were displayed by placing a pin flag at the nearest bank or shore. The sample number was marked on the pin flag with indelible ink.

Surface Water and Sediment Analytical Program

The analytical program initiated for the surface water and sediment investigation at Site 69 focused on suspected contaminants of concern and the overall surface water/sediment quality. As mentioned previously, the contaminants of concern were identified from previous investigations. Both surface water and sediment samples were analyzed for full TCL organics, TAL inorganics, CWMs, and thiodiglycol.

Quality Assurance and Quality Control Samples

Field QA/QC samples were also collected during the surface water and sediment investigations, including duplicate samples, equipment rinsate samples, and trip blanks. The QA/QC sample collection frequencies are the same as those described in Section 2.2.3.3. Table 2-7 summarizes field QA/QC samples collected for the surface water and sediment program.

Field Screening and Air Monitoring

Several air monitoring and field screening procedures were implemented for the surface water and sediment sampling activities for health and safety and initial contaminant monitoring. Air monitoring and field screening procedures implemented at Site 69 were: screening of the surface water, and screening of the sediment with a PID to measure for volatile organic vapor. Measurements obtained in the field were recorded in a field logbook. Field instruments were calibrated and documented on calibration forms prior to the start of field work each day.

2.2.3.6 Ecological and Aquatic Survey

A ecological and aquatic survey was conducted of Site 69 under the field operations of OU. No. 2 during the period from August to November, 1992. Three AOCs were investigated. The three areas included: the unnamed tributary to the New River which is located north of Site 69, Everett Creek which is located approximately 1/4 mile south of Site 69, and the New River which is located approximately 1/4 mile to the east of Site 69. The following subsections discuss the type of media sampled, the sampling locations, the sampling procedures, the analytical program, and QA/QC sampling program.

Media Types

The following media types were selected to be sampled: surface water, sediment, fish, shellfish, and benthic macroinvertebrate organisms. These media types were selected to assess any potential impacts related to the former disposal operations that took place at Site 69.

Surface Water/Sediment/Fish/Shellfish/Benthic Sampling Locations

Surface water and sediment samples were collected from all three stations located on the unnamed tributary. Benthic samples were also collected from all the stations. Only one location was sampled for fish; shallow water precluded site access during the times the sampling events were planned for the other two fish locations. Shellfish were not collected at the sampling stations located on the unnamed tributary, due to the absence of shellfish organisms.

Surface water and sediment samples along Everett Creek were collected from Stations 1, 3, and 4. Benthic and fish samples were collected from Stations 2, 3, and 4. Benthic and fish samples were not collected from Station 1 due to upstream inaccessibility with the boat. However, only one shellfish sample was collected from Everett Creek at Station 4. Shellfish were not collected from the remaining two sampling locations because they were not present at these sampling stations during the period of sampling.

Surface water and sediment samples along with benthic and fish samples were collected from all three stations located on the New River. However only two shellfish samples were collected from the New River. Shellfish were not collected from the remaining one sampling location because they were not present at this sampling station during the period of sampling.

Surface water and sediment sampling locations are shown on Figure 2-13.

Surface Water/Sediment/Fish/Shellfish/Benthic Sampling Procedures

At all sampling stations, surface water samples were collected by dipping the sample container directly into the water surface. Most samples were collected at the approximate vertical mid-point by dipping the sample bottles directly into the water. Samples analyzed for volatiles were obtained prior to any other sample collection. Care was taken to avoid excessive agitation that could result in loss of VOCs. At all surface water locations, water quality readings were taken (i.e., pH, specific conductance, dissolved oxygen, salinity and temperature).

Sediment samples at all sampling locations were collected by pushing a sediment corer into the subsurface. The sediment corer is a metal tube with a inner retractable plastic tube. As the tube is driven into the subsurface, the sediment is pushed into the plastic tube. The sediment corer is then removed from the subsurface and opened. A push rod then is used to force the sediment out of the plastic tube, this gives the sampling personnel a undisturbed sediment core to sample. This procedure was performed at each station to acquire sediment samples from 0 to 0.5 feet, and 0.5 to 1.0-foot zones.

Fish were collected via three procedures. The first procedure was the use of a electrofisher. The electrofisher produces a DC current which was applied to the sampling station area. This current stuns the fish, and they float to the surface. Stunned fish were collected with one-inch mesh or smaller dip nets. The second procedure was the use of gill nets. The gill nets were 6 feet deep by 50 feet long with a stretch mesh size ranging from three to four inches, and an approximate twine break strength of 29 pounds. The nets were deployed in the morning or evening, and they were checked for fish within twelve hours after deployment. The third procedure was the use of haul seines. The haul seine was deployed with one person securing the seine on the shore and another person walking out in a loop. The bottom of the net was kept in contact with the sediment to prevent fish from swimming under the net. When the person deploying the net arrived back at shore, the net was pulled in.

Shellfish were collected manually at all locations at the three areas of concern.

Benthic macroinvertebrates were collected by using a standard ponar sampler. The ponar was deployed from the boat. Once the ponar was retrieved with a sediment sample, it was opened into a clean tub and the larger sediments were removed. The sediments were then transferred to a 0.5 mm sieve that was agitated to remove small particles. The remaining contents in the sieve were then placed into a plastic sample jars containing a 10 percent formalin solution for preservation. These samples were then transported to Baker Ecological Laboratory for sample processing.

Surface Water/Sediment/Fish/Shellfish/Benthic Analytical Program

The analytical program initiated for the ecological and aquatic investigation at Site 69 focused on suspected contaminants of concern. As mentioned previously, the contaminants of concern were identified from previous investigations. In general, the media types were selected and sampled to accurately assess any impacts resulting from former disposal operations. All media types were analyzed for TCL organics and TAL inorganics.

Quality Assurance and Quality Control Samples

Field QA/QC samples were also collected during the ecological and aquatic survey including duplicate samples, equipment rinsate samples, and trip blanks. The QA/QC sample collection frequencies are the same as those described in Section 2.2.3.3. Table 2-8 summarizes field QA/QC samples collected for the ecological and aquatic survey.

2.3 Decontamination Procedures

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

For heavy equipment, the following procedures were implemented:

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

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

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

Temporary decontamination pads, constructed of wood and plastic, were constructed to minimize spillage onto the ground surface. Decontamination fluids generated during the field program were containerized and handled according to the procedures outlined in Section 2.4.

2.4 Investigation Derived Waste (IDW) Handling

Field investigation activities at Site 69 resulted in the generation of various IDW. This IDW included drilling mud, soil cuttings, well development and purge water, and solutions used to decontaminate non-disposable sampling equipment. The general management techniques utilized for the IDW were:

1. Collection and containerization of IDW material.
2. Temporary storage of IDW while awaiting analytical data on characterization from drilling and sampling conducted from January 3 to March 4, 1994, and March 1995.
3. Final disposal of aqueous and solid IDW material.

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

Both non-contaminated and contaminated wastewater were sent off site to a licensed hazardous waste disposal facility. The IDW soils were returned to the source area since the analytical data indicated that they were nonhazardous. Appendix G provides information on the management and disposal of the IDW.

SECTION 2.0 TABLES

TABLE 2-1

SUMMARY OF REMEDIAL INVESTIGATION OBJECTIVES
SITE 69
REMEDIAL INVESTIGATION, CTO-0212
MCB CAMP LEJEUNE, NORTH CAROLINA

Medium or Area of Concern	RI Objective	Criteria for Meeting Objective	Investigation/Study
1. Soil	1a. Assess horizontal and vertical extent of soil contamination in off-site downslope areas.	Characterize contaminant levels in surface and subsurface soils.	Soil Investigation
	1b. Assess the extent of soil contamination at the disposal area.	Characterize contaminant levels in surface and subsurface soils.	Soil Investigation
	1c. Assess the level and nature of surficial soil contamination with respect to possible contact by humans and wildlife.	Characterize contaminant levels in surface areas, trenches, and subsurface soil boundaries.	Soil Investigation
	1d. Identify the buried metal at the site.	Characterize the subsurface soil and metallic debris.	Geophysical Investigation
	1e. Assess human health and ecological risks associated with exposure to surface soils.	Characterize contaminant levels in surface and subsurface soils.	Soil Investigation Risk Assessment
2. Groundwater	2a. Assess health risks posed by potential future usage of both the shallow and deep groundwater.	Evaluate groundwater quality and compare to ARARs and health-based action levels.	Groundwater Investigation Risk Assessment
	2b. Evaluate hydrogeologic characteristics for fate and transport evaluation and remedial technology evaluation, if required.	Estimate hydrogeologic characteristics of both the shallow and deep aquifer (flow direction, transmissivity, storativity, etc).	Groundwater Investigation (Field Investigation/Review of Existing Data)

TABLE 2-1 (Continued)

SUMMARY OF REMEDIAL INVESTIGATION OBJECTIVES
SITE 69
REMEDIAL INVESTIGATION, CTO-0212
MCB CAMP LEJEUNE, NORTH CAROLINA

Medium or Area of Concern	RI Objective	Criteria for Meeting Objective	Investigation/Study
3. Sediment	3a. Assess human health and ecological risks associated with exposure to contaminated sediments.	Characterize the nature and extent of contamination in sediment.	Sediment Investigation of on-site ponded areas and Drainage Areas to the Southeast and Northeast Risk Assessment
	3b. Assess potential ecological impacts posed by contaminated sediments.	Evaluate stress to benthic and fish communities.	Sediment Investigation of on-site ponded areas and Drainage Areas to the Southeast and Northeast Sediment Investigation
	3c. Determine the extent of sediment contamination for purposes of identifying areas of remediation.	Identify extent of sediment contamination where contaminant levels exceed risk-based action levels or EPA Region IV TBCs for sediment.	Sediment Investigation Risk Assessment
	3d. Asses the potential direct contact with sediment by recreational users and wildlife.	Evaluate sediment quality in drainage areas, nearby streams and tributaries, Everett Creek, and the New River.	Sediment Investigation
4. Surface Water	4a. Assess the presence or absence of surface water contamination on site.	Characterize the nature and extent of contamination in sediment.	Surface Water Investigation
	4b. Assess potential ecological impacts posed by contaminated surface water.	Evaluate stress to benthic and fish communities.	Surface Water Investigation
	4c. Assess the potential direct contact with surface water by recreational users and wildlife.	Evaluate surface water quality in drainage areas, nearby streams and tributaries, Everett Creek, and the New River.	Surface Water Investigation

TABLE 2-2

SOIL SAMPLING SUMMARY
SITE 69
REMEDIAL INVESTIGATION, CTO-0212
MCB CAMP LEJEUNE, NORTH CAROLINA

Sample Location	Depth of Borehole (feet, bgs)	Sampling Interval (feet, bgs)	TCL VOAs	TCL SVOAs	TCL Pest./PCBs	TAL Metals	CSM (Deg. Products)	Thiodiglycol	Mirex	Ordnance	Cyanide	Engineering Parameters(1)	Comments
69-CSA-SB01	1.0	0.0 - 1.0	X	X	X	X	X	X					
69-CSA-SB02	1.0	0.0 - 1.0	X	X	X	X	X	X					
69-CSA-SB03	1.0	0.0 - 1.0	X	X	X	X	X	X					
		0.0 - 1.0	X	X	X	X	X	X					(2)
69-CSA-SB04	1.5	0.0 - 1.5	X	X	X	X	X	X					
69-CSA-SB05	1.0	0.0 - 1.0	X	X	X	X	X	X					
69-CSA-SB06	1.0	0.0 - 1.0	X	X	X	X	X	X					
69-CSA-SB07	1.0	0.0 - 1.0	X	X	X	X	X	X					
69-CSA-SB08	1.0	0.0 - 1.0	X	X	X	X	X	X					(3)
		0.0 - 1.0	X	X	X	X	X	X					(2)
69-CSA-SB09	1.0	0.0 - 1.0	X	X	X	X	X	X					
69-CSA-SB10	1.0	0.0 - 1.0	X	X	X	X	X	X					
69-CSA-SB11	1.0	0.0 - 1.0	X	X	X	X	X	X					
69-CSA-SB12	1.0	0.0 - 1.0	X	X	X	X	X	X					
69-CSA-SB13	1.0	0.0 - 1.0	X	X	X	X	X	X					
69-CSA-SB14	1.0	0.0 - 1.0	X	X	X	X	X	X					
69-CSA-SB15	1.0	0.0 - 1.0	X	X	X	X	X	X					
69-CSA-SB16	1.0	0.0 - 1.0	X	X	X	X	X	X					(3)
		0.0 - 1.0	X	X	X	X	X	X					(2)
69-CSA-SB17	1.0	0.0 - 1.0	X	X	X	X	X	X					

TABLE 2-2 (Continued)

SOIL SAMPLING SUMMARY
SITE 69
REMEDIAL INVESTIGATION, CTO-0212
MCB CAMP LEJEUNE, NORTH CAROLINA

Sample Location	Depth of Borehole (feet, bgs)	Sampling Interval (feet, bgs)	TCL VOAs	TCL SVOAs	TCL Pest./PCBs	TAL Metals	CSM (Deg. Products)	Thiodiglycol	Mirex	Ordnance	Cyanide	Engineering Parameters$^{(1)}$	Comments
69-CSA-SB18	1.0	0.0 - 1.0	X	X	X	X	X	X					
69-CSA-SB19	1.0	0.0 - 1.0	X	X	X	X	X	X					
69-CSA-SB20	1.0	0.0 - 1.0	X	X	X	X	X	X					
69-CSA-SB21	1.0	0.0 - 1.0	X	X	X	X	X	X					
69-CSA-SB22	1.0	0.0 - 1.0	X	X	X	X	X	X					
69-CSA-SB23	1.0	0.0 - 1.0	X	X	X	X	X	X					
69-CSA-SB24	1.0	0.0 - 1.0	X	X	X	X	X	X					
69-CSA-SB25	1.0	0.0 - 1.0	X	X	X	X	X	X					
69-DA-HP01	10.0	5.0 - 7.0	X				X						
69-DA-HP02	5.0	0.0 - 2.0	X				X						
69-DA-HP03	9.0	4.0 - 6.0	X				X						
69-DA-HP04	9.0	4.0 - 6.0	X				X						
69-DA-HP05	9.0	4.0 - 6.0	X				X						
69-DA-HP06	5.0	0.0 - 2.0	X				X						
69-DA-HP07	11.0	6.0 - 8.0	X				X						
69-DA-HP08	9.0	4.0 - 6.0	X				X						
69-DA-HP09	9.0	5.0 - 7.0	X				X						
69-BB-SB01	1.0	0.0 - 1.0	X	X	X	X	X	X					
69-BB-SB02	1.0	0.0 - 1.0	X	X	X	X	X	X					

TABLE 2-2 (Continued)

SOIL SAMPLING SUMMARY
SITE 69
REMEDIAL INVESTIGATION, CTO-0212
MCB CAMP LEJEUNE, NORTH CAROLINA

Sample Location	Depth of Borehole (feet, bgs)	Sampling Interval (feet, bgs)	TCL VOAs	TCL SVOAs	TCL Pest./PCBs	TAL Metals	CSM (Deg. Products)	Thiodiglycol	Mirex	Ordnance	Cyanide	Engineering Parameters(1)	Comments
69-BB-SB03	1.0	0.0 - 1.0	X	X	X	X	X	X					
69-BB-SB04	1.0	0.0 - 1.0	X	X	X	X	X	X					
69-GW02DW	50.0	0.0 - 2.0	X	X	X	X						X	(3)
		0.0 - 2.0	X	X	X	X							(2)
		4.0 - 6.0	X	X	X	X							
69-GW09	21.0	2.0 - 4.0	X	X	X	X							
		8.0 - 10.0	X	X	X	X							
69-GW10	17.0	0.0 - 2.0	X	X	X	X							
		4.0 - 5.5	X	X	X	X							
69-GW11	19.0	2.0 - 4.0	X	X	X	X							
		6.0 - 8.0	X	X	X	X							
69-GW12	13.5	0.0 - 2.0	X	X	X	X							
69-GW12DW	60.0	0.0 - 2.0	X	X	X	X							
69-GW15IW	62.0	1.0 - 3.0	X				X	X					

Note: (1) Engineering Parameters include Particle Size, Atterberg limits.
(2) Duplicate
(3) MS/MSD

TABLE 2-3

SUMMARY OF FIELD QUALITY ASSURANCE/QUALITY CONTROL SAMPLING PROGRAM FOR THE SOIL INVESTIGATION
SITE 69
REMEDIAL INVESTIGATION, CTO-0212
MCB CAMP LEJEUNE, NORTH CAROLINA

QA/QC Sample(1)	Frequency of Collection	Number of Samples	Analytical Parameters(3)
Trip Blanks(2)	One per Cooler	9	TCL Volatiles
Field Blanks(4)	One per Event	7	TCL Organics/TAL Inorganics/ CSM/Thiodiglycol
Equipment Rinsates(5)	One per Day	5	TCL Organics/TAL Inorganics/ CSM/Thiodiglycol
Field Duplicates	10% of Sample Frequency	5	TCL Organics/TAL Inorganics/ CSM/Thiodiglycol

Notes:
(1) QA/QC sample types defined in Section 2.4.3.1 in text.
(2) Trip blanks submitted with coolers which contained samples for volatile analysis. Samples analyzed for TCL volatiles only.
(3) Parameters analyzed according to CLP Protocol.
(4) Field blanks collected from a potable and distilled water sources used for decontamination purposes.
(5) Equipment rinsates collected from various sampling equipment (e.g., split spoons, stainless steel spoons, hollow stem augers, etc.). Note that samples were collected daily but were analyzed every other day of sampling event. Accordingly, the number of samples presented represents the number of samples analyzed.

TABLE 2-4

SUMMARY OF WELL CONSTRUCTION DETAILS
SITE 69
REMEDIAL INVESTIGATION, CTO-0212
MCB CAMP LEJEUNE, NORTH CAROLINA

Monitoring Zone (1)	Well No.	Date Installed	Top of PVC Casing Elevation (feet, above msl)(2)	Ground Surface Elevation (feet, above msl)	Boring Depth (feet, below ground surface)	Well Depth (feet, below ground surface)	Screen Interval Depth (feet, below ground surface)	Sand Pack Interval Depth (feet, below ground surface)	Bentonite Interval Depth (feet, below ground surface)	Stick-Up (feet, above ground surface)
UCH	69-GW02DW	01/21/94	36.94	34.1	50.0	50.0	40.0 - 50.0	37.5 - 50.0	35.0 - 37.5	2.84
SA	69-GW09	01/08/94	12.44	9.0	21.0	20.5	10.5 - 20.5	8.0 - 21.0	3.0 - 8.0	3.44
SA	69-GW10	01/09/94	41.89	39.0	17.0	16.0	6.0 - 16.0	4.0 - 17.0	0.0 - 4.0	2.89
SA	69-GW11	01/07/94	28.82	25.9	19.0	19.0	9.0 - 19.0	6.0 - 19.0	2.0 - 6.0	2.92
SA	69-GW12	01/06/94	11.15	8.4	13.5	12.5	2.0 - 12.5	1.5 - 13.5	0.0 - 1.5	2.75
UCH	69-GW12DW	01/22/94	9.38	7.5	60.0	58.0	48.0 - 58.0	45.0 - 60.0	43.0 - 45.0	1.88
ICH	69-GW02DD	05/19/94	36.98	34.2	127.0	125.0	115-125	110-127	104-110	2.78
UCH	69-GW03I	05/21/94	37.55	35.0	62.0	60.0	50-60	46-62	41-46	2.55
SA	69-GW13	05/24/94	38.12	35.8	13.5	13.0	3-13	2-13.5	0.25-2	2.32
UCH	69-GW13I	05/23/94	38.40	35.7	62.0	60.0	50-60	45-62	38-45	2.70
SA	69-GW14	12/17/94	35.22	33.07	14.0	13.0	3.0 - 13.0	1.5 - 14.0	0.5 - 1.5	2.15
UCH	69-GW14IW	12/17/94	35.21	32.77	62.0	60.0	45.0 - 60.0	40.0 - 62.0	34.0 - 40.0	2.44
ICH	69-GW14DW	12/16/94	35.17	32.67	127.0	125.0	110.0 - 125.0	105.0 - 127.0	100.0 - 105.0	2.50
SA	69-GW15	03/23/95	37.41	35.70	13.0	13.0	3.0 - 13.0	2.0 - 13.0	1.0 - 2.0	1.71
UCH	69-GW15IW	03/24/95	37.54	35.70	60.0	60.0	45.0 - 60.0	43.0 - 60.0	40.0 - 43.0	1.84
DCH	69-MW02BCH	04/18/96	36.79	34.4	233.0	230.0	220 - 230	216 - 233	207 - 216	2.39
DCH	69-MW03BCH	04/08/96	38.52	36.0	233.0	230.0	220 - 230	215.5 - 233	205.5 - 21.5	2.52
DCH	69-MW15BCH	04/03/96	38.63	36.2	250.0	230.0	220 - 230(3)	218 - 250	208 - 218	2.43

Notes:

(1) SA denotes "shallow aquifer"; UCH denotes "Upper Castle Hayne"; ICH denotes "Intermediate Castle Hayne"; DCH denotes "Deep Castle Hayne"

(2) msl - mean sea level
Horizontal positions are referenced to N.C. State Plane Coordinate System (NAD 27) CF = 0.9999397 from USMC Monuments L-8 and L-9.
Vertical datum NGVD 29.

(3) 20 feet of 2-inch diameter rise was installed below the screen to support the installed well to the bottom of the borehole (230-250 feet).

TABLE 2-5

SUMMARY OF FIELD QUALITY ASSURANCE/QUALITY CONTROL SAMPLING PROGRAM FOR THE GROUNDWATER INVESTIGATION
SITE 69
REMEDIAL INVESTIGATION, CTO-0212
MCB CAMP LEJEUNE, NORTH CAROLINA

QA/QC Sample(1)	Frequency of Collection	Number of Samples	Analytical Parameters(3)
Trip Blanks(2)	One per Cooler	10	TCL Volatiles
Field Blanks(4)	One per Event	5	TCL Organics/TAL Inorganics
Equipment Rinsates(5)	One per Day	9	TCL Organics/TAL Inorganics
Field Duplicates	10% of Sample Frequency	4	TCL Organics/TAL Inorganics

Notes:
(1) QA/QC sample types defined in Section 2.3.3.1 in text.
(2) Trip blanks submitted with coolers which contained samples for volatile analysis. Samples analyzed for volatiles only.
(3) Volatiles analyzed according to EPA Method 524.2; all other parameters analyzed according to CLP Protocol.
(4) Note field blanks were collected during the soil investigation at Site 69.
(5) Equipment rinsates collected from various sampling equipment (e.g., bailer). Note that samples were collected daily but were analyzed every other day of sampling event. Accordingly, the number of samples presented represents the number of samples analyzed.

TABLE 2-6

SEDIMENT SAMPLING SUMMARY
SITE 69
REMEDIAL INVESTIGATION, CTO-0212
MCB CAMP LEJEUNE, NORTH CAROLINA

Sample Location	Depth of Borehole (feet, bgs)	Sampling Interval (feet, bgs)	TCL VOAs	TCL SVOAs	TCL Pest./PCBs	TAL Metals	CSM (Deg. Products)	Thiodiglycol	Comments
69-OS-SD01	0.5	0.0 - 0.5	X	X	X	X	X	X	(2)
		0.0 - 0.5	X	X	X	X	X	X	(1)
69-OS-SD02	0.5	0.0 - 0.5	X	X	X	X	X	X	
69-OS-SD03	0.5	0.0 - 0.5	X	X	X	X	X	X	
69-DA-SD01	0.5	0.0 - 0.5	X	X	X	X	X	X	
69-DA-SD02	0.5	0.0 - 0.5	X	X	X	X	X	X	
69-DA-SD04	0.5	0.0 - 0.5	X	X	X	X	X	X	
69-DA-SD06	0.5	0.0 - 0.5	X	X	X	X	X	X	

Notes: (1) Duplicate
(2) MS/MSD

TABLE 2-7

SUMMARY OF FIELD QUALITY ASSURANCE/QUALITY CONTROL SAMPLING PROGRAM FOR THE SURFACE WATER AND SEDIMENT INVESTIGATION
SITE 69
REMEDIAL INVESTIGATION, CTO-0212
MCB CAMP LEJEUNE, NORTH CAROLINA

QA/QC Sample(1)	Frequency of Collection	Number of Samples	Analytical Parameters(3)
Trip Blanks(2)	One per Cooler	4	TCL Volatiles
Equipment Rinsates(4)	One per Day	1	TCL Organics/TAL Inorganics/ CSM/Thiodiglycol
Field Duplicates	10% of Sample Frequency	1	TCL Organics/TAL Inorganics/ CSM/Thiodiglycol

Notes:
(1) QA/QC sample types defined in Section 2.4.3.1 in text.
(2) Trip blanks submitted with coolers which contained samples for volatile analysis. Samples analyzed for TCL volatiles only.
(3) Parameters analyzed according to CLP Protocol.
(4) Equipment rinsates collected from various sampling equipment (e.g., split spoons, stainless steel spoons, hollow stem augers, etc.). Note that samples were collected daily but were analyzed every other day of sampling event. Accordingly, the number of samples presented represents the number of samples analyzed.

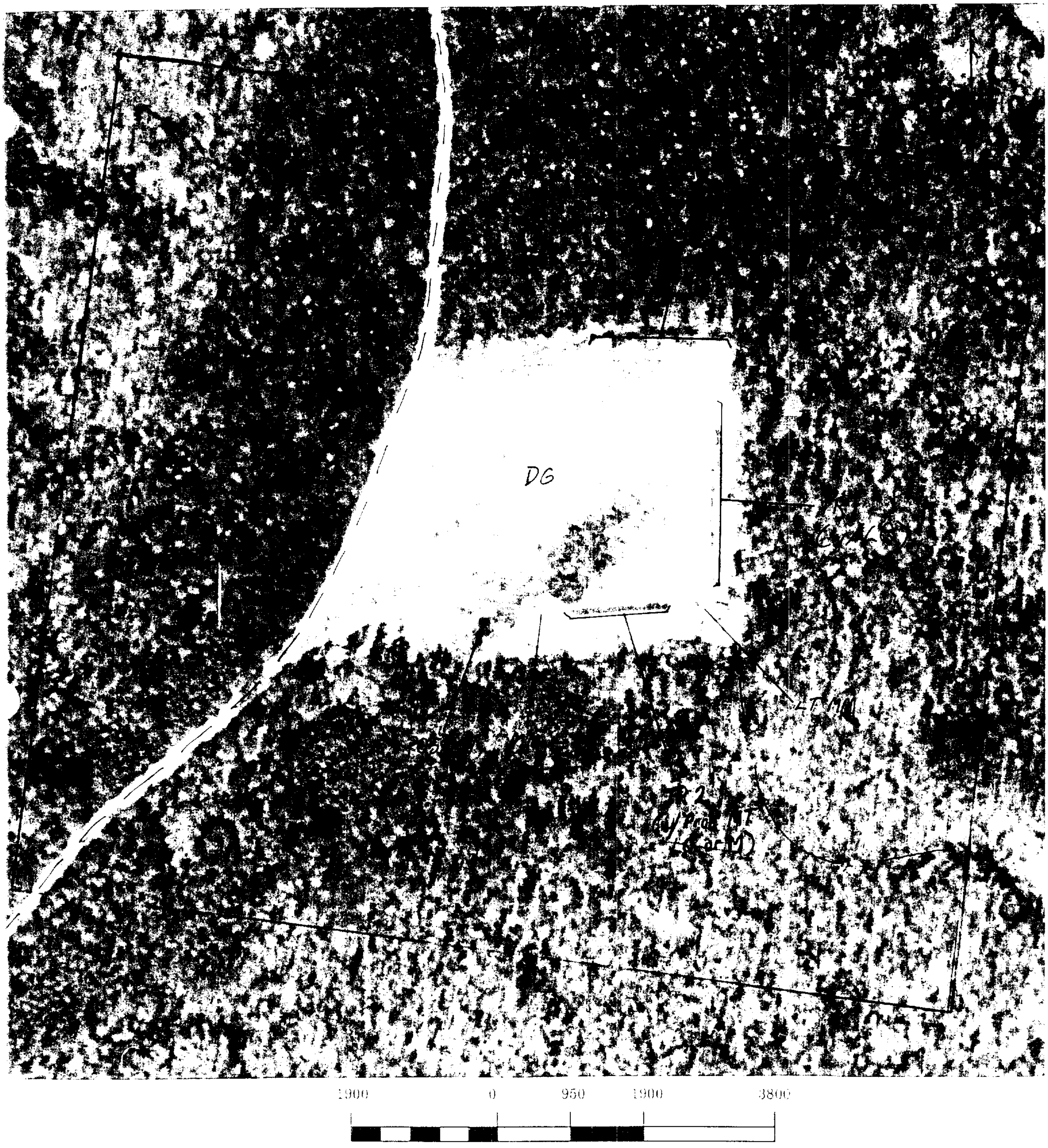
TABLE 2-8

SUMMARY OF FIELD QUALITY ASSURANCE/QUALITY CONTROL SAMPLING PROGRAM FOR THE ECOLOGICAL AND AQUATIC SURVEY
SITE 69
REMEDIAL INVESTIGATION CTO-0212
MCB CAMP LEJEUNE, NORTH CAROLINA

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

Notes:
(1) QA/QC sample types defined in Section 2.2.2.1 in text.
(2) Trip blanks submitted with coolers which contained samples for volatile analysis. Samples analyzed for TCL volatiles only.
(3) Parameters analyzed according to CLP Protocol.
(4) Field blank collected during Site 69 investigation.
(5) Equipment rinsates collected from various sampling equipment (e.g., split spoons, stainless steel spoons, hollow stem augers, etc.). Note that samples were collected daily but were analyzed every other day of sampling event. Accordingly, the number of samples presented represents the number of samples analyzed.

SECTION 2.0 FIGURES



DG - Disturbed Ground
TR-1 - Trench #1
LQ - Liquid
LT - Light Toned
MM - Mounded Material
MT - Medium Toned

Source: EPIC, 1992

M - Material
POSS - Possible
ST - Stain
TR-2 - Trench #2
→ - Natural Drainage
- - - - - Access Road

FIGURE 2-1

SITE 69
AERIAL PHOTOGRAPHY OF SITE 69,
FEBRUARY 1, 1956

REMEDIAL INVESTIGATION CTO-0212
MARINE CORPS BASE, CAMP LEJEUNE
NORTH CAROLINA

1 inch = 1900 ft.

DG - Disturbed Ground
TR-1 - Trench #1
LQ - Liquid
LT - Light Toned
MM - Mounded Material
MT - Medium Toned
CA - Cleared Area
REV - Revegetated

Source: EPIC, 1992

PROB - Probable
TR-3 - Trench #3
M - Material
POSS - Possible
ST - Stain
TR-2 - Trench #2
→ - Natural Drainage
- - - - - Access Road

FIGURE 2-2

SITE 69
AERIAL PHOTOGRAPHY OF SITE 69,
FEBRUARY 10, 1964

REMEDIAL INVESTIGATION CTO-0212
MARINE CORPS BASE, CAMP LEJEUNE
NORTH CAROLINA

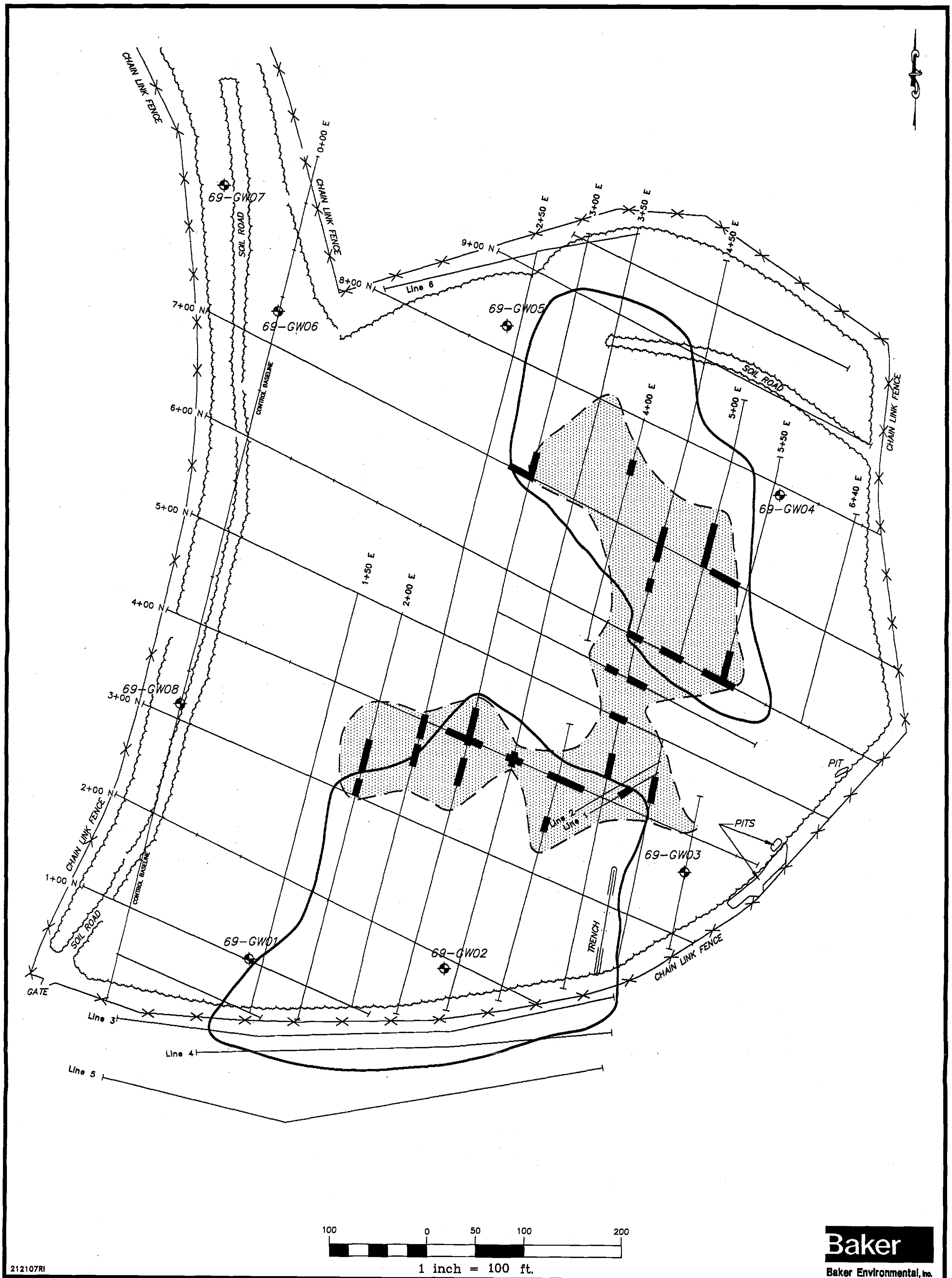
DG - Disturbed Ground	PROB - Probable
TR-1 - Trench #1	TR-3 - Trench #3
LQ - Liquid	GR - Graded
LT - Light Toned	M - Material
MM - Mounded Material	POSS - Possible
MT - Medium Toned	ST - Stain
CA - Cleared Area	TR-2 - Trench #2
REV - Revegetated	→ - Natural Drainage
	---- - Access Road

Source: EPIC, 1992

FIGURE 2-3

SITE 69
AERIAL PHOTOGRAPHY OF SITE 69,
OCTOBER 4, 1970

REMEDIAL INVESTIGATION CTO-0212
MARINE CORPS BASE, CAMP LEJEUNE
NORTH CAROLINA



Baker

Baker Environmental, Inc.

LEGEND

⊕ MONITORING WELL

├──┤ EM AND MAG SURVEY LINE

── INTERPRETED LIMIT OF INCREASED CONDUCTIVITY(>10 mmhos/m) INDICATIVE OF BACKFILL MATERIALS AND/OR CONTAMINANT PLUME

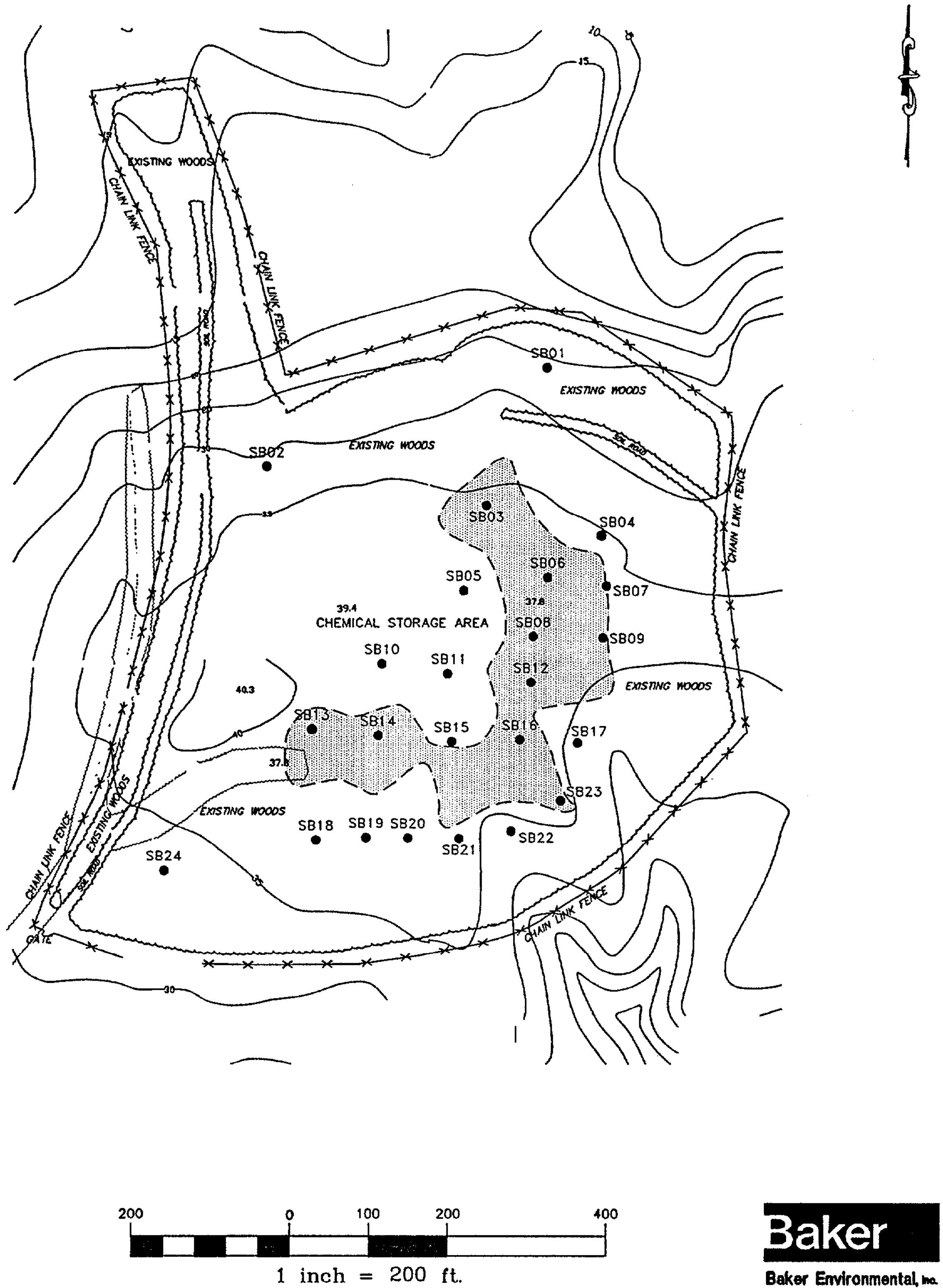
▨ INTERPRETED LIMIT OF INCREASED MAGNETIC INTENSITY INDICATIVE OF BURIED FERROUS METAL

▬ BURIED METALLIC OBJECT

FIGURE 2-4
GEOPHYSICAL GRID RESULTS
SITE 69 - RIFLE RANGE
CHEMICAL DUMP
REMEDIAL INVESTIGATION CTO-0212
MARINE CORPS BASE, CAMP LEJEUNE
NORTH CAROLINA

01761N04Z

212108RI



Baker

Baker Environmental, Inc.

LEGEND

SB01 ● SAMPLING STATION FOR SURFICIAL SOIL

▨ DENOTES PROBABLE BURIED METAL

FENCE

VEGETATION

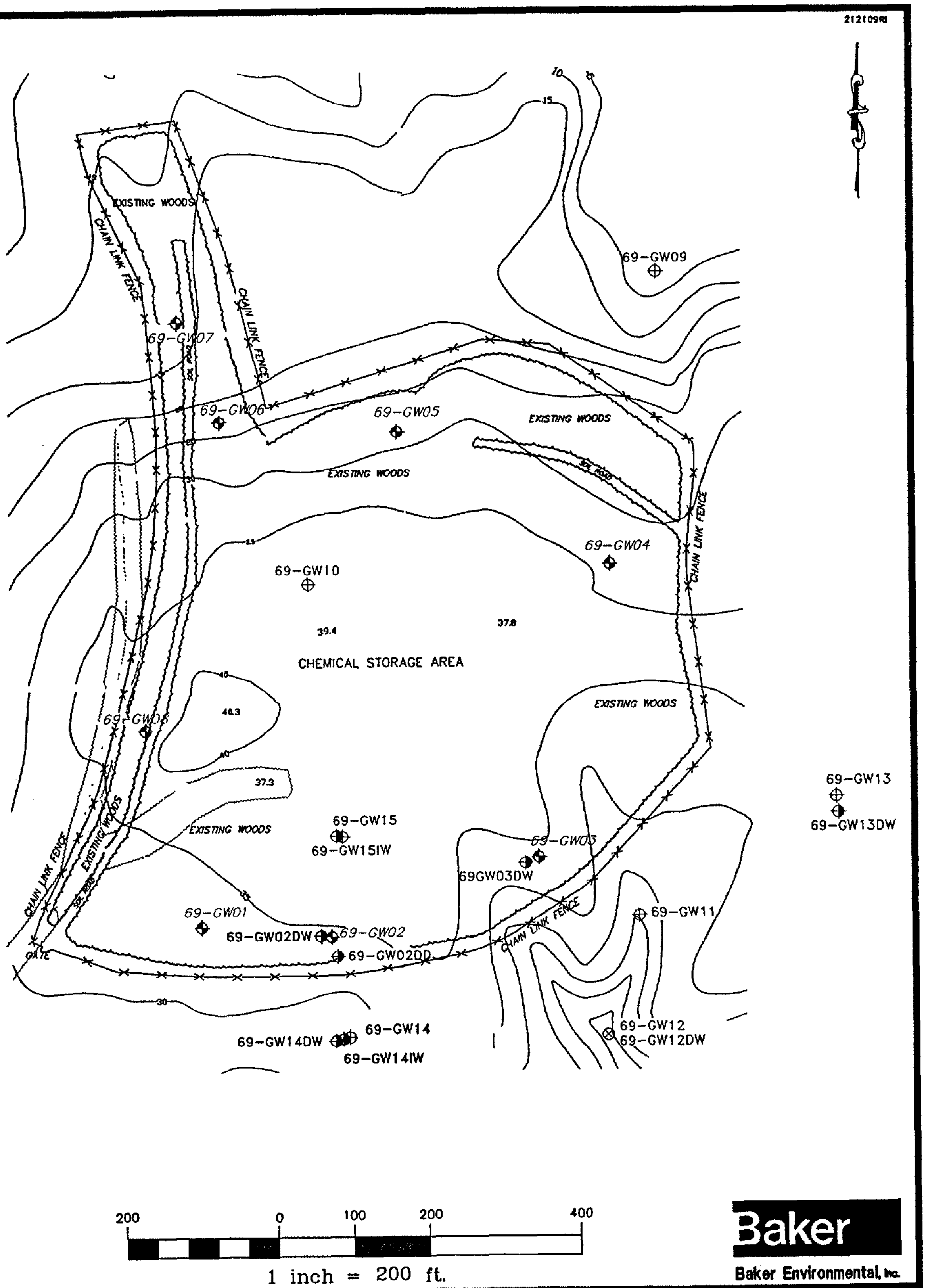
TOPOGRAPHIC ELEVATION LINES (FEET, MSL)

CSA – CHEMICAL STORAGE AREA

SOURCE: REVISED FROM LANTDIV, OCT. 1991

FIGURE 2-5
CSA SOIL SAMPLING GRID
SITE 69 – RIFLE
RANGE CHEMICAL DUMP
REMEDIAL INVESTIGATION CTO-0212
MARINE CORPS BASE, CAMP LEJEUNE
NORTH CAROLINA

212109RI



Baker Environmental, Inc.

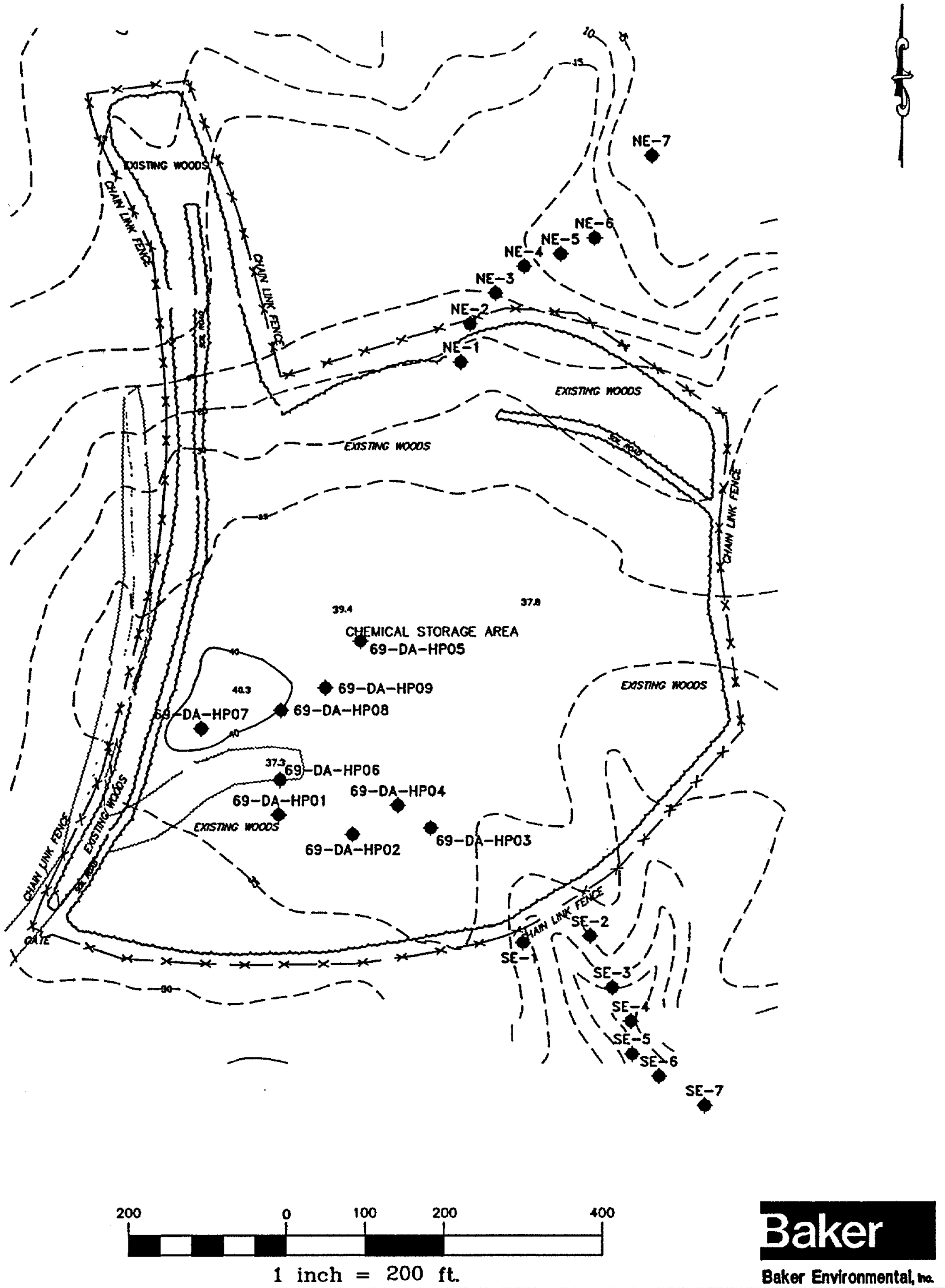
LEGEND

69-GW02
- ⊕ EXISTING SHALLOW WELLS
- ◐ PROPOSED DEEP WELL
- ⊕ PROPOSED SHALLOW WELL
- ⊗ PROPOSED PAIR OF SHALLOW AND DEEP WELLS
- ✕—✕ FENCE
- ~~~ VEGETATION
- ⌒ TOPOGRAPHIC ELEVATION LINES (FEET, MSL)

SOURCE: REVISED FROM LANTDIV, OCT. 1991

FIGURE 2-6
PROPOSED SHALLOW AND DEEP
WELL LOCATIONS
SITE 69 – RIFLE RANGE CHEMICAL DUMP
REMEDIAL INVESTIGATION CTO-0212
MARINE CORPS BASE, CAMP LEJEUNE
NORTH CAROLINA

212110R



Baker

Baker Environmental, Inc.

LEGEND

SE-1 ◆ HYDROPUNCH LOCATION

-×- FENCE

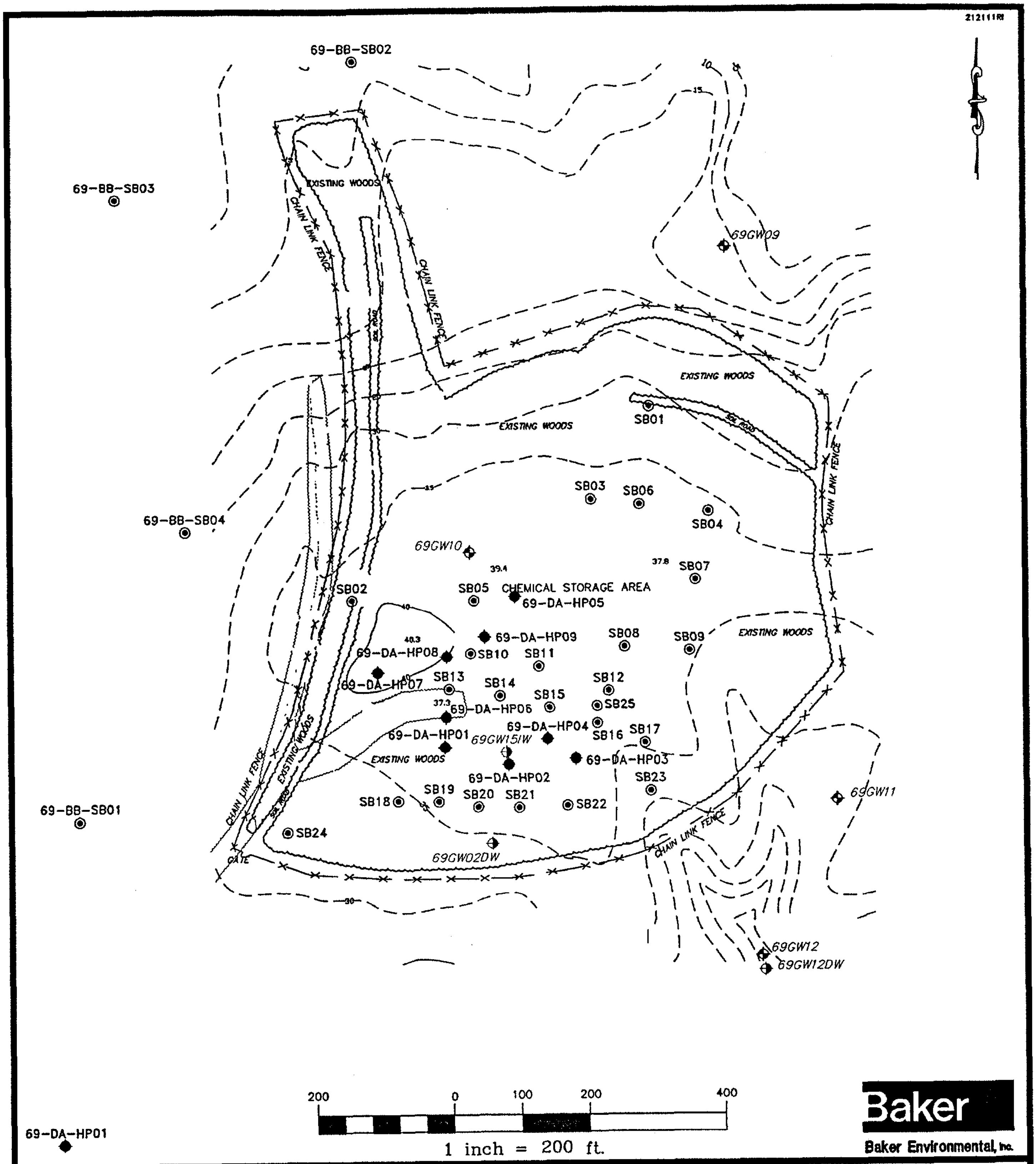
VEGETATION

TOPOGRAPHIC ELEVATION LINES (FEET, MSL)

SOURCE: REVISED FROM LANTDIV, OCT. 1991

FIGURE 2-7
HYDROPUNCH LOCATIONS
SITE 69 - RIFLE RANGE CHEMICAL DUMP
REMEDIAL INVESTIGATION CTO-0212

MARINE CORPS BASE, CAMP LEJEUNE
NORTH CAROLINA



Baker

Baker Environmental, Inc.

LEGEND

69GW9 ⊕ SHALLOW MONITORING WELL LOCATION

69GW02DW ⊕ DEEP MONITORING WELL LOCATION

SB01 ◉ SURFACE SOIL SAMPLING LOCATION

69-DA-HP01 ◆ HYDROPUNCH LOCATION

-x- -x- FENCE

~~~~ VEGETATION

/—40—\ TOPOGRAPHIC ELEVATION LINES (FEET, MSL)

SOURCE: REVISED FROM LANTDIV, OCT. 1991

FIGURE 2-8
SURFACE AND SUBSURFACE SOIL SAMPLING LOCATIONS
SITE 69 - RIFLE RANGE CHEMICAL DUMP
REMEDIAL INVESTIGATION CTO-0212
MARINE CORPS BASE, CAMP LEJEUNE
NORTH CAROLINA
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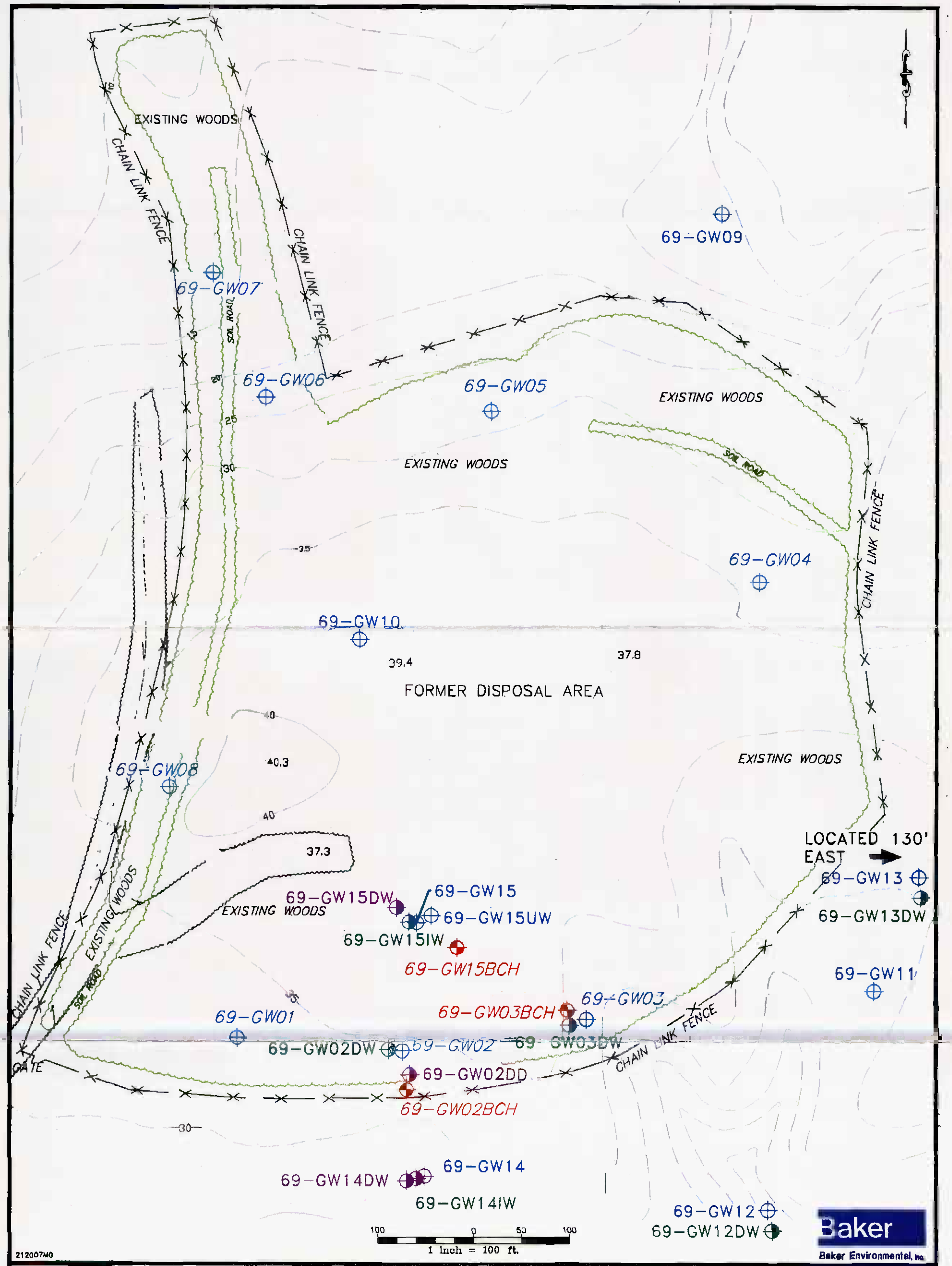


LEGEND

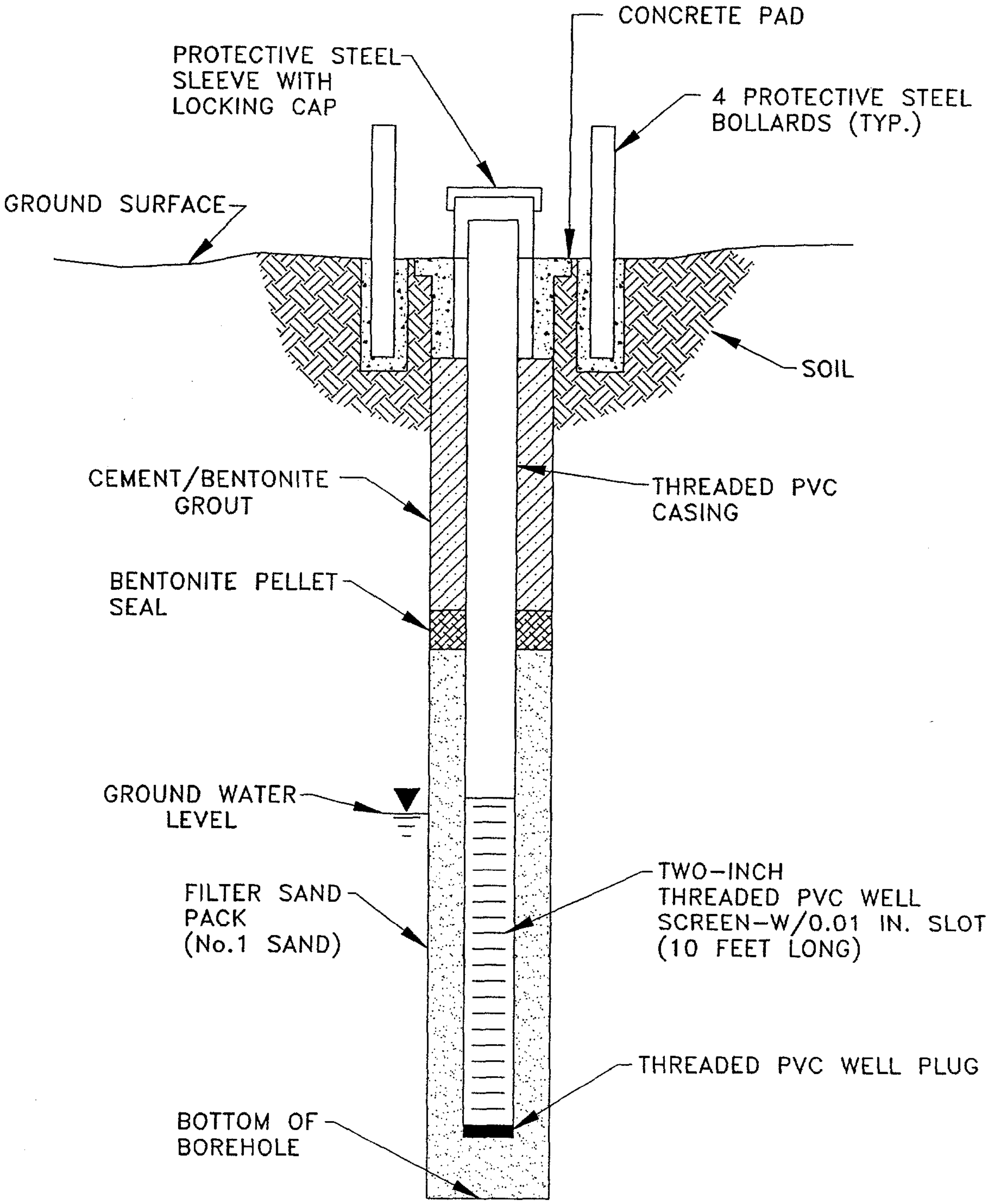
69GW15BCH ⊕	DEEP ZONE CASTLE HAYNE WELLS
69GW09 ⊕	SHALLOW WELLS
69GW02DW ⊕	UPPER ZONE CASTLE HAYNE WELLS
69-GW02DD ⊕	INTERMEDIATE ZONE CASTLE HAYNE WELLS
30	TOPOGRAPHIC ELEVATION LINES (FEET, MSL)

SOURCE: REVISED FROM LANTDIV, OCT. 1991

FIGURE 2-9
MONITORING WELL LOCATIONS
SITE 69 – RIFLE RANGE CHEMICAL DUMP
REMEDIAL INVESTIGATION CTO-0212

MARINE CORPS BASE, CAMP LEJEUNE
NORTH CAROLINA

212113RI



N.T.S.

Baker
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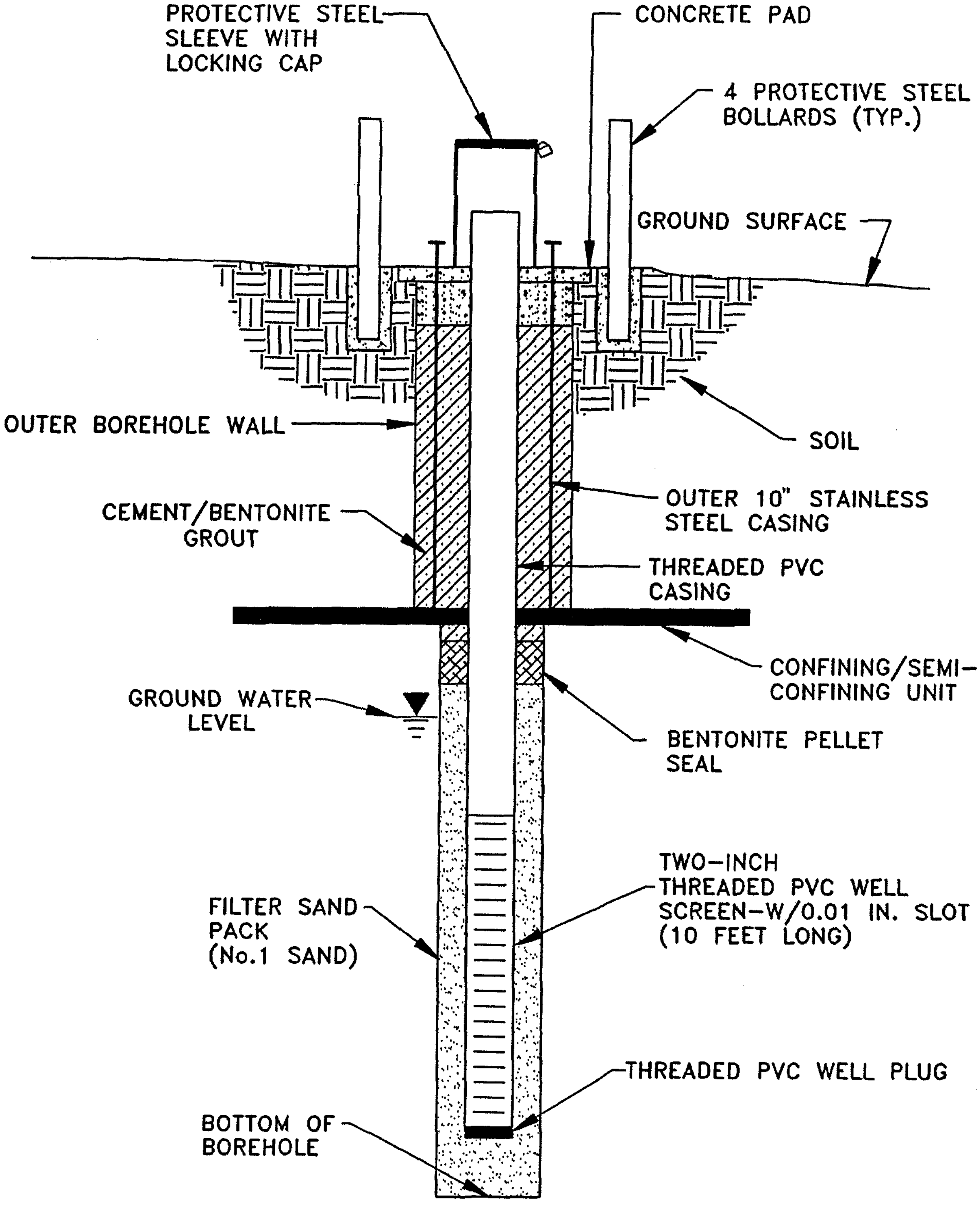
FIGURE 2-10
TYPICAL TYPE II GROUNDWATER
MONITORING WELL CONSTRUCTION DIAGRAM
REMEDIAL INVESTIGATION CTO-0212

MARINE CORPS BASE, CAMP LEJEUNE
NORTH CAROLINA

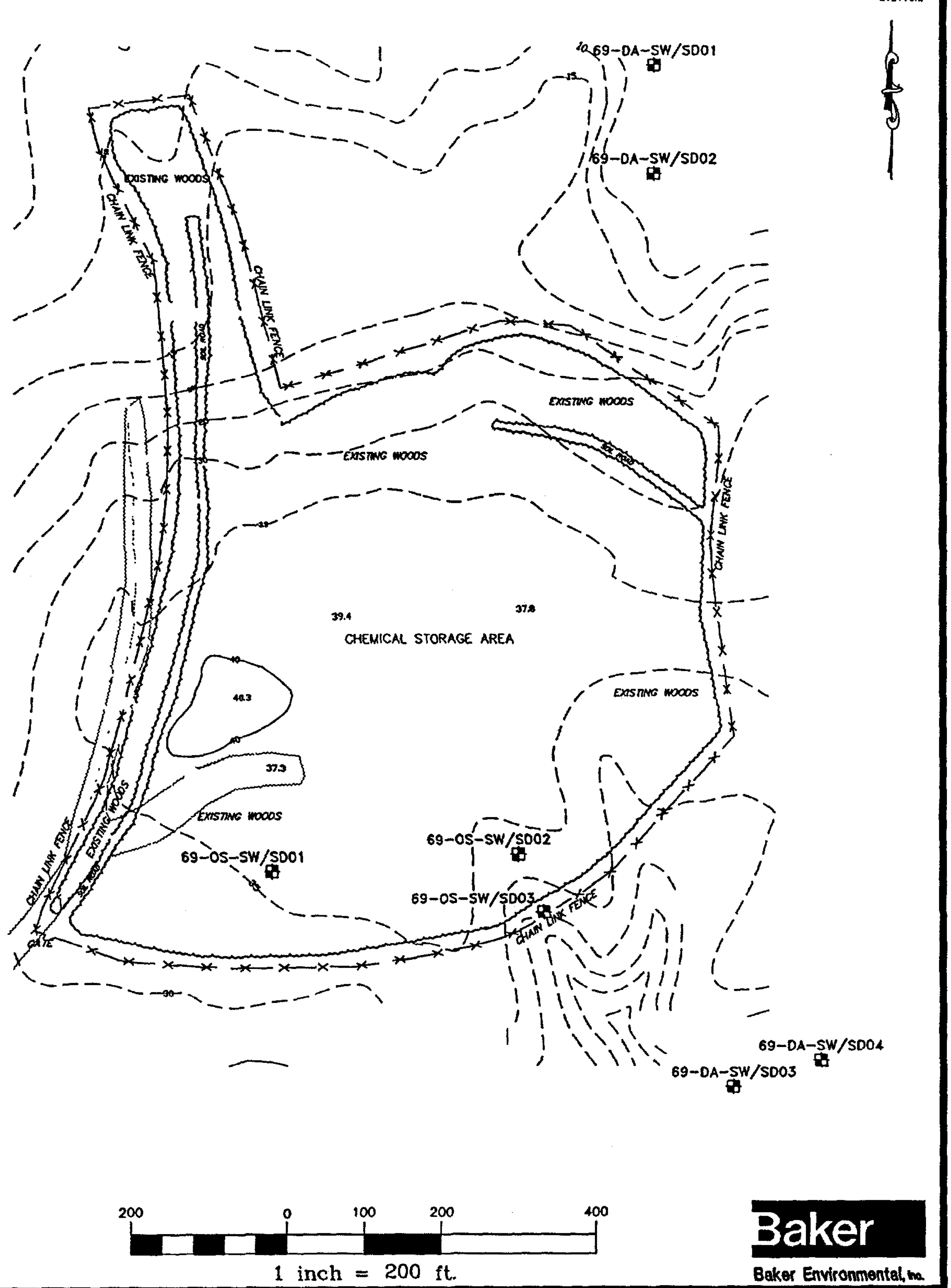


N.T.S.

Baker
Baker Environmental, Inc.

FIGURE 2-11
TYPICAL TYPE III GROUNDWATER
MONITORING WELL CONSTRUCTION DIAGRAM
REMEDIAL INVESTIGATION CTO-0212

MARINE CORPS BASE, CAMP LEJEUNE
NORTH CAROLINA



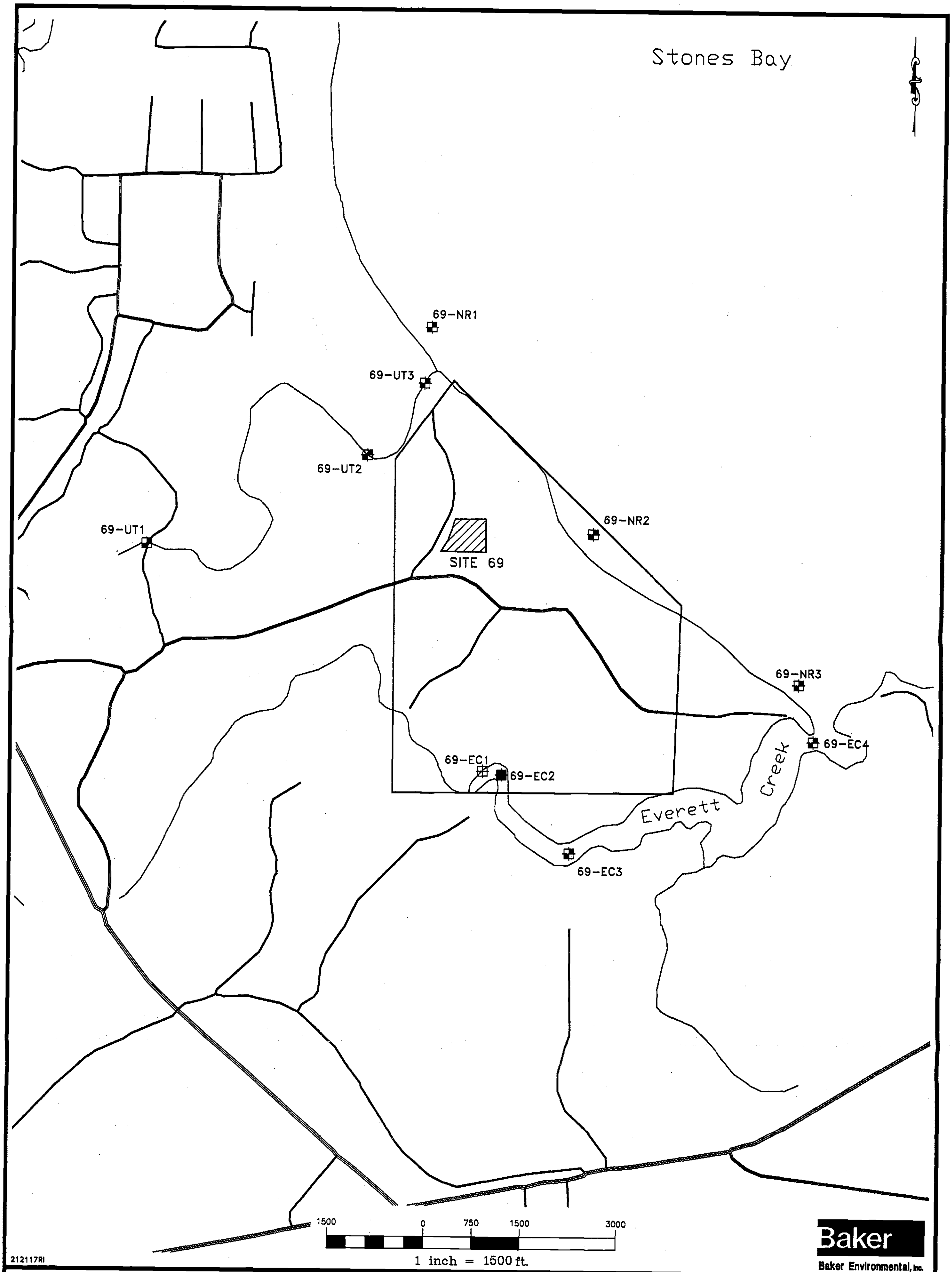
Baker Environmental, Inc.

LEGEND

69-OS-SW01	SURFACE WATER/SEDIMENT SAMPLE LOCATION
	FENCE
	VEGETATION
	TOPOGRAPHIC ELEVATION LINES (FEET, MSL)

SOURCE: REVISED FROM LANTDIV, OCT. 1991

FIGURE 2-12
SURFACE WATER/SEDIMENT SAMPLING LOCATIONS
SITE 69 - RIFLE RANGE CHEMICAL DUMP
REMEDIAL INVESTIGATION CTO-0212
MARINE CORPS BASE, CAMP LEJEUNE
NORTH CAROLINA



LEGEND

UT – UNNAMED TRIBUTARY
EC – EVERETT CREEK
NR – NEW RIVER

69–EC3 ▣	SURFACE WATER/SEDIMENT/FISH/SHELLFISH/ BENTHIC SAMPLING STATION
69–EC1 ⊞	SURFACE WATER/SEDIMENT SAMPLING STATION ONLY
69–EC2 ■	FISH/SHELLFISH/BENTHIC SAMPLING STATION ONLY

FIGURE 2–13
ECOLOGICAL AND AQUATIC
SAMPLING LOCATIONS – SITE 69
REMEDIAL INVESTIGATION CTO–0212

MARINE CORPS BASE, CAMP LEJEUNE
NORTH CAROLINA

01761N062

3.0 PHYSICAL CHARACTERISTICS OF THE STUDY AREA

This section describes the regional and site-specific environmental setting. A discussion of topography, surface hydrology and drainage, geology, hydrogeology, ecology, land use and demographics, climate/meteorology, and water supplies is presented for MCB, Camp Lejeune and Site 69. The tables and figures for Section 3 are contained at the back of the section.

3.1 Topography and Surface Features

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

Site 69 is situated at a topographic high from the immediate surrounding area. Most of the site within the fence is flat; however, the land surrounding the site slopes gently in all directions, as shown on Figure 3-1. The site and surrounding area is heavily wooded. During a site reconnaissance in 1991 and the subject RI, portions of the site area exhibited standing water, which could indicate poor drainage. Everett Creek is located approximately one half mile to the southwest and the New River is located approximately one quarter mile to the northeast.

3.2 Surface Water Hydrology

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

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

Water quality criteria for surface waters in North Carolina have been published under Title 15 of the North Carolina Administrative Code. At MCB, Camp Lejeune, the New River falls into two classifications: SC (estuarine waters not suited for body contact sports or commercial shellfishing) and SA (estuarine waters suited for commercial shellfishing). The SC classification applies to three areas of the New River at MCB, Camp Lejeune, including the Marine Corps Air Station (MCAS). The rest of the New River at MCB, Camp Lejeune falls into the SA classification.

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

The U.S. Corp 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.

Site 69

The main surface water features in the area around Site 69 are the New River to the east and Everett Creek to the south/southwest. Surface water runoff from the southeast portion of the site drains to unnamed ditches that drain into the New River. Surface runoff from the southwest portion of the site drains into the Everett Creek Basin, which could potentially drain into Everett Creek and the New River. Surface water runoff from the northern portion of the site may drain toward the unnamed tributary located to the north. The surrounding areas are heavily wooded and consist of a thick understory, which could inhibit overland surface runoff at great distances.

3.3 Geology and Soils

3.3.1 Regional Geology and Soils

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, 1992). These sediments were deposited in marine or near-marine environments, 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 of geologic and hydrogeologic units for this area.

United States Geological Survey (USGS) studies at MCB, Camp Lejeune indicate that the Base is underlain by seven sand and limestone aquifers separated by confining units of silt and clay. These include the water table (i.e., surficial, water-bearing layer), Castle Hayne, Beaufort, Peedee, Black Creek, and upper and lower Cape Fear aquifers. The combined thickness of these sediments is approximately 1,500 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. Figure 3-2 depicts the locations of hydrogeologic cross-sections of MCB Camp Lejeune area. The cross-sections illustrating the relationship between aquifers in this area are presented on Figure 3-3.

3.3.2 Site 69 Geology and Soils

Information obtained during the RI program indicated that Site 69 is underlain primarily by unconsolidated deposits of silty sand, sandy clay, sand and clay, and clayey sand. These soils represent the Quaternary age "undifferentiated" Formation which characterizes the shallow water table aquifer. Silty sands were encountered from the ground surface to depths ranging from 5 to 18 feet. Beneath the silty sand is a fairly continuous sandy clay, and sand and clay units, which may serve as a groundwater flow retarding layer. This unit shows an apparent thickness ranging from 6 to 27 feet.

Locations of the geologic cross-sections prepared for this site are shown on Figure 3-4. Figure 3-5 presents three geologic cross-sections for the site. Cross-section A-A' depicts the site lithology from south to north and cross-section B-B' depicts the lithology from southeast to north. Cross-section C-C' depicts the lithology from west to east. An evaluation of the cross-sections indicate that the surface of the Castle Hayne dips towards the south/southeast. The soil boring at monitoring well location 69-GW02DW indicates the top of the Castle Hayne at an elevation of 0 feet mean sea level (msl), whereas it was encountered at location 69-GW12DW at an elevation of -27 msl.

As shown on cross-sections A-A', B-B', and C-C', the surficial soils are comprised of fine grained sand with varying amounts of silt between 5 and 22 feet thick. Beneath the surficial silty sand is a fairly continuous silty clay and sandy clay unit ranging in thickness from 0 to approximately 25 feet thick. The clay unit was not observed at well location 69-GW12, southeast of the site. The Castle Hayne formation lies below the clay unit. The upper portion of the formation is comprised of silty sand with shell and limestone fragments with an average thickness of approximately 40 feet. Below the silty sand is a sand unit with trace to little silt. This unit also exhibits a sandy clay/clayey sand layer, with an approximate thickness of 10 feet, at a depth of 145 feet. The deep borings to the bottom of the Castle Hayne encountered limestone beds in the lower portion, beneath the sand unit. These limestone beds are identified in the literature as "marker beds" for the bottom of the Castle Hayne, and were encountered in the three deep borings performed in March/April 1996 at depths of approximately 207 feet.

Monitoring well boring 69-GW15BCH was the deepest boring drilled during the 1996 field program; total depth of 252 feet. Beneath the limestone beds is silty sand with a 4 foot thick silty, sandy clay layer/lenses. At a depth of 245 feet, a silty sand unit was encountered which appeared to be glauconitic. Glauconitic is a descriptive term which refers to a greenish platy mineral which occurs in sediments of marine origin. A glauconitic sand unit is identified as part of the Beaufort formation which lies below the Castle Hayne aquifer and the Beaufort confining unit. The identification of the limestone "marker beds" and the glauconitic sand unit was used as a basis for terminating the boring and installing monitoring wells GW15BCH, GW02BCH, and GW03BCH below the limestone beds.

Relative soil densities were obtained from results of the standard penetration tests (blows per 6 inches for a standard spoon sampler). These densities indicate the shallow soils to be very loose to medium dense. The deep shelly sands have a relative density of medium dense to very dense. One soil sample was submitted from Site 69 (69-GW02DW from 6 to 8 feet) for grain size distribution and Atterberg limits. Laboratory data classified the sample as a loamy sand. This classification generally correlates with the field description of a silty sand. Unified Soil Classification System (USCS) designations for the soils encountered at the site are SM (silty sands), CL (sandy clays) and SC (clayey sands).

3.4 Hydrogeology

3.4.1 Regional Hydrogeology

The following summary of regional hydrogeology was originally presented in Harned et al. (1989).

The surficial water table aquifer consists of a series of sediments, primarily sand and clay, which commonly extend to depths of 50 to 100 feet. This unit is not used as a water supply on the Base.

The principal water supply for the Base is found in the series of sand and limestone beds that occur between 50 and 300 feet below land surface (bls). This series of sediments generally is known as the Castle Hayne Formation, associated with the Castle Hayne Aquifer. This aquifer is about 150 to 350 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 5 to 30 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 northwestern 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 part of the Castle Hayne Aquifer.

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

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

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

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

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

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

3.4.2 Site 69 Hydrogeology

Shallow groundwater was encountered during drilling at Site 69 during the RI at depths ranging from 1.23 to 5.26 feet bgs (elevation 7.17 to 3.74 feet msl). Groundwater levels measured in existing and newly installed shallow monitoring wells over a 2-year period and are presented in Table 3-2.

Shallow groundwater contour maps were constructed for the shallow water-bearing unit and are presented on Figures 3-6, 3-7, 3-8, and 3-9. The groundwater contour maps indicate a relatively flat mound centered at the site with the shallow groundwater surface sloping away radially from the site at an approximate gradient of 0.065 ft/ft (range 0.07 to 0.06). Shallow groundwater likely discharges into the New River located approximately one quarter mile to the east, and into Everett Creek one half mile to the southwest. This correlates with the general topography of the site. Groundwater recharge appears to occur within the central portion of the site.

Groundwater level measurements were obtained from all wells at Site 69 on May 2, 1996. Groundwater level measurements are presented in Table 2. Groundwater elevations for the shallow water table are similar to previously-measured levels. The upper zone Castle Hayne wells (approximately 60 feet bgs) indicate groundwater levels between 4.62 feet and 33.96 feet bgs (elevation 4.44 to 8.91 feet msl). Figures 3-10, 3-11 and 3-12 depict groundwater contours for the upper zone of the Castle Hayne aquifer. In the southern portion of the site, groundwater flow in the upper Castle Hayne is east-southeast.

Groundwater levels in the intermediate and bottom zone Castle Hayne wells (125 and 230 feet bgs) were 27.22 feet to 32.54 feet bgs (elevation 5.14 to 9.57 feet msl). There would appear to be some interconnection between the shallow water table aquifer and the Castle Hayne aquifer due to the similar groundwater elevations at some of the monitoring well locations. A groundwater contour map (refer to Figure 3-13) was constructed for the deepest zone of the Castle Hayne aquifer from monitoring wells installed in April 1996. The contour map indicates an eastward groundwater flow direction towards the New River. Recharge for the Castle Hayne aquifer would be from the west, and possibly from the surficial aquifer as the units are separated by a semiconfining layer. The gradient for the deep Castle Hayne aquifer on May 2, 1996 is 0.002 ft/ft, which is flat.

The shallow aquifer at Site 69 was characterized by performing in situ rising head slug tests in monitoring wells 69-GW09, 69-GW10 and 69-GW12. This testing was performed on April 29 and 30, 1994. An electronic data logger (In-Situ Hermit Model SE2000) and pressure transducer assembly were used to record the recovery of groundwater in these monitoring wells to static level. All data were recorded on a logarithmic scale to 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). All slug test data were analyzed using Geraghty & Miller's AQTESOLV computer program for performing quantitative groundwater assessments. The Bouwer and Rice solution for slug tests in unconfined aquifers was used to evaluate all test data. The input parameters and plots generated are contained in Appendix H.

Table 3-3 lists the hydraulic conductivity (K) values obtained from the data analysis, the average hydraulic gradient, the assumed effective porosity, and the calculated value for groundwater velocity. The average estimated K value from all three wells is 0.66 feet/day (2.3×10^{-4} cm/second). The average K value is within the acceptable range for silty sands (Freeze/Cherry, 1979). Average calculated hydraulic gradient from groundwater measurements was 0.065 ft/ft. Published effective porosity values indicate a range of 25 to 50 percent for sands and silts (Freeze/Cherry, 1979). Due to the silty nature of the sands, a value of 35 percent was used for effective porosity. The estimated 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 the above variables, the average groundwater velocity (V) is estimated to be 0.12 feet/day (44 feet/year). This is a conservative estimate because of the nature of the silty sand and the variability in the estimated K values from the slug test data.

An approximate transmissivity value (T) can be obtained from the hydraulic conductivity (K) and the thickness of the aquifer (b). Assuming a shallow aquifer thickness of 36 feet (maximum saturated thickness of surficial deposits above the Castle Hayne), an estimated T of 24 feet^2/day was calculated. A recent hydrogeologic investigation conducted by Baker in the MCAS area (1994), which included an aquifer pump test within the shallow water-bearing zone (approximately 15 feet), indicated K and T values of 6.3 feet/day (2.2 x 10^{-3} cm/sec) and 703 gallons/day/foot (94 feet^2/day), respectively. The estimated values obtained at Site 69 from the slug test data are approximately ten times the values obtained from the pump test. This may be due to the fact that well 69-GW09 was actually screened within the upper portion of the Castle Hayne and well 69-GW12 may have been screened partially within the sandy clay deposits. Values for T determined from a pump test performed at Hadnot Point on the opposite side of the New River from Site 69 were 561 gallons/day/foot (75 feet^2/day). The average transmissivity value for the two pump tests is 40 feet^2/day. The calculated transmissivity value from slug tests at Site 69 was approximately one-third of the average pump test value.

In situ falling head and rising head slug tests were performed in the two deep monitoring wells which are installed in the upper unit of the Castle Hayne Aquifer. Analysis of these slug tests was performed as stated for the shallow aquifer. Appendix H contains the input parameters and plots generated for the deep wells. Table 3-3 lists the K values obtained from the data analysis, the average hydraulic gradient, and the assumed effective porosity. The average estimated K value from the two wells is 3.5 feet/day (1.2 x 10^{-3} cm/sec). The average K value is within the acceptable range for silty sands (Freeze/Cherry, 1979). An estimated hydraulic gradient for the Castle Hayne Aquifer is 0.016 ft/ft. Published effective porosity values indicate a range of 25 to 50 percent for sands and silts (Freeze/Cherry, 1979). Due to the silty nature of the sands, a value of 35 percent was used for porosity. The estimated average linear groundwater velocity for the Upper Castle Hayne was calculated by using the following formula:

$$V = Ki/n$$

Using the variables listed above, the deep groundwater velocity (V) is estimated to be 0.16 feet/day (58 feet/year). This is a conservative estimate because of the nature of the silty sand and the variability in the estimated K values from the slug test data. Estimates of transmissivity for the deep aquifer are available from well performance tests conducted in a potable water supply well in the Castle Hayne aquifer in the vicinity of the Rifle Range. Transmissivity value from well RR-229 testing was 19,400 feet^2/day (145,110 gallons/day/foot).

3.5 Land Use Demographics

3.5.1 Regional

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 had 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.

The existing land use pattern for the various developed geographic areas within the MCB are listed, per geographic area, on Table 3-4. In addition, the number of acres comprising each land use category has been estimated and provided on the table. Site 69 is located to the south of the rifle range area in the western region of MCB, Camp Lejeune.

3.5.2 Site 69

The area around Site 69 is used for military training. A fence has been constructed around the site to prevent access. Future land use of the area is reserved for military training only. Hunting is not permitted in this area.

Sensitive environmental areas would include the unnamed tributary to the north of the site and Everett Creek to the south. Both water bodies are in a coastal wetland. There are no sensitive human receptors within one mile of the site. An elementary school is located approximately two miles west of the site.

Site 69 (Rifle Range Chemical Dump) is located approximately one mile southeast of the Rifle Range. Approximately 73 acres of development exists at the Rifle Range. Troop housing straddles both sides of the entrance road and supporting facilities are situated directly behind the housing. This main area permits easy access to the large training range. A small secondary cluster of barracks and associated administrative and classroom training areas located southeast of the main area are scheduled to be demolished.

3.6 Climate and Meteorology

MCB, Camp Lejeune experiences mild winters, and hot and humid summers. The average yearly rainfall is greater than 50 inches, and the potential evapotranspiration in the region varies from 34 to 36 inches of rainfall equivalent per year. The winter and summer seasons usually receive the most precipitation. Temperature ranges are reported to be 33 to 53 degrees Fahrenheit (°F) in the winter (i.e., January) and 71 to 88°F in the summer (i.e., July). Winds are generally south-southwesterly in the summer and north-northwesterly in the winter (Water and Air Research, 1983). Table 3-5 presents a climatic summary for the MCAS New River. Tidal data for the New River in Jacksonville, North Carolina is presented in Table 3-6.

3.7 Water Supply

MCB, Camp Lejeune water is supplied entirely from groundwater 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).

The water supply wells are all located within the boundaries of the base. The average water supply well at the base has a depth of 162 feet, a casing diameter of 8 inches, and yields 174 gallons per minute (gpm) (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 gpm in municipal and industrial wells in the MCB, Camp Lejeune area. The water retrieved is typically a hard, calcium bicarbonate type.

There are no Base water supply wells within a one-mile radius of Site 69.

No Base supply wells were sampled during this investigation. Specific supply wells are periodically sampled for full organic and inorganic analysis. Supply wells located near Site 41 do not appear to be potentially impacted by Site 69 because it is not located downgradient from Site 69. Greenhorn &

O'Mara performed a study in 1992 ("Preliminary Draft Report Wellhead Monitoring Study," December 1992) sampling Base water supply wells and tabulating the results. The wells were analyzed for VOCs, selected SVOCs, organochlorine pesticides, PCBs, herbicides, pentachlorophenol, and selected metals. These parameters are similar to those analyzed during this RI for CTO-0212. Well HP-621 was not sampled during the Greenhorn & O'Mara study as it has been taken out of service. Results for HP-629 indicated concentrations for organics below the detection limit. For metals, only iron (580 μg/L) and manganese (20 μg/L) were detected above detection limits. Iron was detected above the Federal Secondary MCL and NCWQS of 300 μg/L. The Federal Secondary MCL and NCWQS for manganese is 50 μg/L.

SECTION 3.0 TABLES

TABLE 3-1

GEOLOGIC AND HYDROGEOLOGIC UNITS IN THE COASTAL PLAIN OF NORTH CAROLINA
REMEDIAL INVESTIGATION, CTO-0212
MCB CAMP LEJEUNE, NORTH CAROLINA

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

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

Source: Harned et al., 1989.

TABLE 3-2

SUMMARY OF WATER LEVEL MEASUREMENTS FROM MONITORING WELLS ON JANUARY 20-22, 1994, JANUARY 23, 1994, FEBRUARY 16, 1994, MARCH 1, 1994, APRIL 30, 1994, JANUARY 25, 1995, FEBRUARY 20, 1995, AND MAY 2, 1996
SITE 69
REMEDIAL INVESTIGATION, CTO-0212
MCB CAMP LEJEUNE, NORTH CAROLINA

Monitoring Zone (See Legend)	Well No.	Top of PVC Casing Elevation(1) (feet, above msl)	Depth to Groundwater (feet, below top of casing) (01/20/94 - 01/22/94)	Groundwater Elevation (feet, above msl) (01/20/94 - 01/22/94)	Depth to Groundwater (feet, below top of casing) (01/23/94)	Groundwater Elevation (feet, above msl) (01/23/94)	Depth to Groundwater (feet, below top of casing) (02/16/94)	Groundwater Elevation (feet, above msl) (02/16/94)
SA	69-GW01(2)	32.14	8.18	23.96	10.65	21.49	4.84	27.30
SA	69-GW02(2)	37.02	5.76	31.26	5.88	31.14	4.08	32.94
SA	69-GW03(2)	35.04	5.36	29.68	5.54	29.50	5.40	29.64
SA	69-GW04(2)	39.81	7.42	32.39	7.44	32.37	7.14	32.67
SA	69-GW05(2)	37.12	10.02	27.10	9.66	27.46	9.13	27.99
SA	69-GW06(2)	30.57	25.14	5.43	25.21	5.36	24.61	5.96
SA	69-GW07(2)	19.76	12.98	6.78	13.33	6.43	13.02	6.74
SA	69-GW08(2)	38.03	7.98	30.05	8.12	29.91	8.23	29.80
SA	69-GW09(3)	12.44	8.70	3.74	8.71	3.73	3.90	8.54
SA	69-GW10(3)	41.89	7.50	34.39	7.47	34.42	7.41	34.48
SA	69-GW11(3)	28.86	7.30	21.56	6.99	21.87	5.83	23.03
SA	69-GW12(3)	11.2	3.98	7.22	4.30	6.90	3.90	7.30
SA	69-GW13(4)	38.18	NA	NA	NA	NA	NA	NA
SA	69-GW14(5)	35.22	NA	NA	NA	NA	NA	NA
SA	69-GW15(6)	37.41	NA	NA	NA	NA	NA	NA
UCH	69-GW02DW(3)	36.94	NA	NA	NA	NA	32.24	4.70
UCH	69-GW03IW(4)	37.55	NA	NA	NA	NA	NA	NA
UCH	69-GW12DW(3)	9.38	NA	NA	NA	NA	4.94	4.44
UCH	69-GW13IW(4)	38.40	NA	NA	NA	NA	NA	NA
UCH	69-GW14IW(5)	35.21	NA	NA	NA	NA	NA	NA
UCH	69-GW15IW(6)	37.54	NA	NA	NA	NA	NA	NA
ICH	69-GW02DD(4)	36.98	NA	NA	NA	NA	NA	NA
ICH	69-GW14DW(5)	35.17	NA	NA	NA	NA	NA	NA
BCH	69-GW02BCH(7)	36.79	NA	NA	NA	NA	NA	NA
BCH	69-GW03BCH(7)	38.52	NA	NA	NA	NA	NA	NA
BCH	69-GW15BCH(7)	38.63	NA	NA	NA	NA	NA	NA

Notes:
(1) Mean sea level
(2) Existing monitoring well installed by ESE, Inc., November 1986.
(3) Phase I monitoring well installed by Baker Environmental, Inc., January 1994.
(4) Monitoring well installed by Baker, May 1994.
(5) Monitoring well installed by Baker, December 1994.
(6) Monitoring well installed by Baker, March 1995.
(7) Monitoring well installed by Baker, April 1996
NA = Not Available

Legend:
SA - Shallow Aquifer
UCH - Upper Zone of Castle Hayne
ICH - Intermediate Zone of Castle Hayne
BCH - Bottom Zone of Castle Hayne

TABLE 3-2 (Continued)

SUMMARY OF WATER LEVEL MEASUREMENTS FROM MONITORING WELLS ON JANUARY 20-22, 1994, JANUARY 23, 1994, FEBRUARY 16, 1994, MARCH 1, 1994, APRIL 30, 1994, JANUARY 25, 1995, FEBRUARY 20, 1995, AND MAY 2, 1996
SITE 69
REMEDIAL INVESTIGATION, CTO-0212
MCB CAMP LEJEUNE, NORTH CAROLINA

Monitoring Zone (See Legend)	Well No.	Depth to Groundwater (feet, below top of casing) (03/01/94)	Groundwater Elevation (feet, above msl) (03/01/94)	Depth to Groundwater (feet, below top of casing) (04/30/94)	Groundwater Elevation (feet, above msl) (04/30/94)	Depth to Groundwater (feet, below top of casing (01/25/95)	Groundwater Elevation (feet, above msl) (01/25/95)	Depth to Groundwater (feet, below top of casing (02/20/95)	Groundwater Elevation (feet, above msl) (02/20/95)	Depth to Groundwater (feet, below top of casing (5/2/96)	Groundwater Elevation (feet, above msl) (5/2/96)
SA	69-GW01(2)	4.62	27.52	5.89	26.25	3.73	28.41	3.24	28.90	6.72	25.42
SA	69-GW02(2)	5.33	31.69	6.36	30.66	4.10	32.92	3.40	33.62	5.79	31.23
SA	69-GW03(2)	5.61	29.43	6.35	28.69	4.82	30.22	4.38	30.66	7.87	27.17
SA	69-GW04(2)	7.39	32.42	7.82	31.99	5.85	33.96	5.35	34.46	7.58	32.23
SA	69-GW05(2)	9.28	27.84	9.92	27.20	9.46	27.66	9.19	27.93	10.24	26.88
SA	69-GW06(2)	24.63	5.94	25.20	5.37	16.44	14.13	17.05	13.52	24.64	5.93
SA	69-GW07(2)	13.20	6.56	14.22	5.54	8.50	11.26	8.47	11.29	13.85	5.91
SA	69-GW08(2)	8.40	29.63	8.97	29.06	7.71	30.32	7.57	30.46	8.36	29.67
SA	69-GW09(3)	8.38	4.06	9.09	3.35	7.12	5.32	7.15	5.29	8.80	3.64
SA	69-GW10(3)	7.60	34.29	8.10	33.79	6.12	35.77	5.72	41.17	7.65	34.24
SA	69-GW11(3)	5.91	22.95	6.73	22.13	5.20	23.66	5.12	23.74	7.37	21.49
SA	69-GW12(3)	4.01	7.19	4.55	6.65	2.79	8.41	2.67	8.53	4.24	6.96
SA	69-GW13(4)	NA	NA	NA	NA	3.91	34.27	3.15	35.03	5.19	32.99
SA	69-GW14(5)	NA	NA	NA	NA	4.91	30.31	4.31	30.91	7.82	27.40
SA	69-GW15(6)	NA	NA	NA	NA	NA	NA	NA	NA	3.22	34.19
UCH	69-GW02DW(3)	28.12	8.82	28.60	8.34	30.35	6.59	26.33	10.61	28.43	8.51
UCH	69-GW03IW(4)	NA	NA	NA	NA	27.00	10.55	26.95	10.60	29.05	8.50
UCH	69-GW12DW(3)	4.67	4.71	5.04	4.34	3.35	6.03	3.10	6.28	4.62	4.76
UCH	69-GW13IW(4)	NA	NA	NA	NA	35.54	2.86	32.30	6.10	33.96	4.44
UCH	69-GW14IW(5)	NA	NA	NA	NA	24.40	10.81	24.37	10.84	26.30	8.91
UCH	69-GW15IW(6)	NA	NA	NA	NA	NA	NA	NA	NA	29.39	8.15
ICH	69-GW02DD(4)	NA	NA	NA	NA	26.36	10.62	30.11	6.87	31.84	5.14
ICH	69-GW14DW(5)	NA	NA	NA	NA	28.40	6.77	28.15	7.02	29.88	5.29
BCH	69-GW02BCH(7)	NA	NA	NA	NA	NA	AN	NA	9.57	27.22	9.57
BCH	69-GW03BCH(7)	NA	NA	NA	NA	NA	NA	NA	9.24	29.28	9.24
BCH	69-GW15BCH(7)	NA	NA	NA	NA	NA	NA	NA	9.44	29.19	9.44

Notes:

(1) Mean sea level
(2) Existing monitoring well installed by ESE, Inc., November 1986.
(3) Phase I monitoring well installed by Baker Environmental, Inc., January 1994.
(4) Monitoring well installed by Baker, May 1994.
(5) Monitoring well installed by Baker, December 1994.
(6) Monitoring well installed by Baker, March 1995.
(7) Monitoring well installed by Baker, April 1996
NA = Not Available

Legend:
SA - Shallow Aquifer
UCH - Upper Zone of Castle Hayne
ICH - Intermediate Zone of Castle Hayne
BCH - Bottom Zone of Castle Hayne

TABLE 3-3

AQUIFER CHARACTERISTICS - MONITORING WELLS
SITE 69
REMEDIAL INVESTIGATION, CTO-0212
MCB CAMP LEJEUNE, NORTH CAROLINA

Well No.	Hydraulic Conductivity (K) (feet/day)	Hydraulic Gradient (i) (feet/feet)	Effective Porosity (n)	Groundwater Velocity (V) (feet/day)
69-GW09	1.702	0.065	0.35	0.32
69-GW10	0.167	0.065	0.35	0.03
69-GW12	0.118	0.065	0.35	0.02
69-GW02DW	0.292	0.016	0.35	0.05
69-GW12DW	6.6629	0.016	0.35	1.25

TABLE [illegible]

LAND UTILIZATION: DEVELOPED AREAS ACRES/LAND USE (PERCENT)
REMEDIAL INVESTIGATION, CTO-0212
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 3-5

CLIMATIC DATA SUMMARY
MARINE CORPS AIR STATION, NEW RIVER
REMEDIAL INVESTIGATION, CTO-0212
MCB, CAMP LEJEUNE, NORTH CAROLINA

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

* = Mean no. of days less than 0.5 days

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

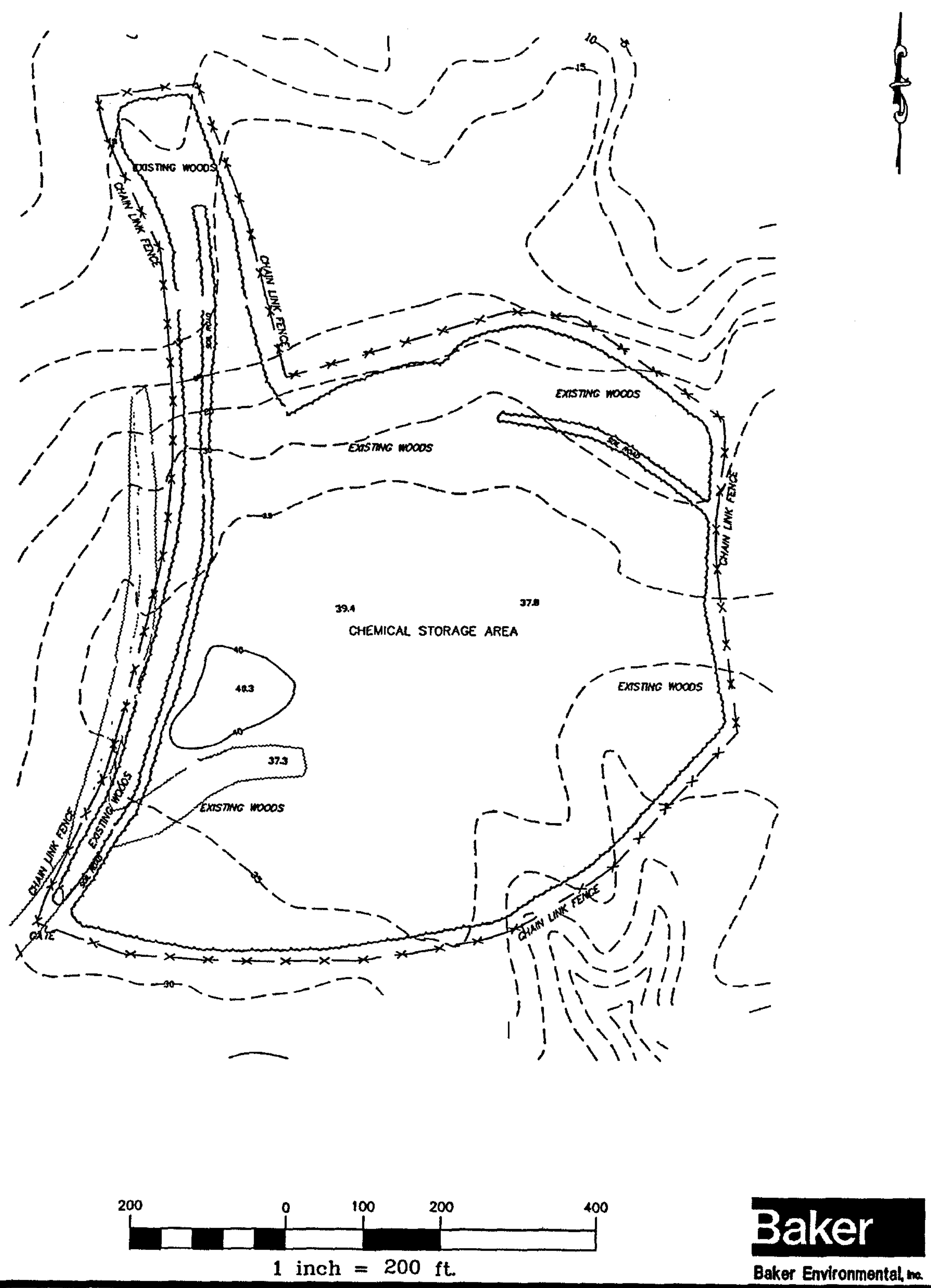
TABLE 3-6

TIDE DATA FOR THE NEW RIVER IN JACKSONVILLE, NORTH CAROLINA
REMEDIAL INVESTIGATION, CTO-0212
MCB CAMP LEJEUNE, NORTH CAROLINA

Date	High Tide		Low Tide	
	Time	Hgt (ft)	Time	Hgt (ft)
08/01/92	13	1.7	7.9	0.88
	NA	NA	20.3	0.92
08/02/92	1.5	1.62	NA	NA
	14.1	1.62	8.8	0.84
	NA	NA	21.2	0.9
08/03/92	2.5	1.55	9.5	0.93
	15.0	1.64	22.2	0.92
08/04/92	3.3	1.5	10.1	0.95
	16.5	1.67	22.6	1.05
08/05/92	4.5	1.54	11.4	1.05
	16.9	1.62	NA	NA
08/06/92	NA	NA	0.4	1.02
	5.4	1.47	12.4	1.03
	18.1	1.59	NA	NA
08/07/92	NA	NA	1.3	1.04
	6.3	1.49	13.3	1.04
	19.0	1.59	NA	NA
08/08/92	NA	NA	2.0	1.08
	7.3	1.47	14.4	1.02
	2.10	1.58	NA	NA
08/09/92	8.6	1.44	3.4	1.02
	20.8	1.55	15.4	1.03
08/10/92	9.6	1.5	4.1	1.02
	21.8	1.59	16.2	1.01
08/11/92	10.2	1.52	4.9	1.03
	NA	NA	16.9	1.02
08/12/92	0.3	1.72	NA	NA
	11.1	1.57	5.7	0.99
	22.8	1.59	17.6	0.96
08/13/92	11.4	1.59	6.1	1.02
	NA	NA	18.0	1.06
08/14/92	0.04	1.81	NA	NA
	11.9	1.76	6.4	1.19
	NA	NA	19.0	1.21
08/15/92	0.4	1.84	NA	NA
	12.6	1.79	8.0	1.27
	NA	NA	19.7	1.20
08/16/92	1.0	1.76	NA	NA
	13.0	1.73	7.7	1.22
	NA	NA	19.9	1.16
08/17/92	1.4	1.67	NA	NA
	13.7	1.66	8.2	1.11
	NA	NA	20.4	1.14
08/18/92	1.9	1.62	NA	NA
	14.5	1.65	8.6	1.09
	NA	NA	21.4	1.12
8/19/92	2.7	1.55	9.3	1.05
	15.2	1.64	22.2	1.13
08/20/92	3.7	1.54	10.0	1.12
	15.4	1.66	23.3	1.17
08/21/92	4.2	1.55	11.2	1.13
	16.6	1.64	NA	NA
08/22/92	NA	NA	0.2	1.14
	5.0	1.51	12.0	1.06
	17.6	1.58	NA	NA
08/23/92	NA	NA	0.9	1.07
	6.1	1.48	13.1	1.02
	18.7	1.60	NA	NA
08/24/92	NA	NA	2.0	1.05
	7.3	1.52	14.2	1.01
	20.0	1.64	NA	NA
08/25/92	NA	NA	3.1	1.02
	8.4	1.56	15.1	0.95
	21.0	1.65	NA	NA
08/26/92	9.2	1.59	4.0	0.95
	21.8	1.71	16.2	0.90
08/27/92	10.3	1.71	5.0	0.97
	22.5	1.74	17.3	0.95
08/28/92	11.2	1.73	6.0	0.95
	NA	NA	18.5	0.89
08/29/92	0.5	1.64	NA	NA
	12.5	1.81	6.9	0.97
	NA	NA	19.5	0.96
08/30/92	0.9	1.74	NA	NA
	12.9	1.75	7.7	0.96
	NA	NA	20.2	0.93
08/31/92	1.4	1.57	NA	NA
	14.1	1.61	8.5	0.84
	NA	NA	21.0	0.91
09/01/92	2.5	1.56	NA	NA
		NA	9.2	0.96
	14.8	1.65	21.9	1.00
09/02/92	3.1	1.52	10.4	0.94
	15.6	1.59	22.8	0.98
09/03/92	4.1	1.45	11.0	0.95
	16.7	1.55	NA	NA
09/04/92	NA	NA	0.2	1.02
	4.8	1.39	12.0	0.99
	17.7	1.53	NA	NA
09/05/92	NA	NA	0.7	1.02
	6.2	1.44	13.2	1.04
	18.8	1.58	NA	NA
09/06/92	NA	NA	1.7	1.15
	7.2	1.60	14.1	1.15
	19.9	1.68	NA	NA
09/07/92	NA	NA	2.7	1.23
	8.1	1.62	14.9	1.17
	20.4	1.66	NA	NA
09/08/92	8.8	1.55	3.4	1.12
	21.1	1.59	15.7	1.08
09/09/92	9.6	1.55	4.0	1.04
	21.9	1.57	16.5	1.04
09/10/92	10.4	1.54	4.8	0.99
	22.5	1.55	17.2	1.02
09/11/92	10.8	1.66	4.8	1.05
	23.3	1.66	18.1	1.12
09/12/92	11.4	1.71	6.1	1.14
	23.7	1.64	18.5	1.12
09/13/92	12.1	1.69	6.7	1.09
	NA	NA	18.9	1.10
09/14/92	0.3	1.64	NA	NA
	12.7	1.70	7.0	1.08
	NA	NA	19.8	1.11
09/15/92	0.9	1.61	NA	NA
	13.1	1.69	7.6	1.07
	NA	NA	20.2	1.11
09/16/92	1.4	1.58	NA	NA
	13.9	1.62	8.1	1.05
	NA	NA	21.0	1.04
09/17/92	2.2	1.50	9.1	1.00
	14.6	1.57	21.8	1.02
09/18/92	2.9	1.43	9.8	0.96
	15.4	1.56	22.8	1.03

Source:
NOAA Tide Station in Hampton Roads, VA
NA - Not Available

SECTION 3.0 FIGURES



Baker

Baker Environmental, Inc.

LEGEND

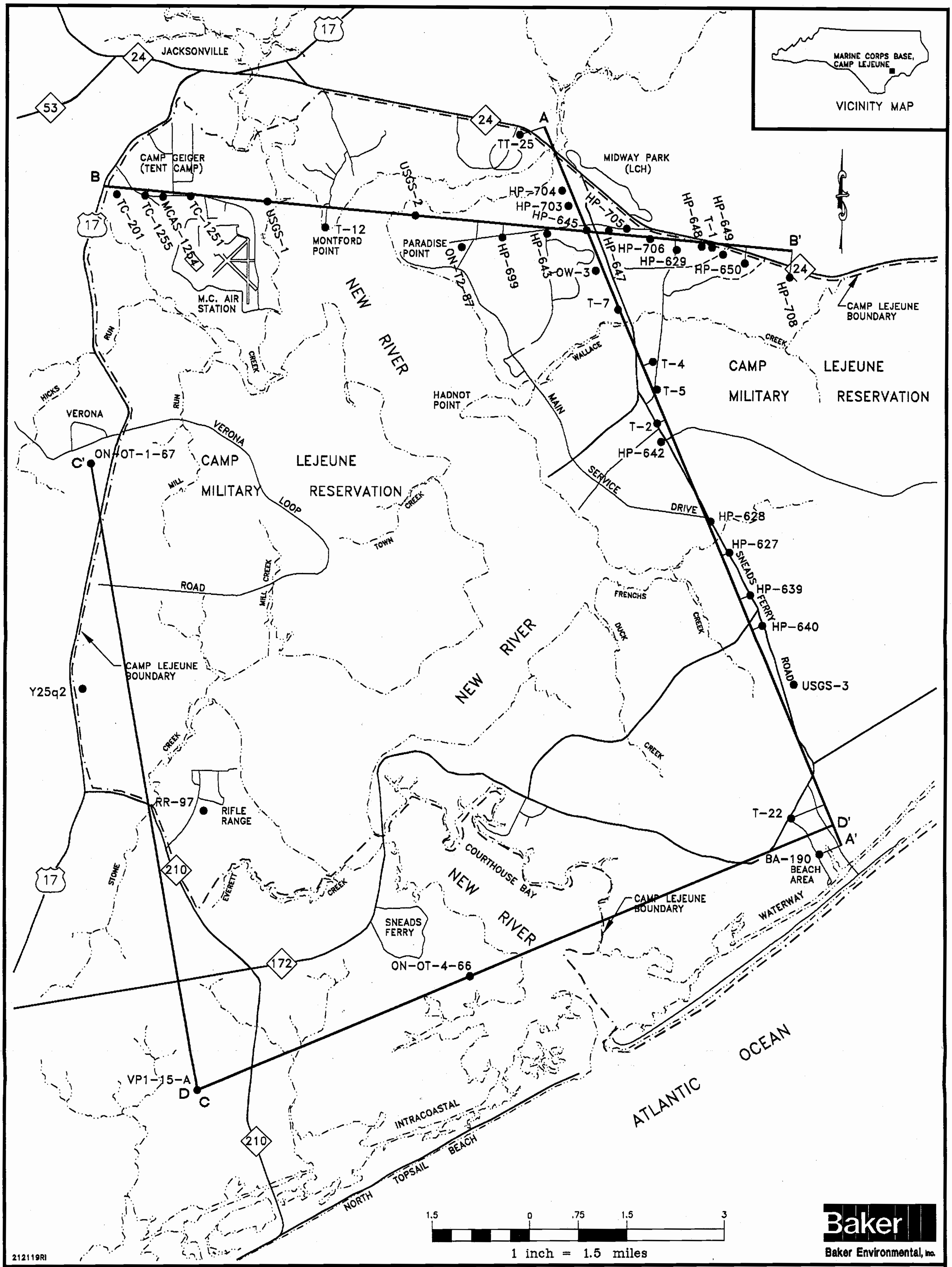
✕— —✕ FENCE

VEGETATION

TOPOGRAPHIC ELEVATION LINES (FEET, MSL)

SOURCE: REVISED FROM LANTDIV, OCT. 1991

FIGURE 3-1
TOPOGRAPHY AND SURFACE FEATURES
SITE 69 – RIFLE RANGE CHEMICAL DUMP
REMEDIAL INVESTIGATION CTO-0212
MARINE CORPS BASE, CAMP LEJEUNE
NORTH CAROLINA



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

FIGURE 3-2
LOCATION OF HYDROGEOLOGIC CROSS-SECTIONS
MARINE CORPS BASE, CAMP LEJEUNE
REMEDIAL INVESTIGATION CTO-0212

MARINE CORPS BASE, CAMP LEJEUNE
NORTH CAROLINA

01761N07Z

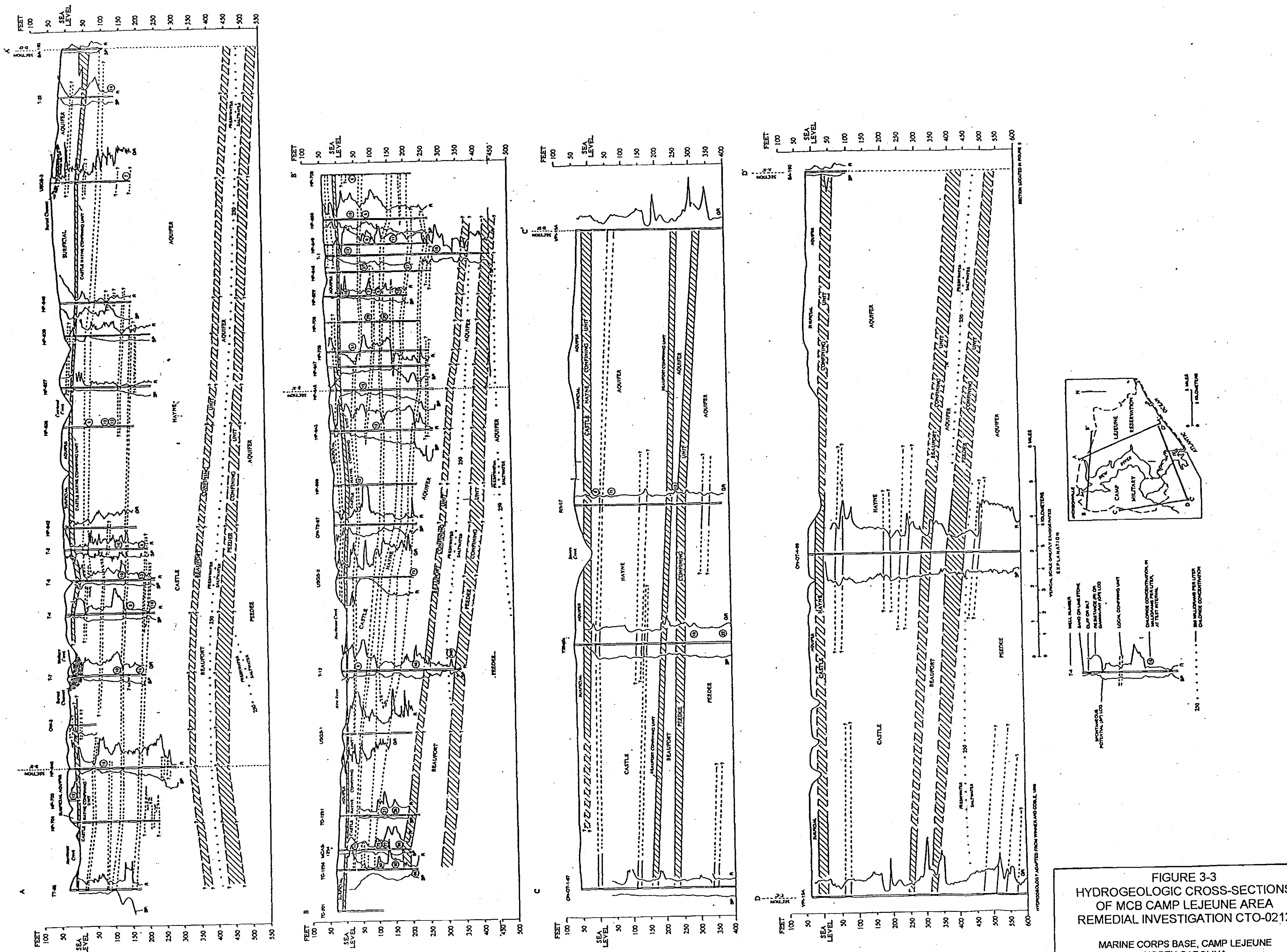
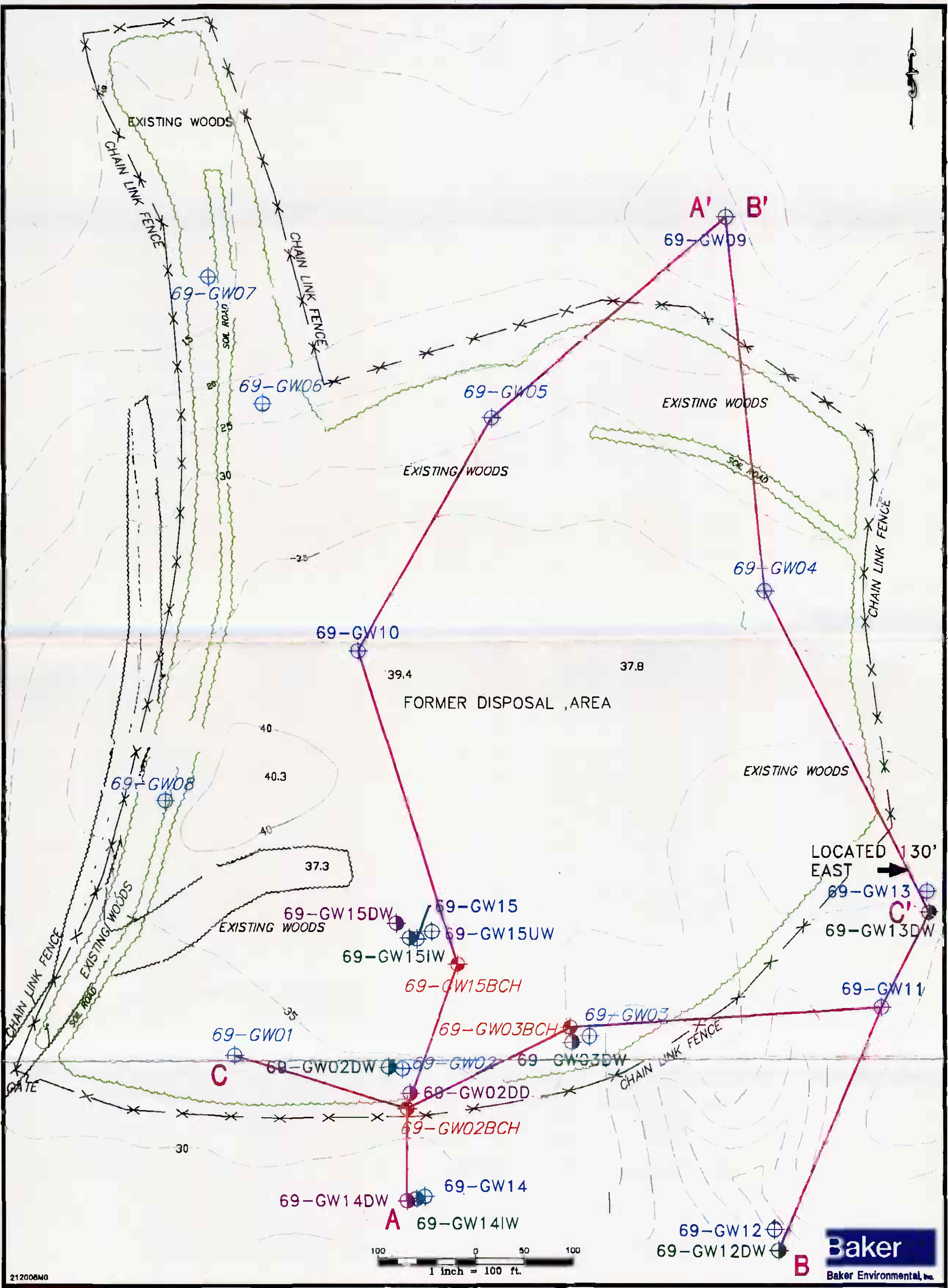


FIGURE 3-3
HYDROGEOLOGIC CROSS-SECTIONS
OF MCB CAMP LEJEUNE AREA
REMEDIAL INVESTIGATION CTO-0212

MARINE CORPS BASE, CAMP LEJEUNE
NORTH CAROLINA

01761N08Z

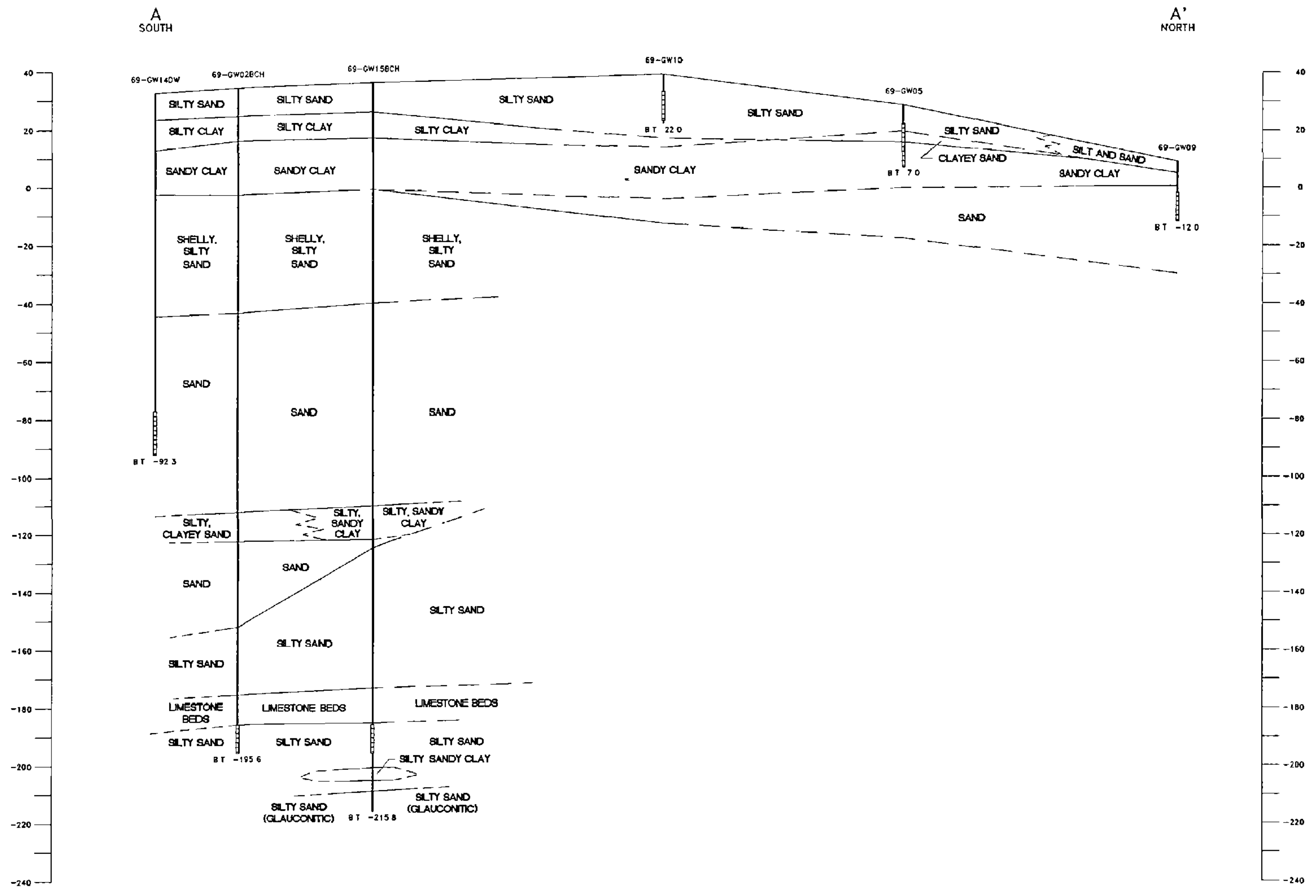


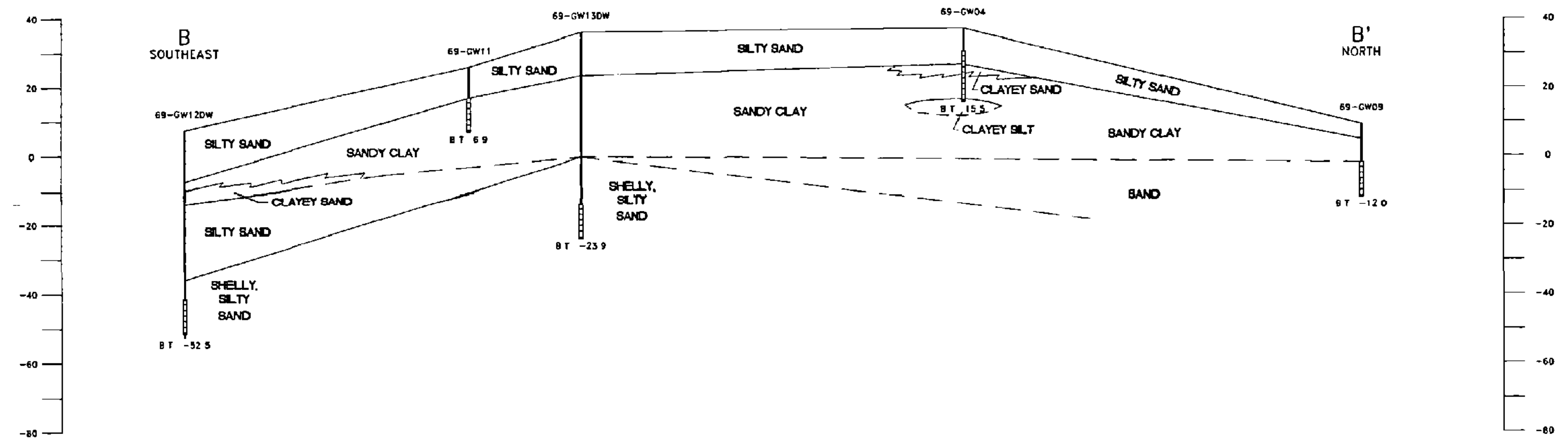
LEGEND

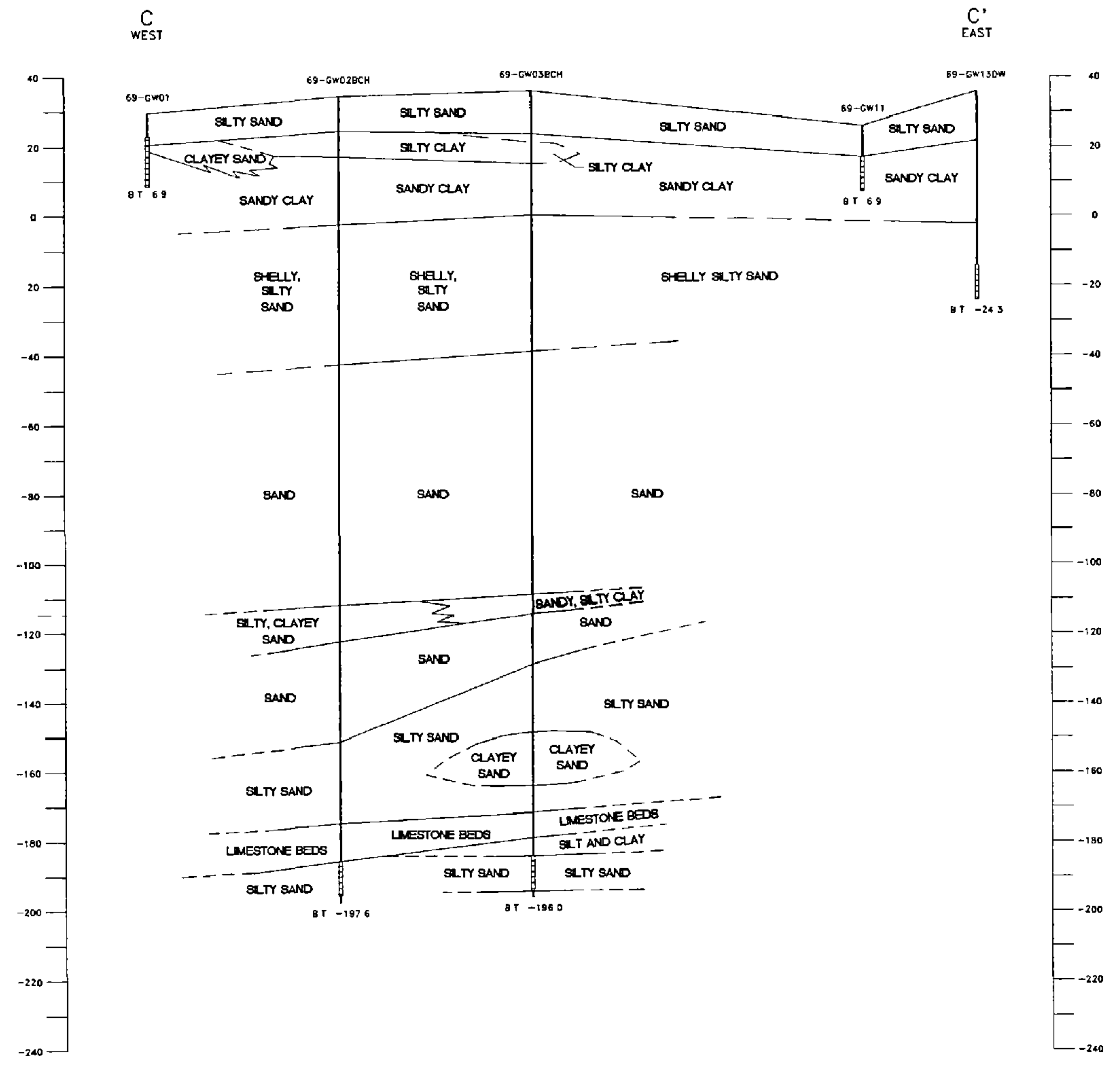
69GW15BCH ⊕ DEEP ZONE CASTLE HAYNE WELLS
69GW09 ⊕ SHALLOW WELLS
69GW02DW ⊕ UPPER ZONE CASTLE HAYNE WELLS
69-GW02DD ⊕ INTERMEDIATE ZONE CASTLE HAYNE WELLS
30 TOPOGRAPHIC ELEVATION LINES (FEET, MSL)
SOURCE: REVISED FROM LANTDIV. OCT. 1991

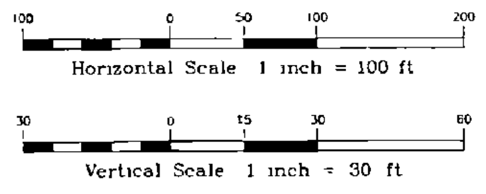
FIGURE 3-4
CROSS-SECTION LOCATION MAP
SITE 69 – RIFLE RANGE CHEMICAL DUMP
REMEDIAL INVESTIGATION CTO-0212

MARINE CORPS BASE, CAMP LEJEUNE
NORTH CAROLINA









LEGEND

DRAWN WAC
REVIEWED EJK
SO# 62470-212
CADD# 212010MG

NORTH

SITE 69 - CHEMICAL DISPOSAL AREA
REMEDIAL INVESTIGATION, CTO - 0212
MARINE CORPS BASE CAMP LEJEUNE
NORTH CAROLINA

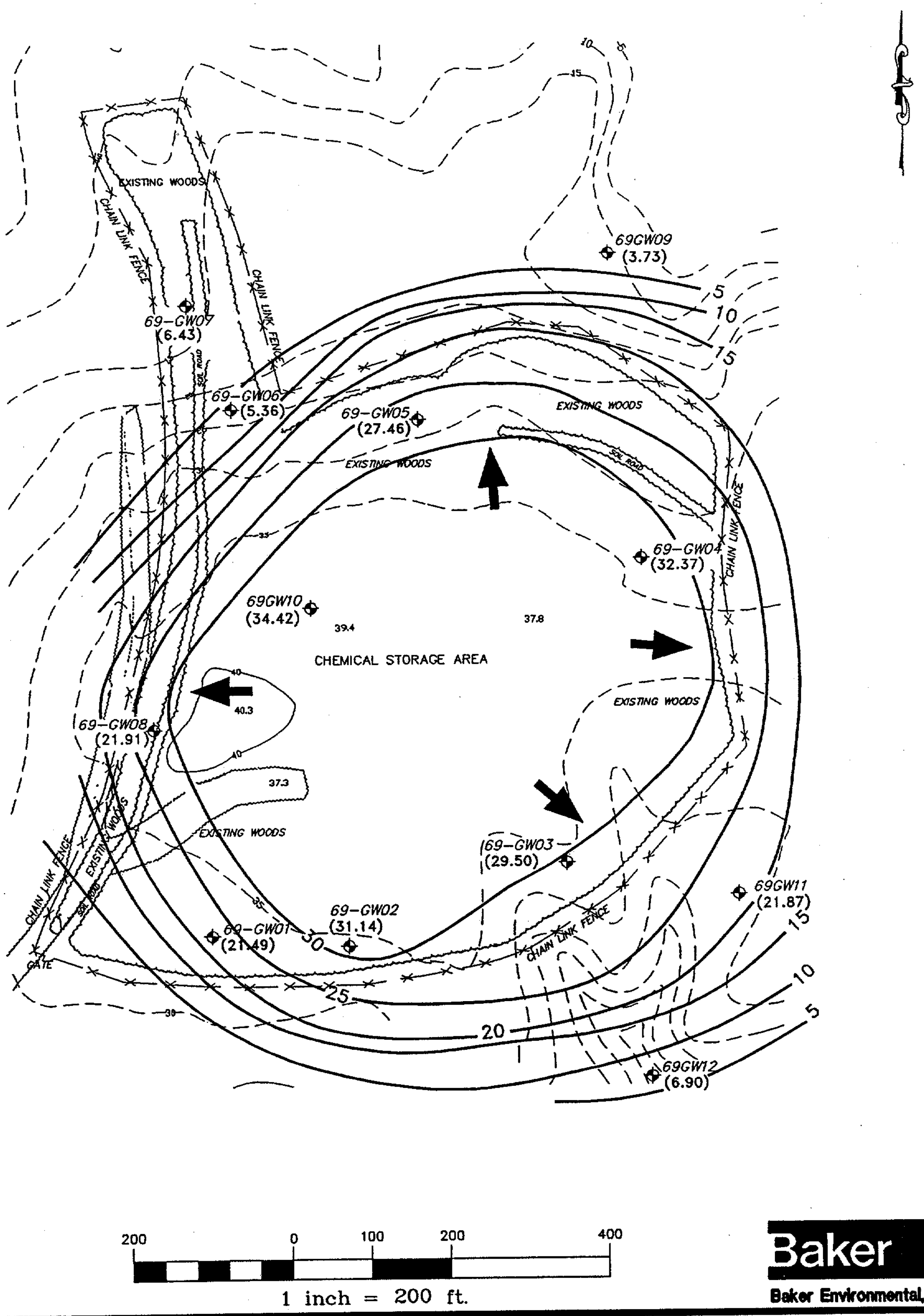
BAKER ENVIRONMENTAL, Inc.
Coraopolis, Pennsylvania

Baker
Baker Environmental, Inc.

HYDROGEOLOGIC CROSS-SECTIONS
A-A', B-B', AND C-C'

SCALE AS SHOWN
DATE DECEMBER 1996

FIGURE NO
3-5



Baker

Baker Environmental, Inc.

LEGEND

69-GW02 ⊕ EXISTING SHALLOW WELLS

(3.73) GROUNDWATER ELEVATION (FEET, MSL)

—10— GROUNDWATER CONTOUR

➡ GROUNDWATER FLOW DIRECTION

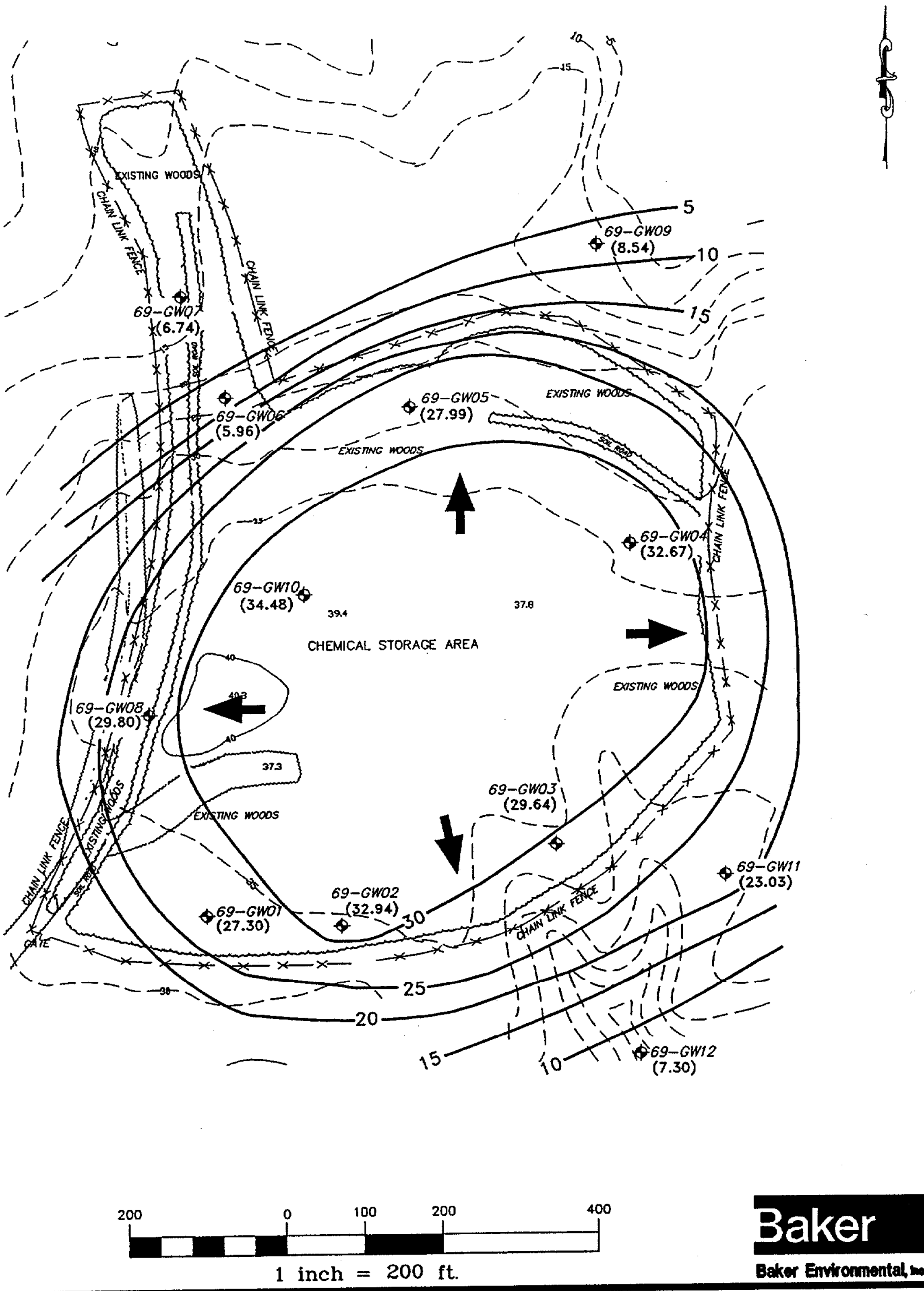
—x— FENCE

~~~ VEGETATION

—40— TOPOGRAPHIC ELEVATION LINES (FEET, MSL)

SOURCE: REVISED FROM LANTDIV, OCT. 1991

FIGURE 3-6
SHALLOW GROUNDWATER ELEVATION CONTOURS – JANUARY 23, 1994
SITE 69 – RIFLE RANGE CHEMICAL DUMP
REMEDIAL INVESTIGATION CTO-0212
MARINE CORPS BASE, CAMP LEJEUNE
NORTH CAROLINA
~~~



Baker

Baker Environmental, Inc.

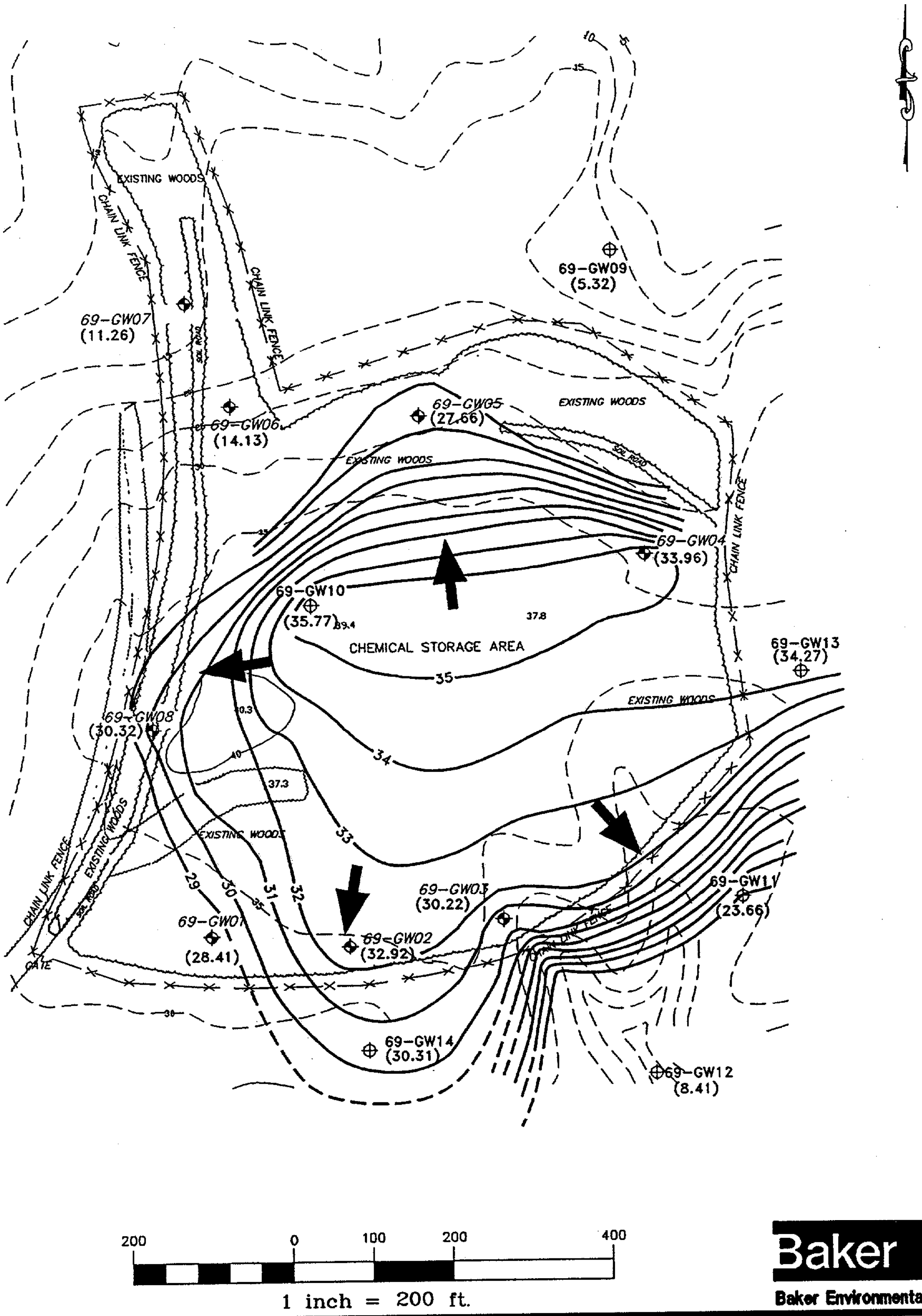
LEGEND

69GW2 ⌖	EXISTING SHALLOW WELLS
(4.06)	GROUNDWATER ELEVATION (FEET, MSL)
10	GROUNDWATER CONTOUR
➡	GROUNDWATER FLOW DIRECTION
×— —×	FENCE
	VEGETATION
40	TOPOGRAPHIC ELEVATION LINES (FEET, MSL)

SOURCE: REVISED FROM LANTDIV, OCT. 1991

FIGURE 3-7
SHALLOW GROUNDWATER ELEVATION CONTOURS – FEBRUARY 16, 1994
SITE 69 – RIFLE RANGE CHEMICAL DUMP
REMEDIAL INVESTIGATION CTO-0212
MARINE CORPS BASE, CAMP LEJEUNE
NORTH CAROLINA

212125RI



Baker

Baker Environmental, Inc.

LEGEND

69-GW02 ⊕ EXISTING SHALLOW WELLS (ESE)

69-GW09 ⊕ EXISTING SHALLOW WELLS (BAKER)

(28.36) GROUNDWATER ELEVATION (FEET, MSL)

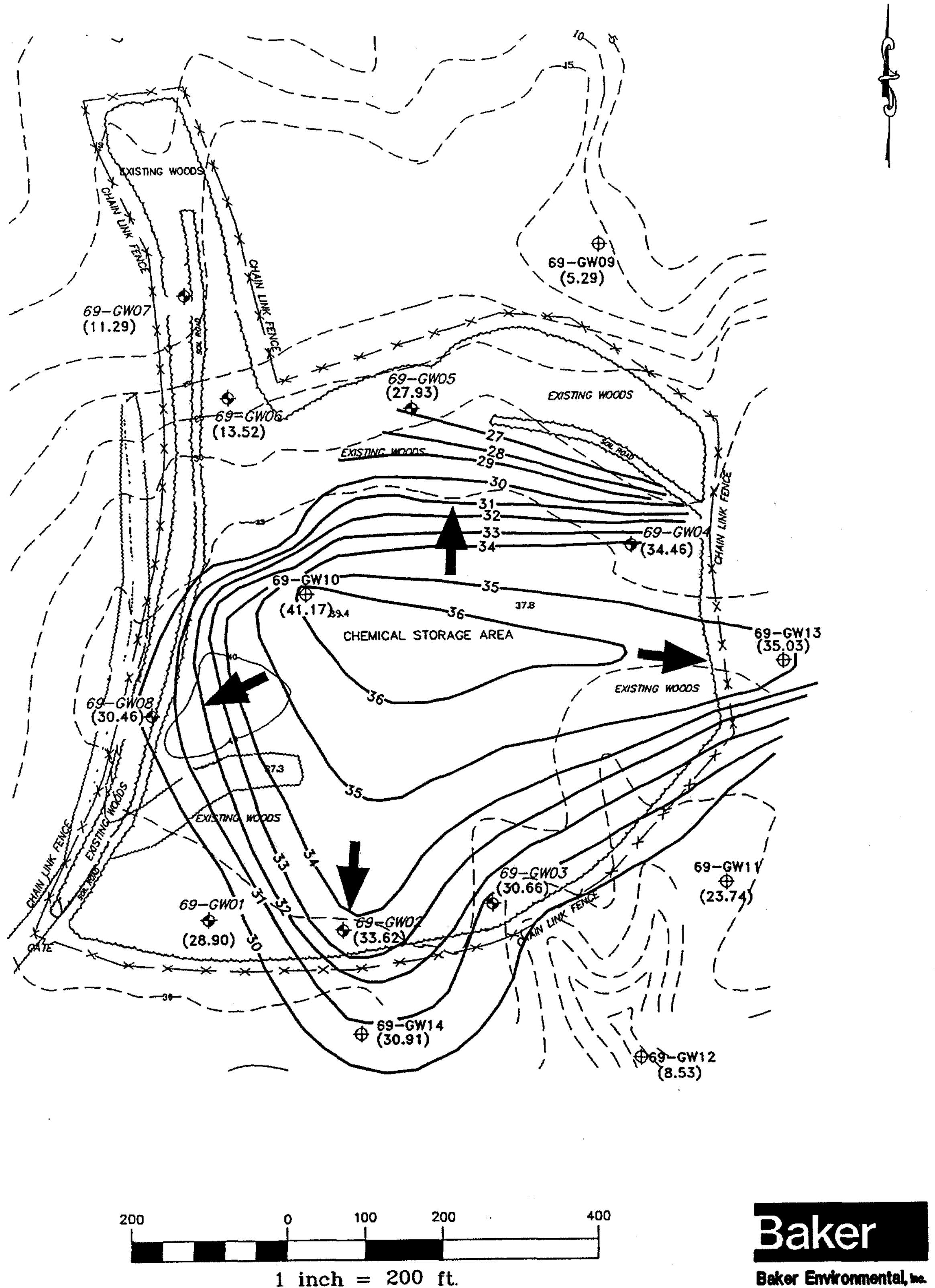
——— GROUNDWATER ELEVATION CONTOUR

– – – GROUNDWATER ELEVATION CONTOUR (INFERRED)

➡ GROUNDWATER FLOW DIRECTION

SOURCE: REVISED FROM LANTDIV, OCT. 1991

FIGURE 3-8
SHALLOW GROUNDWATER ELEVATION CONTOURS - JANUARY 25, 1995
SITE 69 - RIFLE RANGE CHEMICAL DUMP
REMEDIAL INVESTIGATION CTO-0212
MARINE CORPS BASE, CAMP LEJEUNE
NORTH CAROLINA



Baker

Baker Environmental, Inc.

LEGEND

69-GW02 ⊕ EXISTING SHALLOW WELLS (ESE)

69-GW09 ⊕ EXISTING SHALLOW WELLS (BAKER)

(28.85) GROUNDWATER ELEVATION (FEET, MSL)

—— GROUNDWATER ELEVATION CONTOUR

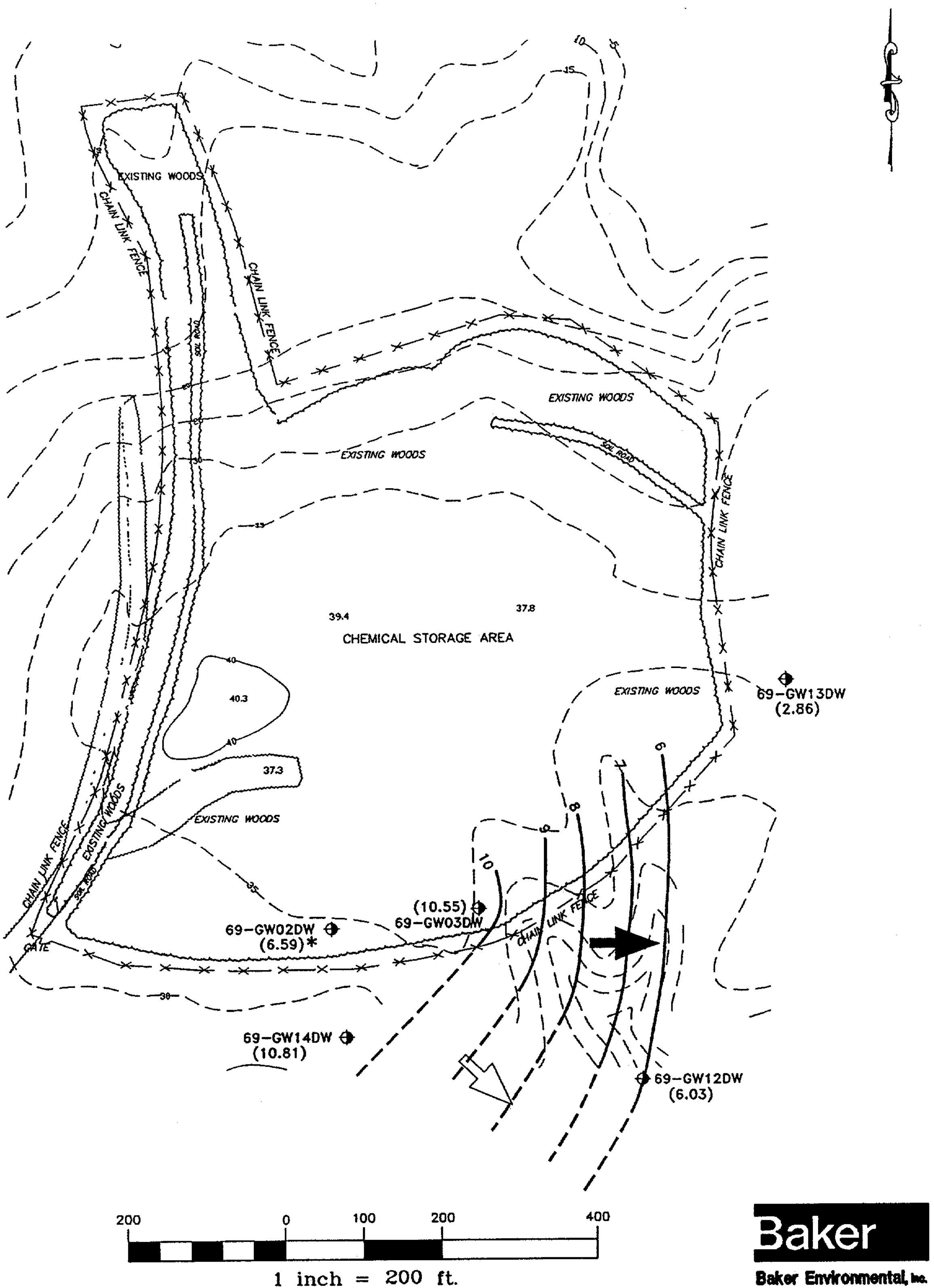
- - - GROUNDWATER ELEVATION CONTOUR (INFERRED)

➡ GROUNDWATER FLOW DIRECTION

SOURCE: REVISED FROM LANTDIV, OCT. 1991

FIGURE 3-9
SHALLOW GROUNDWATER ELEVATION
CONTOURS - FEBRUARY 20, 1995
SITE 69 - RIFLE RANGE CHEMICAL DUMP
REMEDIAL INVESTIGATION CTO-0212
MARINE CORPS BASE, CAMP LEJEUNE
NORTH CAROLINA

212127RI



Baker

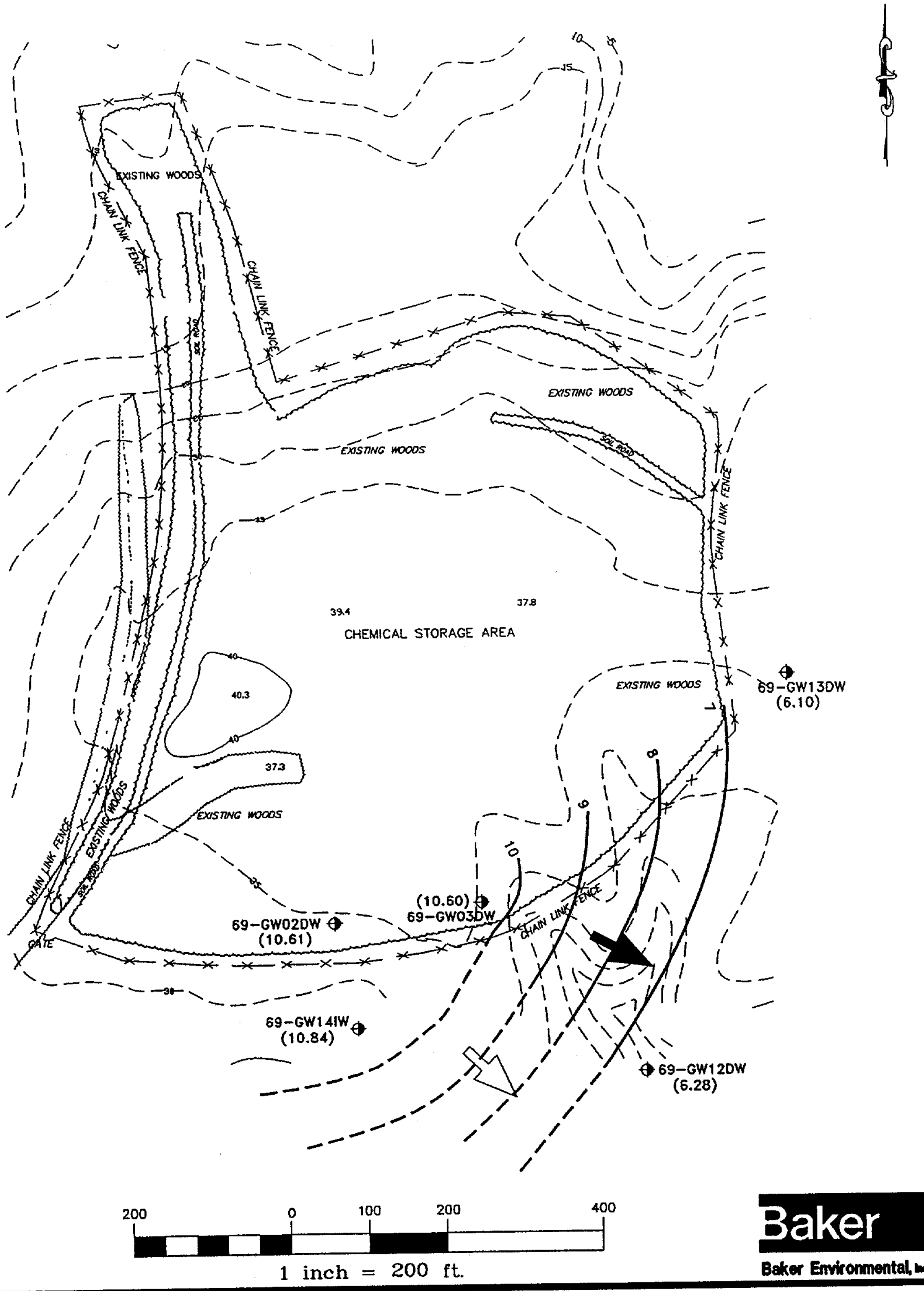
Baker Environmental, Inc.

LEGEND

69-GW02DW (28.36) EXISTING DEEP WELLS (BAKER)
(28.36) GROUNDWATER ELEVATION (FEET, MSL)
GROUNDWATER ELEVATION CONTOUR
GROUNDWATER ELEVATION CONTOUR (INFERRED)
➡ GROUNDWATER FLOW DIRECTION
⇨ GROUNDWATER FLOW DIRECTION (INFERRED)

*GROUNDWATER LEVEL MEASUREMENT IS QUESTIONABLE.
SOURCE: REVISED FROM LANTDIV, OCT. 1991

FIGURE 3-10
UPPER CASTLE HAYNE GROUNDWATER
ELEVATION CONTOURS – JANUARY 25, 1995
SITE 69 – RIFLE RANGE CHEMICAL DUMP
REMEDIAL INVESTIGATION CTO-0212
MARINE CORPS BASE, CAMP LEJEUNE
NORTH CAROLINA

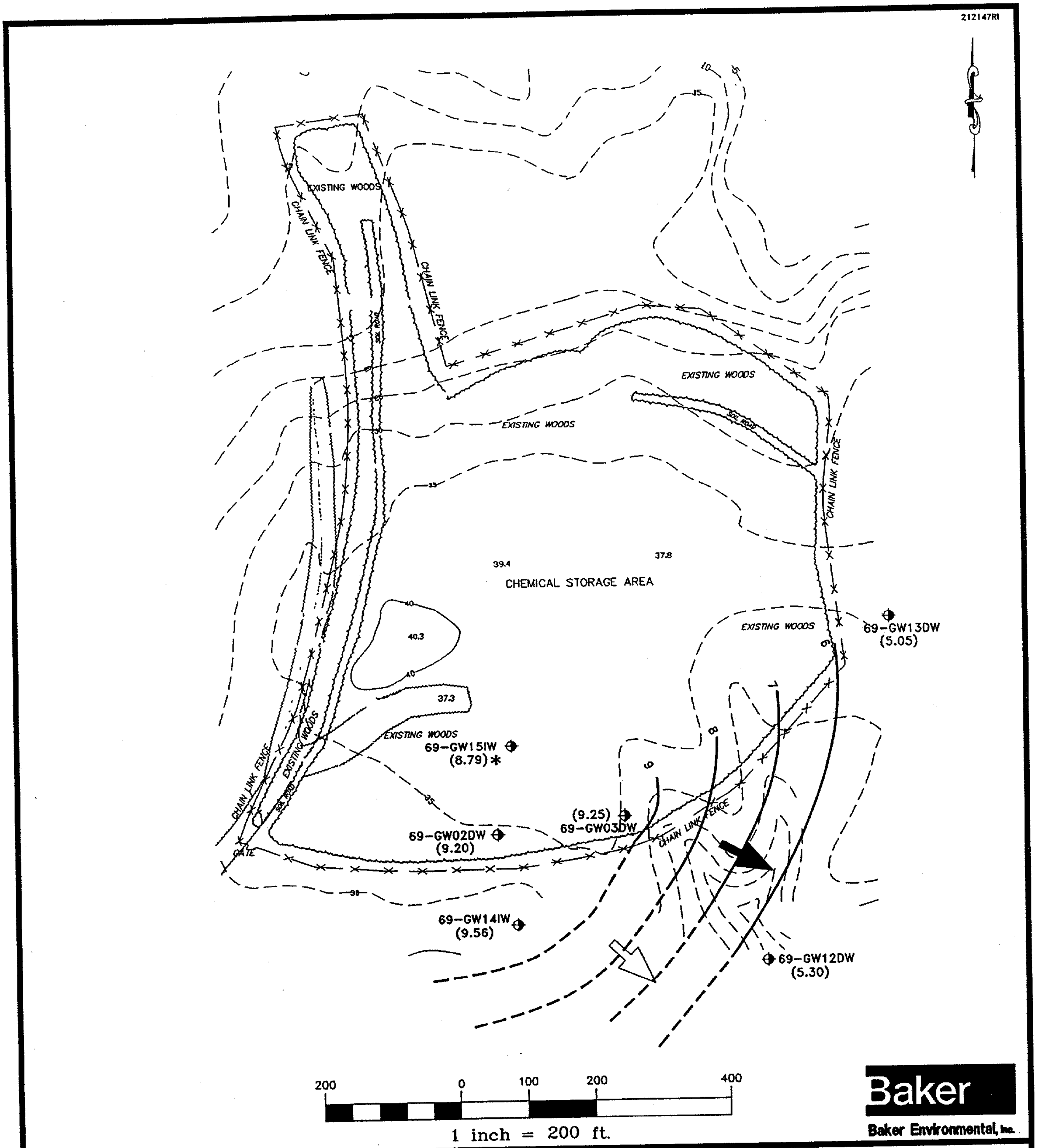


LEGEND

69-GW02DW EXISTING DEEP WELLS (BAKER)
(28.36) GROUNDWATER ELEVATION (FEET., MSL)
GROUNDWATER ELEVATION CONTOUR
GROUNDWATER ELEVATION CONTOUR (INFERRED)
➡ GROUNDWATER FLOW DIRECTION
⇨ GROUNDWATER FLOW DIRECTION (INFERRED)

SOURCE: REVISED FROM LANTDIV, OCT. 1991

FIGURE 3-11
UPPER CASTLE HAYNE GROUNDWATER
ELEVATION CONTOURS - FEBRUARY 20, 1995
SITE 69 - RIFLE RANGE CHEMICAL DUMP
REMEDIAL INVESTIGATION CTO-0212
MARINE CORPS BASE, CAMP LEJEUNE
NORTH CAROLINA



Baker
Baker Environmental, Inc.

LEGEND

69-GW02DW ⊕ EXISTING DEEP WELLS (BAKER)

(28.36) GROUNDWATER ELEVATION (FEET., MSL)

—— GROUNDWATER ELEVATION CONTOUR

- - - GROUNDWATER ELEVATION CONTOUR (INFERRED)

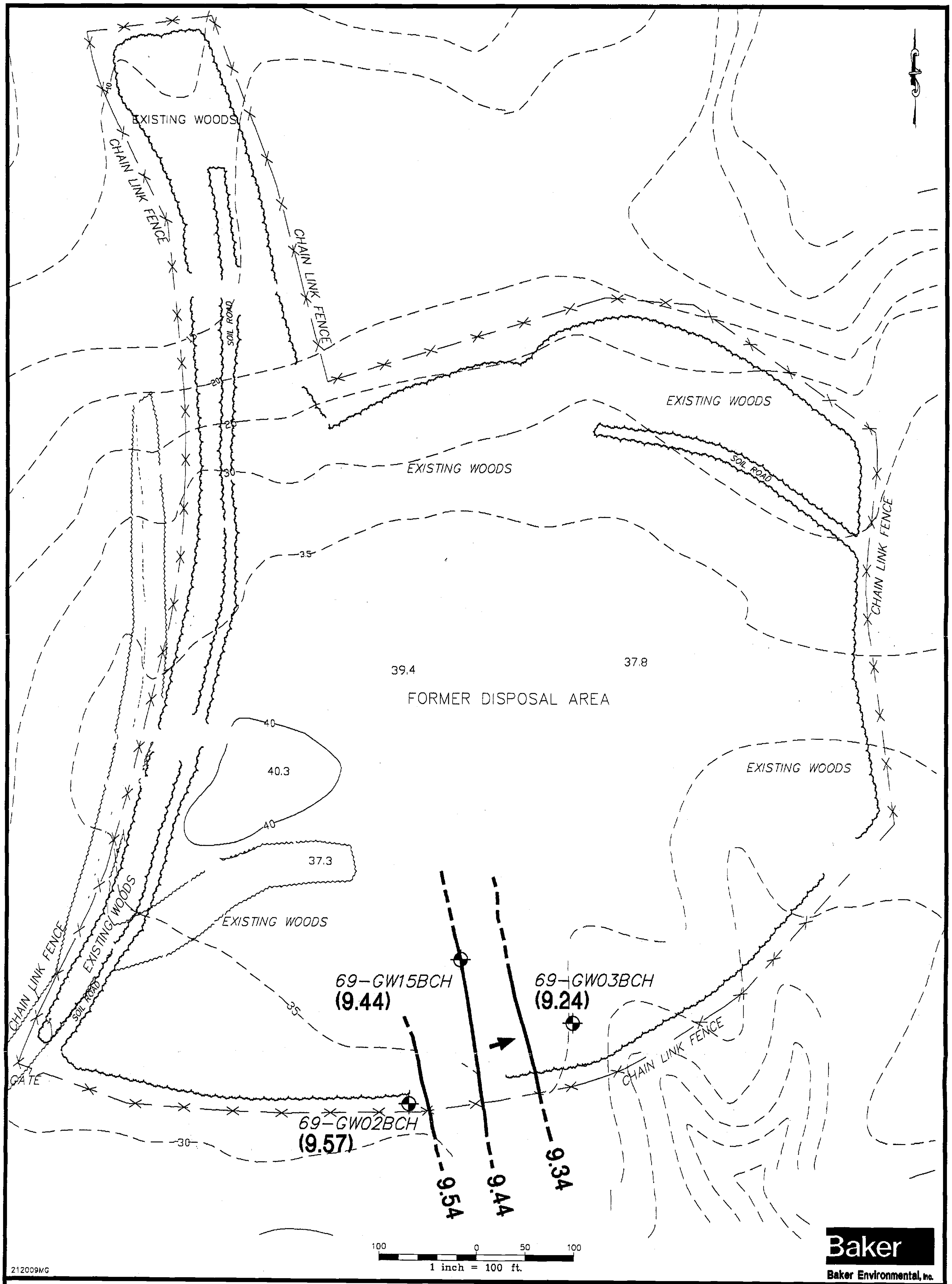
➡ GROUNDWATER FLOW DIRECTION

⇨ GROUNDWATER FLOW DIRECTION (INFERRED)

* GROUNDWATER LEVEL MEASUREMENT IS QUESTIONABLE

SOURCE: REVISED FROM LANTDIV, OCT. 1991

FIGURE 3-12
UPPER CASTLE HAYNE GROUNDWATER
ELEVATION CONTOURS - MARCH 26, 1995
SITE 69 - RIFLE RANGE CHEMICAL DUMP
REMEDIAL INVESTIGATION CTO-0212
MARINE CORPS BASE, CAMP LEJEUNE
NORTH CAROLINA



LEGEND

69-GW15BCH
⊕ DEEP WELLS (DEEP CASTLE HAYNE)
(9.57) GROUNDWATER ELEVATION (FEET, MSL)
— —30— — TOPOGRAPHIC ELEVATION LINES (FEET, MSL)
—9.44— GROUNDWATER CONTOUR
➡ GROUNDWATER FLOW DIRECTION

SOURCE: REVISED FROM LANTDIV, OCT. 1991

FIGURE 3-13
DEEP CASTLE HAYNE GROUNDWATER
ELEVATION CONTOURS - MAY 2, 1996
SITE 69 - RIFLE RANGE CHEMICAL DUMP
REMEDIAL INVESTIGATION CTO-0212
MARINE CORPS BASE, CAMP LEJEUNE
NORTH CAROLINA

01761N112

4.0 NATURE AND EXTENT OF CONTAMINATION

This section presents and evaluates the results of the Remedial Investigation (RI) performed at Operable Unit (OU) No. 14 (Site 69). As a supplement to this discussion, positive detection summary tables and figures are presented at the end of Section 4. A summary of the analytical results is presented in Appendix I. Appendices J through L present the Engineering Parameters, Field Duplicate and Quality Assurance/Quality Control Summaries of OU No. 14 for the various media. Appendix M 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.

4.1 Data Management and Tracking

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

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

The management and tracking of data from the time of field collection to receipt of the validated electronic analytical results is of primary importance and reflects the overall quality of the analytical results. Field samples and their corresponding analytical tests were recorded on the chain-of-custody sheets, which are included as Appendix E. The chain-of-custody forms were checked against the Field Sampling and Analysis Plan (Baker, 1993) to determine if all designated samples were collected for the appropriate parameters. Upon receipt of the laboratory results, a comparison to the field information was made to determine if each sample received by the laboratory was analyzed for the correct parameters. Similarly, the validated information was compared to laboratory information as a final check. In summary, the tracking information was used to identify the following items:

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

4.2 Non-Site Related Analytical Results

Many of the organic and inorganic constituents detected in soil, groundwater, surface water, and sediments at Site 69 are attributable to non-site related conditions or activities. Two primary sources of non-site related results include laboratory contaminants and naturally-occurring inorganic elements. In addition, non-site related operational activities and conditions may contribute to "on-site" contamination. A discussion of non-site related analytical results for Site 69 is provided in the following subsections.

4.2.1 Laboratory Contaminants

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

Common laboratory contaminants (i.e., acetone, 2-butanone, chloroform, methylene chloride, toluene, and phthalate esters) were considered as positive results only when observed concentrations exceeded ten times the maximum concentration detected in any blank. If the concentration of a common laboratory contaminant was less than ten times the maximum blank concentration, then it was concluded that the chemical was not detected in that particular sample (USEPA, 1989). The maximum concentrations of detected common laboratory contaminants in blanks for Site 69 were as follows:

●	acetone	190J µg/L
●	methylene chloride	19J µg/L
●	chloroform	10J µg/L
●	toluene	1J µg/L
●	di-n-butylphthalate	1J µg/L
●	bis(2-ethylhexyl)phthalate	4J µg/L

Organic constituents contained in blanks that are not considered common laboratory contaminants (i.e., all other TCL compounds) were considered as positive results only when observed concentrations exceeded five times the maximum concentration detected in any blank (USEPA, 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 Site 69 were as follows:

●	xylenes (total)	4J µg/L
●	bromodichloromethane	4J µg/L
●	dibromochloromethane	2J µg/L
●	heptachlor	0.02J µg/L

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

4.2.2 Naturally-Occurring Inorganic Elements

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

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

The following subsections address the various comparison criteria used to evaluate the analytical results from soil, groundwater, surface water, and sediment samples collected at Site 69.

4.2.2.1 Soil

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

Site background and Base background concentration values for inorganic elements in surface and subsurface soils at MCB Camp Lejeune are presented in Tables 4-1 and 4-2, respectively. The Base background ranges are based on analytical results of background samples collected in areas not known to have been impacted by site operations or disposal activities at MCB, Camp Lejeune. In subsequent sections, which discuss the analytical results of samples collected during the soil investigation, only those inorganic parameters with concentrations exceeding these ranges will be considered.

4.2.2.2 Groundwater

Monitoring wells were located in an upgradient direction of Site 69 to provide groundwater data to assess background conditions in groundwater. Background wells are often installed to assess the natural state and quality of groundwater. Natural in this sense implies that the groundwater has not been altered due to human activity. In some cases, these monitoring wells provide data that is representative of naturally occurring conditions. In other cases, these wells may not be representative of naturally occurring conditions, if other base-related activities have altered the natural state of groundwater. In the latter cases, these wells would produce "control" samples. Control samples are samples which may not represent background conditions, but represent the current state of groundwater quality upgradient of the site. During the past four years, a number of background wells have been installed throughout the Base as part of individual site investigations. Most of the background wells installed throughout the base produce control samples. The data collected from these wells have generated data that is representative of "base-wide" groundwater quality.

Chemical-specific ARARs are available for evaluation of groundwater analytical results. In the subsequent sections, which address the analytical results of samples collected during the groundwater investigation, only those inorganic parameters with concentrations exceeding applicable Federal and/or State regulations will be discussed. In order to supplement comparison criteria, a number of base-specific background (i.e., upgradient) samples were compiled as part of a study to evaluate levels of inorganic elements in groundwater at MCB, Camp Lejeune (refer to Appendix M).

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

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

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

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

Groundwater in the MCB, Camp Lejeune area is naturally rich in iron and manganese. Iron and manganese concentrations (i.e., total and dissolved) in groundwater at MCB, Camp Lejeune often exceed the Federal MCLs and NCWQS of 300 and 50 μg/L, respectively. Elevated levels of iron and manganese, at concentrations above the MCLs and/or NCWQS, were reported in samples collected from a number of Base potable water supply wells which were installed at depths greater than 162 feet bgs (Greenhorne and O'Mara, 1992). Iron and manganese concentrations in several monitoring wells at Site 69 exceeded the MCLs and NCWQS but fell within the range of concentrations for samples collected elsewhere at MCB, Camp Lejeune. There is no record of any historical use of iron and manganese at Site 69. In light of this, it is assumed that iron and manganese are naturally-occurring inorganic elements in groundwater, and their presence is not attributable to site operations.

4.2.2.3 Surface Water and Sediment

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

Site 2 -	Overs Creek
Site 6 -	Bearhead Creek Wallace Creek
Site 41 -	unnamed tributary Tank Creek northeast tributary to unnamed tributary
Site 69 -	unnamed tributary

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

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

4.3 State and Federal Criteria and Standards

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

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

In general, chemical-specific criteria and standards are not available for soil. Therefore, base-specific background concentrations were compiled to evaluate background levels of inorganic constituents in the surface and subsurface soil. Organic contaminants were not detected in the base-specific background samples. Therefore, it is likely that all organic contaminants detected in the surface and subsurface soil, within OU No. 14, are attributable to the practices which have or are currently taking place within the areas of concern. Additionally, in order to evaluate soil concentrations, the risk-based concentrations (RBCs) for residential soil ingestion developed by USEPA (Region III) were used as guidance criteria to evaluate soil concentrations. The RBCs were used as a benchmark for evaluating site investigation data and to assist in predicting single-contaminant health risks. These values were used in conjunction with other criteria in the selection of the COPCs.

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

Maximum Contaminant Levels - MCLs are enforceable standards for public water supplies promulgated under the Safe Drinking Water Act and are designed for the protection of human health. MILS 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. MILS also consider the technical feasibility of removing the contaminant from the public water supply.

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

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

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

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

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

4.4 Analytical Results

The analytical results, the extent of contamination, and a summary of the findings for Site 69 surface soil, subsurface soil, groundwater, surface water, and sediment are presented in the following sections. A summary of site contamination, by media, is provided in Table 4-5.

4.4.1 Soil Investigations

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

All surface and subsurface soil samples submitted for analysis were analyzed using CLP protocols and Level III data quality.

4.4.1.1 Surface Soil

A total of 25 surface soil samples were collected from within the site area (i.e., within the fenced-in area). Table 4-5 indicates detected volatiles included methylene chloride, acetone, chlorinated solvents, and BTEX constituents. Methylene chloride and acetone concentrations were detected at less than 10 times the maximum detected levels in QA/QC blank samples. Xylenes (total) were detected at less than 5 times the maximum concentration detected in QA/QC blank samples. Methylene chloride, acetone and xylene levels indicate that these constituents are not considered site related, but a laboratory or field procedure contaminant. 1,2-Dichloroethene (4J µg/kg), 2-butanone (10.9J µg/kg), 1,1,1-trichloroethane (2J µg/kg), trichloroethene (3J µg/kg) and tetrachloroethene (2J µg/kg) were each detected in only one sample. 4-Methyl-2-pentanone was detected in 6 samples at concentrations ranging from 1J to 12J µg/kg.

The only semivolatiles detected in the surface soil at Site 69 were bis(2-ethylhexyl)phthalate and di-n-butylphthalate. Concentrations for bis(2-ethylhexyl)phthalate ranged from 43J to 48J µg/kg and di-n-butylphthalate ranged from 36J to 280J µg/kg. The maximum concentrations of these compounds detected in QA/QC blanks were 4J µg/kg and 1J µg/kg, respectively. Both phthalates were detected at concentrations above 10 times the maximum concentrations detected in QA/QC blank samples.

The pesticides beta-BHC (11J µg/kg), 4,4'-DDE (4.8J µg/kg), endosulfan II (3.4J µg/kg) and 4,4'-DDT (13.3J µg/kg) were each detected in only one sample. Aroclor 1260 was detected at a concentration of 94J µg/kg at location 69-CSA-SB19.

Acetophenone and hydroxyacetophenone (chemical surety degradation compounds) were detected at location 69-CSA-SB17 at concentrations of 51J µg/kg and 160J µg/kg, respectively. No ordnance related constituents were detected in the surface soil.

Fourteen of 24 inorganics were detected in surface soil at Site 69. Antimony, arsenic, beryllium, cadmium, cobalt, copper, mercury, nickel, sodium and thallium were not detected in the surface soil at Site 69. Only silver and zinc were detected above Base background concentrations. A summary of detected inorganics and concentrations, and a comparison to Base background levels for surface soils is presented in Table 4-5.

4.4.1.2 Subsurface Soil

Methylene chloride, acetone, 1,1,1-trichloroethane and ethylbenzene were detected in the subsurface soil at Site 69. The concentrations of methylene chloride were less than 10 times the maximum concentration detected in QA/QC blank samples. Acetone was detected in 8 of 10 samples at concentrations ranging from 13J µg/kg to 45,000 µg/kg. Seven of the eight detected concentrations of acetone were greater than 10 times the maximum concentration detected in QA/QC blank samples.

1,1,1-Trichloroethane and ethylbenzene were each detected at concentrations of 2J µg/kg.

Phthalates were the only semivolatiles detected in the subsurface soil. Bis(2-ethylhexyl)phthalate (53J µg/kg) and di-n-butylphthalate (53J to 120J µg/kg) concentrations were above 10 times the maximum concentrations detected in the QA/QC blanks. Diethylphthalate (260J µg/kg) was not detected in the QA/QC blanks.

Low levels of pesticides were detected in the subsurface soil. 4,4'-DDE (1.2J µg/kg) and 4,4'-DDD (5.7J µg/kg) were detected at location 69-GW10 (1 to 3 feet). Endrin (1.2J µg/kg) and 4,4'-DDT (5.7J µg/kg) were detected in sample 69-GW02DW (1 to 3 feet).

No PCBs, chemical surety degradation compounds or ordnance related constituents were detected in the subsurface soil.

The only inorganics not detected in subsurface soil included antimony, cobalt, selenium and thallium. Beryllium was the only inorganic detected above Base background levels in subsurface soil. A summary of detected inorganics and concentrations, and a comparison to Base background levels for surface soils is presented in Table 4-5.

4.4.2 Groundwater Investigations

Several rounds of groundwater samples were collected during the RI at Site 69. The initial round of samples were collected in January 1994 from all eight existing shallow wells and six newly-installed monitoring wells. In order to further characterize the extent of groundwater contamination, four additional wells were installed in May 1994 and sampled in June 1994. In December 1994, a three-well cluster was installed (GW14, GW14IW, and GW14DW) south of the site just beyond the fenceline. These three wells, as well as all existing wells, were sampled in February 1995. Limited sampling events followed in March 1995, September 1995, and April 1996. A summary of the results and extent of groundwater contamination is described in this section.

4.4.2.1 Round One

Positive detection summaries for Round One are presented in Tables 4-10 (organics), 4-11 (total metals), and 4-12 (dissolved metals).

Shallow Groundwater

Round One results indicated that vinyl chloride (VC), 1,2-dichloroethene (1,2-DCE), trichloroethene (TCE), and 1,1,2,2-tetrachloroethene (1,1,2,2-PCE) were the primary VOCs detected, based on concentration levels and/or frequency. Vinyl chloride (31J µg/L) was detected in only one well, 69-GW02. 1,2-Dichloroethene (total) was the most frequently detected chlorinated solvent, with concentrations ranging from 2J µg/L to 2400 µg/L. The highest levels were detected in wells 69-GW02 and 69-GW03. Trichloroethane was detected in two wells at concentrations of 1J µg/L and 23J µg/L. 1,1,2,2-Tetrachloroethene was detected in three wells at a concentration range of 1J µg/L to 22J µg/L. Toluene was detected at concentrations of 1J µg/L and 4J µg/L. Toluene concentrations were less than 10 times the concentration detected in QA/QC blanks. Chlorobenzene was detected in only one well at a concentration of 25J µg/L.

1,4-Dichlorobenzene was the only semivolatile detected in the shallow groundwater at Site 69 during the Round One sampling event. It was detected at a concentration of 2J µg/L in well 69-GW03.

The pesticides alpha-BHC and delta-BHC were detected in well 69-GW03 at concentrations of 0.04J µg/L and 2.4J µg/L, respectively. Well 69-GW10 exhibited trace levels of beta-BHC of (0.07NJ µg/L).

No PCBs, chemical surety degradation compounds or ordnance-related constituents were detected in the shallow groundwater during Round One.

Twenty-one of 23 TAL total metals were detected in the shallow groundwater during Round One at Site 69. Silver and thallium were not detected in the shallow groundwater. Total metal concentrations were generally one order of magnitude higher than dissolved metal concentrations. Aluminum, antimony, beryllium, cadmium, chromium, iron, manganese, and zinc were detected above their respective Federal and/or State standards, generally within an order of magnitude or less. Total metal concentrations in the shallow groundwater at Site 69 during Round One sampling were within the ranges determined for MCB Camp Lejeune (refer to Appendix M).

Groundwater field parameter results for pH, temperature, and specific conductance are presented in Table 4-13. These values represent all field measurements obtained during groundwater sampling activities (i.e., from each well volume purged). Reviewing the last readings obtained for each shallow well, which are representative of groundwater conditions following purging, pH values ranged from 3.7 to 6.33 s.u., specific conductance values ranged from 67 to 731 micromhos/cm, and temperature values ranged from 11 to 19° C. Specific conductance values appear to be generally within the range of natural waters which is 50 to 500 micromhos/cm (Pagenkopf, 1978), except for the one reading at Well 69-GW05. All values for pH are below the range of Federal Secondary Drinking Water MCLs (6.5 to 8.5 s.u.).

Shallow groundwater samples were collected by Target Environmental Services, Inc (Target) on January 6 and 7, 1994. These samples were collected via hydropunch method from the drainage areas northeast and southeast of the disposal area, for purposes of screening these areas for evaluating the extent of off-site groundwater contamination. The northeast drainage area starts from the northeast corner of the site and extends in a northeast direction along a swale or low area. The southeast drainage area starts from the southeast corner of the site and extends in the southeast direction along a path of low elevation. The samples were analyzed in the field using a gas chromatograph (GC). The constituent with the highest concentration in both drainage areas was cis-1,2-dichloroethene. Appendix B contains the report for this limited investigation.

Castle Hayne Aquifer

Vinyl chloride (8.37J g/L), TCE (29.4J g/L) and 1,2-DCE (total) (788 g/L) were detected in well 69-GW02DW. These were the only organics detected in the Castle Hayne Aquifer during Round One. Vinyl chloride was detected above both the MCL and NCWQS criteria.

Fourteen of 23 TAL total metals were detected in the Castle Hayne Aquifer at Site 69. Concentrations of total metals were within an order of magnitude or less of the dissolved metal concentrations. Aluminum, iron and manganese were detected above their respective Federal and/or State standards. Aluminum and manganese were detected within an order of magnitude of standards. Iron was detected one to two orders of magnitude above the Federal and State standards.

Groundwater field parameter results for pH, temperature, and specific conductance are presented in Table 4-13. These values represent all field measurements obtained during groundwater sampling activities (i.e., from each well volume purged). Reviewing the last readings obtained for each Castle Hayne well, which are representative of groundwater conditions following purging, pH values ranged from 7.6 to 9.29 s.u., specific conductance values ranged from 272 to 362 micromhos/cm, and temperature values ranged from 16 to 21°C. Specific conductance values were within the range of natural waters which is 50 to 500 micromhos/cm (Pagenkopf, 1978). The values for pH are in the upper range of Federal Secondary Drinking Water MCLs (6.5 to 8.5 s.u.) or just above. There appears to be a significant change between shallow and deep aquifer characteristics.

4.4.2.2 Round Two

In May 1994, 1 shallow, 2 intermediate and 1 deep well were installed to better define the extent of VOC contamination. In December 1994, an additional shallow, intermediate, and deep well were installed to better define the extent of VOC contamination. A round of groundwater samples was collected from 14 shallow, 5 intermediate, and 2 deep wells in February 1995. These samples were only analyzed for volatile organic compounds (VOCs).

Shallow Groundwater

With respect to concentration levels and frequency, the primary VOCs detected included trans-1,2-DCE, TCE and vinyl chloride. Generally, the concentrations of VOCs for Round Two were lower than Round One. Well 69-GW02 exhibited a vinyl chloride concentration of 5 μg/L (compared to 31 μg/L for Round One). Trans-1,2-dichloroethene was detected in well 69-GW02 at a concentration of 230 μg/L (compared to 2,400 μg/L for Round One). Trichloroethene was detected in wells 69-GW02 and 69-GW03 at concentrations of 10 μg/L and 8 μg/L, respectively.

Groundwater field parameter results for pH, temperature, and specific conductance are presented in Table 4-15. These values represent all field measurements obtained during groundwater sampling activities (i.e., from each well volume purged). Reviewing the last readings obtained for each shallow well, which are representative of groundwater conditions following purging, pH values ranged from 4.07 to 6.09 s.u., specific conductance values ranged from 34 to 152 micromhos/cm, and temperature values ranged from 9.9 to 19.4°C. Specific conductance values were within the range of natural waters, which is 50 to 500 micromhos/cm (Pagenkopf, 1978), except for well 69-GW08. The values for pH are below Federal Secondary Drinking Water MCLs (6.5 to 8.5 s.u.).

Castle Hayne Aquifer

The only VOC detected in the Castle Hayne Aquifer was trans-1,2-DCE in intermediate well 69-GW02DW at a concentration of 8 μg/L.

Groundwater field parameter results for pH, temperature, and specific conductance are presented in Table 4-15. These values represent all field measurements obtained during groundwater sampling activities (i.e., from each well volume purged). Reviewing the last readings obtained for each Castle Hayne well, which are representative of groundwater conditions following purging, pH values ranged from 6.67 to 9.12 s.u., specific conductance values ranged from 208 to 477 micromhos/cm, and temperature values ranged from 14.3 to 17.9°C. Specific conductance values were within the range of natural waters, which is 50 to 500 micromhos/cm (Pagenkopf, 1978). The values for pH were in the upper range of Federal Secondary Drinking Water MCLs (6.5 to 8.5 s.u.) or just above. There appears to be a significant change between shallow and deep aquifer characteristics. Water quality values for intermediate (60 foot depth) and deep (125 foot depth) wells within the Castle Hayne Aquifer are similar.

4.4.2.3 Limited Sampling Rounds

Three limited sampling events were conducted in June 1994, January 1995, and March 1995. In June 1994, samples were collected from wells 69-GW02DD, 69-GW03IW, 69-GW13, and 69-GW13IW. These four wells were installed in May 1994 to better define the vertical and horizontal extent of contamination. The construction details are discussed in Section 2.2.3.4, and their locations are shown on Figure 2-9. In January 1995, groundwater samples was collected from three newly-constructed wells (69-GW14, 69-GW14IW, and 69-GW14DW) that were installed in December 1994. These wells were installed south of well cluster 69-GW02 (see Figure 2-9) to assess offsite VOC migration. In March 1995, a round of groundwater samples was collected from two more newly-installed wells (69-GW15 and 69-GW15IW), and "existing" wells 69-GW02, 69-GW02DW, 69-GW02DD, 69-GW03, 69-GW03IW, 69-GW13, 69-GW13IW, 69-GW14, 69-GW14IW, and 69-GW14DW. Wells 69-GW15 and 69-GW15IW were located based on the results of a hydropunch investigation performed by Target to further investigate the source of the volatile contamination exhibited in the southern area of the site. This investigation consisted of collecting nine hydropunch samples in the central portion of the site. These samples were also screened in the field using a GC. Sample location 69-DA-HP02 (north of well location 69-GW02) exhibited the highest volatile concentrations. Trans-1,2-dichloroethene was detected at a concentration of 1,100 µg/L and cis-1,2-dichloroethene was detected at a concentration of 850 µg/L. Trichloroethene and tetrachloroethene were detected at location 69-DA-HP02 at concentrations of 389 µg/L and 59 µg/L, respectively.

Table 4-16 presents a comparison of the volatile organic results for these limited sampling events, which focused in the south/southeastern and eastern areas of the site. It should be noted that the January 1995 groundwater results are "unusable" since cross-contamination from another sampling event (i.e., Site 82) was determined to be the cause of contamination in a number of wells. This is evident by comparing the results between sampling rounds for wells 69-GW13, 69-GW13IW, 69-GW14, 69-GW14IW, and 69-GW14DW, as shown in Table 4-16. Because of the cross-contamination problem, January 1995 results were not used to interpret groundwater conditions.

Results indicate a decrease in volatile concentrations between 1994 and 1995. Monitoring wells 69-GW15 and 69-GW15IW exhibited the highest concentrations of 1,2-dichloroethene (2500 µg/L, 69-GW15IW), trichloroethene (2600 µg/L, 69-GW15IW) and 1,1,2,2-tetrachloroethane (3000 µg/L, 69-GW15) during the March 1995 sampling. It is believed that these wells are nearest to the source of the VOC contamination.

4.4.2.4 Pre-Treatability Study Groundwater Investigation

During this stage of the RI, a treatability study (TS) was being implemented to evaluate the effectiveness of a technology known as "in well aeration." The TS focused on remediating the VOCs in-situ as opposed to the more common approach of extracting or collecting groundwater for subsequent physical/chemical treatment and discharge. The TS approach focused on the area near well cluster GW15. During the scoping of the TS, it was determined that the vertical extent of contamination needed to be better defined before completing the final details of the TS. Therefore, as part of the TS, another groundwater investigation was conducted in September 1995. During this investigation, groundwater samples were collected via the hydropunch technique near well cluster GW15 at depths of 50, 60, and 70 feet bgs. From this boring, a well was constructed at a depth of 120 feet bgs (GW15DW) in what is referred to as the intermediate zone of the Castle Hayne. Another well (GW15UW) was installed to a depth of 37 feet bgs to characterize VOC levels in the upper zone of the Castle Hayne, specifically, in the zone just below shallow well GW15.

The results of the September 1995 TS groundwater investigation are provided as Appendix X. Elevated VOCs were detected in the upper zone of the Castle Hayne between 37 and 70 feet bgs. Monitoring well GW15 exhibited high levels of contamination, similar to those levels detected during the March 1995 sampling round. VOC levels decreased from the 70 foot to 120 foot depth.

4.4.2.5 Deep Castle Hayne Groundwater Investigation

Three wells were constructed to monitor groundwater quality at the bottom zone of the Castle Hayne aquifer. Well GW15BCH was installed near the suspected source area. Monitoring well GW02BCH was installed south of the suspected source area, and well GW03BCH was constructed southeast of the suspected source area. The bottom of the well screens were set at a depth of 230 feet bgs. Figure 2-9 depicts the locations of all monitoring wells and has been provided in color to differentiate between wells in the shallow aquifer, and in the upper zone, intermediate zone, and deep zone of the Castle Hayne aquifer.

One round of samples were collected using dedicated bailers, between April 19 and 20, 1996, from the three newly-installed deep wells and from existing deep wells GW02DD, GW03DW, and GW15DW for analysis of Target Compound List (TCL) volatile organics (CLP protocols, Level IV data quality).

Table 4-16A provides a summary of the contaminants which were detected above the contract required quantitation level (CRQL). The presence of acetone and methylene chloride are likely the result of laboratory and field contamination as noted by the presence of these parameters in the rinsate and trip blanks. For purposes of this discussion, it is assumed that these contaminants are not site related even though the concentrations of methylene chloride exceeded the North Carolina Water Quality Standard (WQS) for the protection of groundwater.

None of the three newly-installed deep wells exhibited trichloroethene, 1,2-dichloroethene, or vinyl chloride, which are prevalent in the shallow aquifer, and in the upper and intermediate zones of the Castle Hayne aquifer. This indicates that the solvent constituents have not migrated to the bottom portion of the aquifer.

Deep well GW02BCH exhibited trace levels of chloroform (3J μg/L) above the North Carolina Water Quality Standard (WQS) of 0.19 μg/L. Chloroform was also detected in well GW03BCH above the WQS. Other VOCs detected in well GW03BCH included bromodichloromethane, dibromochloromethane, and bromoform. These contaminants are sometimes found in "tap water" as a result of the breakdown of chlorine, which is used in treatment prior to distribution. These constituents are also referred to as Total THMs (trihalomethane). The presence of THMs in well GW03BCH cannot be explained with respect to a source. It may be possible that these contaminants are associated with laboratory contamination; however, this cannot be verified.

4.4.3 Surface Water Investigations

The following section discusses the results of the surface water investigation performed at Site 69. "On-site" surface water bodies sampled at Site 69 during the 1994 RI include the drainage areas northeast and southeast of the site, and standing water bodies within low-lying areas of the site. As part of the RI, an extensive study involving surface water/sediment sampling, fish/shellfish sampling, and benthic macroinvertebrate sampling was performed during 1992 at "off site" surface water bodies including the New River, the unnamed tributary to the New River, and Everett Creek. The results of this study were combined with the on-site water bodies results in order to fully evaluate the site and to complete the human health and ecological risk assessments. Refer to Table 4-5 for a summary of detected compounds, minimum and maximum concentrations, frequency of detection, comparison criteria values, and number of detections above applicable criteria for surface water analyses.

4.4.3.1 "On-Site" Investigation

Results from surface water samples collected from Site 69 during the "on-site" RI program indicated positive detections of organics and metals (Tables 4-17 and 4-18, respectively).

Vinyl chloride was detected in sample 69-OS-SW01 at a concentration of 8J µg/L. Acetone, chloroform and toluene were detected at concentrations less than 10 times the maximum concentration detected in QA/QC blanks. These constituents are not considered site related, but laboratory or field procedure contaminants. 1,2-Dichloroethene (total) was detected in two samples at concentrations of 13 g/L (69-OS-SW-2) and 55 g/L (69-OS-SW01). Trichloroethene and ethylbenzene were detected in sample 69-OS-SW-1 at concentrations of 4J µg/L and 1J µg/L, respectively. Xylenes (total) were detected in sample 69-DA-SW04 at a concentration of 10 µg/L, which is less than 5 times the maximum concentration detected in QA/QC blanks; therefore, this constituent is not considered site-related but a laboratory or field procedure contaminant.

The semivolatile di-n-butylphthalate was detected in sample 69-DA-SW01 (northeast drainage area) at a concentration of 1.00J µg/L. This concentration is less than 10 times the maximum concentration detected in QA/QC blanks.

Eighteen of 24 TAL metals were detected in all seven surface water samples (antimony, cadmium, cobalt, cyanide, selenium and thallium were not detected). Detected concentrations of metals in on-site surface water at Site 69 were within an order of magnitude of Base upgradient background levels, except for magnesium, sodium and zinc which were two orders of magnitude greater than the Base background levels.

4.4.3.2 "Off Site" Investigation

No organics were detected in the off site surface water samples (collected in 1992) within the New River, the unnamed tributary, and Everett Creek.

Table 4-19 presents the positive detections for total metals for New River. Ten of 24 TAL Metals were detected in the three samples collected. These metals included aluminum, barium, calcium, iron, magnesium, manganese, potassium, silver, sodium, and thallium. Metal concentrations were within an order of magnitude of Base upgradient background levels.

The detected TAL total metals for the unnamed tributary are presented in Table 4-20. Fourteen of 24 TAL total metals were detected including aluminum, barium, cadmium, calcium, cobalt, copper, iron, lead, magnesium, manganese, potassium, sodium, vanadium, and zinc. Metal concentrations were within an order of magnitude of Base upgradient background levels.

Eleven TAL total metals were detected in Everett Creek including aluminum, barium, calcium, copper, iron, lead, magnesium, manganese, potassium, silver, and sodium. Table 4-21 presents the positive detections for metals in Everett Creek. Metal concentrations were within an order of magnitude of Base upgradient background levels.

4.4.4 Sediment Investigations

The following section discusses the results of the sediment investigation performed at Site 69. "On-site" sediment samples were collected at Site 69 during the 1994 RI from the drainage areas northeast and southeast of the site, and standing water bodies within low-lying areas of the site. As part of the RI, an extensive study involving surface water/sediment sampling, fish/shellfish sampling, and benthic macroinvertebrate sampling was performed during 1992 at "off site" surface water bodies including the New River, the unnamed tributary to the New River, and Everett Creek. The results of this study were combined with the on-site water bodies results in order to fully evaluate the site and to complete the human health and ecological risk assessments. Refer to Table 4-5 for a summary of detected compounds, minimum and maximum concentrations, frequency of detection, comparison criteria values, and number of detections above applicable criteria for sediment analyses.

4.4.4.1 "On-Site" Investigation

Results from on-site sediment samples (i.e., the on-site standing water and downslope drainage areas) indicated positive detections of organics and inorganics (Tables 4-22 and 4-23, respectively).

Low levels of volatile organics were detected in all seven of the sediment sample locations in on-site ponded water and drainage areas. Methylene chloride and acetone were detected at concentrations less than 10 times the maximum concentration detected in QA/QC blanks. Toluene was detected in sample 69-DA-SD04 (0 to 6 inches) at a concentration of 18J µg/kg, which is greater than 10 times the maximum concentration detected in QA/QC blanks. 1,2-Dichloroethene was detected in sample 69-OS-SD01 (0 to 6 inches) at a concentration of 9J µg/kg. Sample 69-DA-SD01 (0 to 6 inches) exhibited a 2-butanone concentration of 36J µg/kg. 4-Methyl-2-pentanone was detected at concentrations ranging from 9J µg/kg (69-OS-SD01, 0 to 6 inches) to 17J µg/kg (69-OS-SD02, 0 to 6 inches).

Di-n-butylphthalate was the only semivolatile organic detected. Di-n-butylphthalate was detected at 2 of 7 locations with a concentration of 110.0J µg/kg exhibited for samples 69-OS-SD02 (0 to 6 inches) and 69-OS-SD03 (0 to 6 inches). This concentration is greater than 10 times the maximum concentration detected in QA/QC blanks. Both of these locations are in on-site ponded water bodies in the southeast corner of the site.

Pesticides were detected at four of the on-site sampling locations. Sample 69-OS-SD02 (0 to 6 inches) exhibited the only concentrations of alpha-BHC (3.1J µg/kg), beta-BHC (23.4J µg/kg), and delta-BHC (54.5J µg/kg). 4,4'-DDD was detected in three samples with concentrations ranging from 1.5J µg/kg (69-DA-SD03, 0 to 6 inches) to 13.9J µg/kg (69-DA-SD02, 0 to 6 inches). The pesticide 4,4'-DDT was detected at two sampling locations at concentrations of 2.1J µg/kg (69-OS-SD02, 0 to 6 inches) and 6.6J µg/kg (69-DA-SD04, 0 to 6 inches).

Aroclor 1254 was the only PCB detected in the on-site sediments. It was detected at a concentration of 79J µg/kg in sample 69-OS-SD01-06 (southwest area of the site).

Acetophenone was detected at concentrations of 60.0J µg/kg at 69-OS-SD02 (0 to 6 inches) (southeast area of site) and 960.0J µg/kg at 69-DA-SD01 (0 to 6 inches) (northeast drainage area).

Fifteen of 23 TAL metals were detected in on-site sediment samples. Antimony, arsenic, cadmium, cobalt, nickel, selenium, thallium, and vanadium were not detected. Only mercury, silver and zinc were detected above NOAA comparison criteria. On-site metal concentrations in sediments were within an order of magnitude or less of Base upgradient background levels.

4.4.4.2 "Off Site" Investigation

New River

Tables 4-24 presents the positive detection summaries for organics detected in sediment samples collected from the New River. The only detected volatile was acetone and the only detected semivolatile was bis(2-ethylhexyl)phthalate. No specific QA/QC blank analyses are available to compare organic concentrations to determine which common laboratory contaminants may be site-related.

Table 4-25 presents the positive detection summaries for inorganics detected in sediment samples collected from the New River. Seventeen of 24 TAL inorganics were detected (including aluminum, barium, beryllium, cadmium, calcium, cobalt, copper, iron, lead, magnesium, manganese, potassium, sodium, vanadium, and zinc).

Unnamed Tributary

Tables 4-26 presents the positive detection summary for organics detected in sediment samples collected from the unnamed tributary. Acetone was detected at concentrations ranging from 39J µg/kg (69-UT1-SD, 0 to 6 inches) to 65 µg/kg (69-UT3-SD, 6 to 12 inches). Carbon disulfide was detected in 4 of 5 samples ranging in concentrations from 18J µg/kg (69-UT3-SD, 0 to 6 inches) to 88 µg/kg (69-UT2-SD, 0 to 6 inches). Toluene was detected at a concentration of 2J µg/kg in sample 69-UT1-SD (0 to 6 inches). No specific QA/QC blank analyses are available to compare organic concentrations to determine if acetone and toluene may be considered laboratory contaminants.

Diethylphthalate was detected in sample 69-UT2-SD (6 to 12 inches) at a concentration of 500 µg/kg. Bis(2-ethylhexyl)phthalate was detected in two samples at concentrations of 52J µg/kg (69-UT3-SD, 6 to 12 inches) and 81J µg/kg (69-UT3-SD, 0 to 6 inches). No specific QA/QC blank analyses are available to compare organic concentrations to determine if these phthalates may be considered laboratory contaminants.

Pesticides were detected in 4 of 12 samples. 4,4'-DDE was detected in 3 sediment samples from the unnamed tributary at concentrations ranging from 10J µg/kg (69-UT3-SD, 0 to 6 inches) to 250 µg/kg (69-UT2-SD, 0 to 6 inches and 6 to 12 inches). 4,4'-DDD was detected in 3 sediment samples with concentrations ranging from 14J µg/kg (69-UT1-SD, 0 to 6 inches) to 150 µg/kg (69-UT2-SD, 0 to 6 inches and 6 to 12 inches). Pesticide concentrations for sediments in the unnamed tributary were above NOAA criteria.

The PCB aroclor 1260 was detected in sample 69-UT3-SD (6 to 12 inches) at a concentration of 360 µg/kg.

Seventeen of 23 TAL metals were detected in the sediments of the unnamed tributary. Antimony, mercury, nickel, selenium, silver and thallium were not detected. None of the detected metals were above the specific NOAA ER-Ls and ER-Ms. Table 4-27 present the positive detection summary for inorganics detected in sediment samples collected from the unnamed tributary. Seventeen of 24 TAL inorganics were detected (including aluminum, arsenic, barium, beryllium, cadmium, calcium, chromium, cobalt, copper, iron, lead, magnesium, manganese, potassium, sodium, vanadium, and zinc) in the sediment samples.

Everett Creek

Table 4-28 presents the positive detection summary of organics in sediment samples from Everett Creek. Methylene chloride and 2-butanone were detected in sample 69-EC3-SD (0 to 3 inches) at a concentrations of 1200J µg/kg and 5300 µg/kg, respectively. Acetone was detected in 2 sediment samples at concentrations of 240 µg/kg (69-EC3-SD, 6 to 12 inches) and 4600 µg/kg (69-EC3-SD, 0 to 3 inches). Sample 69-EC3-SD (6 to 12 inches) exhibited a carbon disulfide concentration of 35 µg/kg. No specific QA/QC blank analyses are available to compare organic concentrations to determine if methylene chloride, acetone and 2-butanone may be considered laboratory contaminants.

Bis(2-ethylhexyl)phthalate was the only detected semivolatile, with a concentration range of 85J µg/kg (69-EC4-SD, 0 to 6 inches) to 130J µg/kg (69-EC4-SD, 6 to 12 inches). No specific QA/QC blank analyses are available to compare organic concentrations to determine if this phthalate may be considered laboratory contaminants.

Sample 69-EC4-SD (6 to 12 inches) exhibited a concentration of 6.6J µg/kg for the pesticide 4,4'-DDE.

Everett Creek sediment samples results are presented on Table 4-29 for inorganics. Eighteen of 23 TAL metals were detected (including aluminum, arsenic, barium, beryllium, cadmium, calcium, chromium, cobalt, copper, iron, lead, magnesium, manganese, mercury, potassium, sodium, vanadium, and zinc) in sediment samples. Mercury was the only metal detected above a NOAA criteria (ER-L).

4.4.5 Engineering Parameter Results

Engineering parameters were analyzed for selected soil and groundwater samples collected at Site 69. A soil sample was collected during drilling activities from boring 69-GW02DW and analyzed for grain size distribution and Atterberg limits. Shallow and deep groundwater samples were collected from shallow well 69-GW02 and deep well 69-GW02DW and analyzed for the following engineering parameters: alkalinity, biochemical oxygen demand (BOD), chemical oxygen demand (COD), total phosphorous, total dissolved solids (TDS), total suspended solids (TSS), total Kjeldahl nitrogen, and standard plate count. Engineering parameter results for soil and groundwater are summarized in Appendix J.

Results indicated the following analysis data for soils:

- Sand - 80.7 percent; silt - 6.9 percent; and clay - 12.4 percent
- Liquid limit - 16; and non-plastic
- U.S. Department of Agriculture soil classification is a loamy sand.
- USCS soil classification is SM.

Results indicated the following concentration levels in shallow (69-GW02) groundwater:

alkalinity	<1.0 mg/L
BOD	5.65 mg/L
COD	131 mg/L

•	total phosphorous	<0.010 mg/L
•	TDS	26 mg/L
•	total Kjeldahl N	3.46 mg/L
•	TSS	1950 mg/L
•	standard plate count	9980 CFU/mL

Results indicated the following concentration levels in deep (69-GW02DW) groundwater:

•	alkalinity	107 mg/L
•	BOD	<2 mg/L
•	COD	23.7 mg/L
•	total phosphorous	0.042 mg/L
•	TDS	234 mg/L
•	total Kjeldahl N	0.445 mg/L
•	TSS	232 mg/L
•	standard plate count	2.9 CFU/mL

4.4.6 Quality Assurance/Quality Control Results

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

Organics detected in QA/QC samples include methylene chloride, acetone, chloroform, bromodichloromethane, dibromochloromethane, toluene, xylenes (total), bis(2-ethylhexyl)phthalate, di-n-butylphthalate, and heptachlor. Acetone was detected in one trip blank (69-TB-09) and one rinsate blank (69-RS-03); methylene chloride was detected in one trip blank (69-TB-06); and di-n-butylphthalate was detected in two rinsate blanks (69-RS-03 and 69-RS-05). As stated previously, methylene chloride and acetone are mostly the result of laboratory contamination. Bis(2-ethylhexyl)phthalate and di-n-butylphthalate may be the result of the gloves used in the field. Phthalates are a common component of plastics and the isopropanol alcohol used in deconing may affect the gloves causing the phthalates to be detected in rinsate samples. The presence of acetone may also be the result of decontamination procedures with isopropanol alcohol. Toluene was detected in one field blank (69-FB-01) and xylenes (total) was detected in one trip blank (69-TB-06) submitted for Site 69. Toluene was detected at 1.00J µg/L and xylenes (total) at 4.0J µg/L. Toluene is a common laboratory contaminant. All 24 TAL inorganics were detected in QA/QC samples but most were quantified with U, UJ, J, and R qualifiers.

A field blank (69-FB-01) collected from the potable water source (fire station hydrant at the Rifle Range) used for decontamination of heavy equipment exhibited levels of bis(2-ethylhexyl)phthalate, chloroform, dibromochloromethane, and toluene. Toluene is a common laboratory contaminant which may be the reason for the detected concentration in the potable water source. This field blank also contained levels of inorganics (some with U, UJ, and J qualifiers).

4.5 Extent of Contamination

This section presents the extent of contamination in soil, groundwater, surface water and sediment at OU No. 14, Site 69.

4.5.1 Soil

Presented below is the extent of contamination for surface and subsurface soil at Site 69.

4.5.1.1 Surface Soil

Results indicate the presence of volatiles, semivolatiles, pesticides, PCBs, and chemical surety degradation compounds is isolated within the surface soils at Site 69. Semivolatiles were not present (excluding the phthalate laboratory contaminants) in the surface soils.

The estimated extent and magnitude of volatile contamination in surface soil is depicted on Figure 4-1. VOCs were present in 10 of 25 surface soil samples. The area of VOC contamination is primarily in the central and southern areas of the site. Seven different volatiles were detected (2-butanone, 4-methyl-2-pentanone, 1,1,1-trichloroethane, 1,2-dichloroethene (total), trichloroethene, tetrachloroethene, and xylenes). 4-methyl-2-pentanone was detected the most frequently and with the highest concentration. The levels and extent of volatiles detected in the surface soils are not likely to contribute to further degradation of subsurface soil quality or shallow groundwater quality. The presence of these volatiles is indicative of past reported use of the site as a disposal area.

The phthalates bis(2-ethylhexyl)phthalate and di-n-butylphthalate were detected above 10 times the maximum concentration detected in QA/QC blanks. Di-n-butylphthalate was detected in nearly all surface soil samples collected from the central area of the site. This makes their occurrence potentially due to site related activities; however, no information is available that specifically points to disposal of contaminants related to phthalates having been disposed of at the site. There is the possibility that they are laboratory and/or field procedure contaminants.

Three surface soil sampling locations south of the central portion of the site (refer to Figure 4-2) exhibited low levels of the pesticides beta-BHC, endosulfan II, 4,4'-DDE, and 4,4'-DDT. Historical usage of pesticides at Camp Lejeune for pest control has been well documented (Water and Air Research, 1983). This may also account for the low concentrations detected at the site.

The PCB aroclor 1260 was detected in one surface soil sample (69-CSA-SB19) at a concentration of 94J µg/kg, as shown on Figure 4-3. Although background information indicates the disposal of PCBs at Site 69, the presence of PCBs in surficial soils is limited.

Acetophenone and hydroxyacetophenone were detected at two surface soil locations, 69-CSA-SB08 and 69-CSA-SB17 (see Figure 4-4). Acetophenone and hydroxyacetophenone are components of "riot gas". Although the site is fenced, soil contamination from training activities in the area may have resulted from the deposition of particulates.

The concentrations of inorganics in surface soil were generally below background levels for MCB Camp Lejeune. Table 4-30 presents a comparison of site, site background, and base background values of inorganics in surficial soils. Metal concentrations were for the most part of the same order of magnitude as the Base background levels. Metals with concentrations above the maximum background levels were silver and zinc. Due to the widespread occurrence of inorganics in soils, no positive detection figure is presented.

4.5.1.2 Subsurface Soil

Subsurface soil exhibited volatiles from the 1 to 3 foot and 3 to 5 foot depths at three locations (refer to Figure 4-5). Detected volatiles included ethylbenzene and 1,1,1-trichloroethene, both at concentrations of 2J µg/kg. Samples 69-GW11-02 and 69-GW12DW-01 were collected outside the site area to the southeast; sample 69-GW10-01 was collected in the central portion of the site. The presence of these volatiles is potentially due to former disposal activities at the site. The ethylbenzene may be associated with POL wastes whereas 1,1,1-TCE is associated with solvent wastes. The fact that off-site subsurface soil is contaminated indicates that contaminants have either migrated off-site or spills occurred in the southeast portion of the study area. Nevertheless, the levels detected in subsurface soils are very low and are not likely to further degrade or contribute to shallow groundwater contamination.

Pesticides were detected at two subsurface soil sampling locations; one on the western portion (69-GW10-01) and the other towards the south portion (69-GW02DW-01) of the site. Figure 4-6 presents the detected concentrations of pesticides in subsurface soils. Historical usage of pesticides at Camp Lejeune for pest control has been well documented (Water and Air Research, 1983). Concentrations were low and within the range for pesticides detected throughout MCB Camp Lejeune soils.

PCBs were not detected in subsurface soils.

No chemical surety degradation compounds were detected in the subsurface soils at Site 69.

The concentration ranges for inorganics detected in the site soils were generally within Base background ranges for soils at MCB Camp Lejeune. Table 4-31 presents a comparison of site, and Base background values of inorganics in subsurface soils. The inorganics which exhibited concentrations above the maximum concentration for Base background soil included beryllium and manganese. Due to the widespread occurrence of inorganics in soils, no positive detection figure is presented.

4.5.2 Groundwater

Shallow Aquifer

Figure 4-7 presents the detected concentrations of volatiles above Federal MCLs and/or NCWQS in the shallow aquifer for the various sampling events. Monitoring well 69-GW02 exhibited concentrations of vinyl chloride, 1,2-dichloroethene (total), trichloroethene, and tetrachloroethene above Federal and State standards for the January 1994 sampling event. Subsequent sampling events showed a decrease in concentrations for these contaminants. The final sampling event in March 1995 exhibited no levels of these contaminants above Federal MCLs and/or NCWQS in well 69-GW02. Monitoring well 69-GW03 exhibited the same tendency for 1,2-dichloroethene. Trichloroethene in well 69-GW03 showed an increase in concentration from the January 1994 sampling (1J µg/L) to March 1995 sampling (7J µg/L). Well 69-GW15 exhibited the highest concentrations of vinyl chloride, 1,2-dichloroethene (total), trichloroethene, tetrachloroethene, 1,1,2,2-tetrachloroethane, and chlorobenzene for the March 1995 sampling event. The contaminant plume is centered near well 69-GW15 and migrates south/southeasterly with flow towards wells 69-GW02 and 69-GW03. As discussed in Section 3.4.2, the site is situated at a high area and shallow groundwater flow is radial from the central portion of the site. Results from the RI confirm the analytical results from the

Verification Step performed in July 1984. Elevated levels of 1,2-DCE were detected in groundwater in the south/southeast area of the site (monitoring wells 69-GW15, 69-GW02, and 69-GW03).

Recorded site history indicates the disposal of solvents at the site. However, very few soil samples exhibited VOCs, indicating that VOCs in soils are not widespread. Due to the high concentrations of VOCs in groundwater, the source of the VOCs could be associated with some localized disposal activity in the area of well 69-GW15. There is evidence of a trench excavation just north of well location 69-GW15.

Location 69-GW03 exhibited a very low concentration of 1,4-dichlorobenzene (2.00J µg/L). No Federal or State standard is established for this compound.

Heptachlor was detected in well 69-GW13 in the shallow aquifer at a concentration of 0.068J µg/L (refer to Figure 4-8). The NCWQS for heptachlor is 0.008 µg/L. Heptachlor was the only pesticide detected above a Federal MCL and/or NCWQS. The relatively low concentration and isolated occurrence outside the disposal area indicates a possible localized accumulation due to Base pest control activities.

Organic concentrations within the shallow aquifer were lower than those reported for 1984 and 1986 sampling events. The lower concentration of 1,2-DCE within the shallow aquifer at well 69-GW02 during the RI may be due to a diminishing of the source and dilution/dispersion associated with groundwater movement across the site. The detection of elevated concentrations of VOCs in well 69-GW15 and hydropunch location 69-DA-HP02 better defines the potential source area for the contamination as being north of location 69-GW02.

Total iron was detected in all shallow wells above secondary MCLs and/or NCWQS. Total manganese was detected in all but one shallow well above standards. Chromium, lead, cadmium, and zinc were also detected above MCLs and/or NCWQS. Figure 4-9 presents the detected concentrations of TAL Total Metals above MCLs and/or NCWQS in the shallow aquifer.

Dissolved metal concentrations were lower compared to total metal concentrations. This decrease in concentration indicates that total metal concentrations may be due more to particulates in the samples rather than to disposal operations. The high total suspended solids (TSS) result (1950 mg/L) for the surficial groundwater sample (69-GW02) supports the conclusion that the total metal concentrations are affected by sediment and particulates in the sample. Antimony was detected at a dissolved concentration above MCLs but not at a total concentration. Total and dissolved metal concentrations are comparable with groundwater in other areas of Camp Lejeune, as shown in Table 4-32.

Metal concentrations do not appear to be related to former disposal activities. Metal concentrations in shallow groundwater do not reflect the "traditional" or normal pattern of high concentrations near the source with a decrease in concentrations away from the source. This may indicate that elevated metals may not be due to disposal operations, but rather due to particulates in the samples which have biased the results high. Results from the low flow purge samples showed a decrease in total metals concentrations. These concentrations were similar to dissolved metal concentrations, which support the conclusion that suspended solids in the sample affected total metal concentrations. Table 4-33 presents a comparison of "low-flow purge" sampling results for total and dissolved metals.

Castle Hayne Aquifer

1,2-DCE (total) and trichloroethene were detected above Federal MCLs and/or NCWQS standards in the upper Castle Hayne well 69-GW02DW at concentrations of 788 µg/L and 29.4 µg/L, respectively (refer to Figure 4-10). 1,2-Dichloroethene (total) was detected in the upper Castle Hayne wells 69-GW03DW and 69-GW13DW at concentrations of 24J µg/L and 9J µg/L, respectively, which are below Federal standards. These two wells are further away from the suspected source area. Monitoring wells 69-GW02DW and 69-GW03IW exhibited a decrease in VOC concentrations over subsequent sampling events. Well 69-GW15IW, which is believed to be near the source, exhibited the highest concentrations of VOCs in the upper zone of the Castle Hayne Aquifer. No confining or semiconfining layer with a continuous horizontal extent has been identified at the site. The detected concentrations and the absence of a confining/semiconfining layer verifies a vertical migration of contaminants.

Well 69-GW02DD (125 feet), which monitors the intermediate zone of the Castle Hayne, did not exhibit 1,2-dichloroethene (total) during the January 1994 sampling event; however, this well did exhibit 1,2-DCE (total) at a concentration of 3J µg/L (below the MCL) during the March 1995 sampling event. No contamination was detected in this well during the April 1996 sampling event. The vertical extent of VOC contamination appears to be limited to the intermediate zone of the Castle Hayne aquifer.

Iron and manganese were the only metals which exhibited concentrations above MCLs and/or NCWQS in the intermediate wells (69-GW02DW and 69-GW12DW) (refer to Figure 4-11). The highest concentrations were detected in well 69-GW12DW, located southeast of the site. Concentrations of total and dissolved metals were lower in intermediate/deep wells within the Castle Hayne Aquifer as compared to metal concentrations exhibited in the surficial aquifer.

4.5.3 Surface Water

Volatiles were the only organics detected in surface water samples. Figure 4-12 presents the detected concentrations of volatiles. Surface water samples collected from the New River, the unnamed tributary, and Everett Creek in 1992 did not exhibit volatile concentrations. Surface water sample 69-OS-SW01 in the southwest portion of the site (low-lying "puddles") exhibited the most contamination from volatiles. The volatile with the highest concentration was 1,2-dichloroethene (total). The occurrence of high DCE at this location can be attributed to the shallow groundwater. Sample station 69-OS-SW01 is located in a low area of the site which exhibits ponding. This would be particularly true during times of increased rainfall which would raise the water-table aquifer and potentially intersect the ground surface in low-lying areas. The sediment sample at 69-OS-SW01 also exhibited an elevated level of DCE. Location 69-SW02, east of well location 69-GW02 and near well location 69-GW03, exhibited elevated levels of DCE. This surface water sampling location is generally downgradient from well 69-GW02 and may also be influenced by the same rise in the water-table aquifer. These detections support the possibility that solvent disposal occurred in the southeast portion of the site area. One sample collected in the northeast drainage area exhibited fuel constituents. No fuel constituents were detected in the sediment samples or soil samples collected from the northeast drainage area. No specific source for the fuel can be identified.

TAL Total Metals were detected in all surface water samples. Table 4-34 presents a comparison of "onsite" and "offsite" surface water inorganic results with "base-wide" upgradient inorganic results. The "Base-wide" upgradient results refer to upstream samples inorganic analyses from four Sites (no. 2, 6, 41, and 69) at MCB Camp Lejeune. These results have been compiled as ranges for the various metals and presented as Base upgradient concentrations for surface water. Most TAL metals concentrations for the onsite ponded water bodies and drainage areas were higher than the results obtained for the Base wide study.

4.5.4 Sediment

Low levels of volatiles were detected in 5 of 7 on-site sediment samples. Figure 4-13 presents the concentrations of volatiles for the sediment samples. 1,2-dichloroethene (total) was detected in sample 69-OS-SD01-06 which correlates to the surface water sample (69-OS-SW01) collected at this onsite ponded water location. Samples collected from the onsite ponded water in the southeast area of the site exhibited elevated levels of 4-methyl-2-pentanone. This area of the site did not have detected levels of volatiles in surface or subsurface soils. Neither groundwater nor surface water in the southeast area exhibited concentrations of 4-methyl-2-pentanone. It is suspected that 4-methyl-2-pentanone is present due to laboratory contamination. Toluene was detected in one sediment sample in the southeast drainage area with no correlation to volatiles detected in the soils, surface water or groundwater of this area. Detected volatiles and semivolatiles concentrations in on-site, New River, unnamed tributary, and Everett Creek sediment sample locations were not above NOAA ER-L values, except for benzo(a)pyrene in one unnamed tributary sample. The detected concentration of benzo(a)pyrene was equal to the ER-M value (2,500 µg/kg).

Six pesticides were detected at four of seven sediment sampling locations (refer to Figure 4-14). Three of the locations are in the southeast area of the site and the southeast drainage area. Pesticides were also detected in the surface soils in this area. However, the same pesticides were not detected in each media and concentrations were higher in sediment samples as opposed to soil samples. Very low levels of pesticides were detected in well 69-GW03 in the southeast area of the site, indicating that pesticides may have migrated vertically to the water table. Pesticides were also detected in one sample (69-DA-SD02) in the northeast drainage area. No specific surface soil analytical data is available for this area. Pesticides were not detected in the subsurface soils in the northeast drainage area. No pesticides were detected at the higher elevations within the site above this area, where runoff could account for the detected concentrations. The results for 4,4'-DDE, 4,4'-DDD, and 4,4'-DDT for Site 69 sediment samples are comparable to concentrations detected in other surface water bodies throughout MCB Camp Lejeune. Alpha-BHC, beta-BHC, and delta-BHC were detected in sample 69-OS-SD02 in the southeast area of the site. Beta-BHC was detected in surface soil sample 69-OS-SB25, located north/northeast of the sediment sample 69-OS-SD02. Since these pesticides have not been detected in any other sediment samples collected at the Base, it may indicate a possible source within the former disposal area. On-site sample location pesticide concentrations were between the NOAA ER-L and ER-M values. Unnamed Tributary sediment samples exhibited pesticide concentrations above the ER-L and ER-M values.

The PCB aroclor 1254 was detected in one on-site sediment sample at a concentration of 79J µg/kg (refer to Figure 4-14). Aroclor 1260 was reported in surface soil sample 69-OS-SB19-00 at approximately the same location as sediment sample 69-OS-SD01. This was the only detected PCB in surface soils. No PCBs were detected in the subsurface soils, the shallow and deep groundwater, or surface water. The source for this detected PCB is unknown. The one detected concentration of the PCB aroclor 1260 was above the ER-L (50 µg/kg) but below the ER-M (400 µg/kg) for total PCBs.

Acetophenone was detected in one on-site and one drainage area (northeast) sediment sample, as shown on Figure 4-15. As mentioned before, acetophenone is a degradation compound of "riot gas", and troop training may occur in this area, possibly accounting for the high level of acetophenone. Acetophenone was detected in surface soil sample 69-CSA-SB17 at a similar concentration detected in sediment sample 69-OS-SD02. The detected acetophenone in the northeast drainage area is at a high concentration (960 µg/kg). The drainage area is downslope of the site area.

Figure 4-16 presents detected TCL organics and TAL metals above aquatic reference values (i.e., ARARS, TBCs) in surface water and sediment samples from the New River, Everett Creek, and the unnamed tributary in the area surrounding Site 69. These results are discussed in the Ecological Risk Assessment (Section 7.0).

4.6 Summary

The VOC contamination is most prevalent in the shallow aquifer in the area of shallow well GW15. Samples collected from well GW02, which historically exhibited VOC levels in the ppm range, have exhibited much lower levels over the last few years. Based on the most recent rounds of sampling (1995), it appears that the VOC contamination in the shallow aquifer emanates very close to well GW15 and extends horizontally to the south and to the east of the suspected source area. VOC contamination has been detected at low concentrations in well GW14, which is located approximately 300 feet south of well GW15, and in well GW13, which is located about 700 feet east of well GW15. Based on the low levels detected in these wells, it is unlikely that VOCs are significantly elevated beyond wells GW14 and GW13.

VOCs have migrated vertically from the source area into the Castle Hayne aquifer. The upper zone of the aquifer has exhibited the most elevated levels of VOCs. Table 4-16B provides the VOC levels detected in monitoring wells that monitor the upper and intermediate zones of the Castle Hayne aquifer.

As shown on Table 4-16B, the upper zone of the Castle Hayne aquifer is contaminated with elevated levels of VOCs. The highest levels were detected in wells GW15UW and GW15IW. VOCs have also migrated to the intermediate zone of the aquifer (see the results for well GW15DW). The extent of contamination in the intermediate zone is believed to be limited since well GW02DD, located to the south, did not exhibit much contamination. VOC levels below 120 feet are likely to be lower in concentration since deep well GW15BCH did not exhibit VOC contamination. In summary, VOC levels near the suspected source area decrease significantly from the shallow aquifer to the intermediate zone of the Castle Hayne.

Groundwater flow in the upper and intermediate zones of the Castle Hayne is south-southeast. VOC contamination in well GW02DW consisted only of 1,2-DCE at a concentration of 54 µg/L. Wells GW02DD and GW03DW did not exhibit VOC contamination during the April 1996 sampling round. Historically, wells GW02DW and GW03DW have exhibited some VOCs. The absence of VOCs during the 1996 sampling round cannot be explained. One pattern that has been noted is that VOC levels in well clusters GW02 and GW03 have decreased significantly over the years.

No significant contamination from semivolatiles, pesticides, or PCBs in soil or groundwater is evident.

The chemical surety degradation compound acetophenone, detected in the northeast drainage area and in surface soil samples, can be attributed to training activities utilizing "riot gas". Acetophenone is a breakdown product of chloroacetophenone, which is the primary chemical of "riot gas".

Inorganic levels in soils and groundwater are comparable to levels detected at other sites on the Base, and are not believed to be attributable to former disposal activities.

SECTION 4.0 TABLES

TABLE 4-1

SUMMARY OF BACKGROUND LEVELS FOR SITE 69 AND BASE BACKGROUND LEVELS OF INORGANICS IN SURFACE SOIL
REMEDIAL INVESTIGATION, CTO - 0212
MCB CAMP LEJEUNE, NORTH CAROLINA

	Site Background (mg/kg)	Base Background (mg/kg)
Aluminum	528 - 5,370	17.7 - 9,570
Antimony	0.85 - 0.95	0.33 - 8
Arsenic	0.31 - 0.79	0.065 - 3.9
Barium	5.6 - 20.8	0.65 - 20.8
Beryllium	0.14 - 0.155	0.02 - 0.26
Cadmium	0.26 - 0.29	0.04 - 0.6
Calcium	28.2 - 282	4.25 - 10,700
Chromium	0.75 - 12.5	0.33 - 12.5
Cobalt	2.1 - 2.35	0.185 - 2.355
Copper	1.75 - 1.95	0.5 - 87.2
Iron	426 - 9,640	69.7 - 9,640
Lead	2.8 - 6	0.47 - 142
Magnesium	37.3 - 610	2.55 - 610
Manganese	8.3 - 15.1	0.87 - 66
Mercury	0.015 - 0.06	0.01 - 0.08
Nickel	1.6 - 2.9	0.6 - 3.55
Potassium	32.25 - 361	1 - 416
Selenium	0.27 - 0.3	0.075 - 1.3
Silver	0.045 - 4.3	0.0435 - 4.3
Sodium	20 - 22.4	4.7 - 126
Thallium	0.495 - 0.55	0.06 - 1.2
Vanadium	1.8 - 13.5	0.305 - 18.2
Zinc	3.1 - 10.8	0.3 - 28.3
Total Cyanide	2.2 - 2.4	0.265 - 2.4

ND = Nondetect

TABLE 4-2

SUMMARY OF BASE BACKGROUND LEVELS OF INORGANICS IN SUBSURFACE SOILS
REMEDIAL INVESTIGATION, CTO - 0212
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
Total Cyanide	NA

ND = Nondetect

TABLE 4-3

SUMMARY OF BASE-WIDE UPSTREAM BACKGROUND LEVELS OF INORGANICS IN SURFACE WATER
REMEDIAL INVESTIGATION, CTO-0212
MCB CAMP LEJEUNE, NORTH CAROLINA

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

NA - Not Applicable
ND - Not Detected

TABLE 4-4

SUMMARY OF BASE-WIDE UPSTREAM BACKGROUND LEVELS OF INORGANICS IN SEDIMENT
REMEDIAL INVESTIGATION, CTO-0212
MCB CAMP LEJEUNE, NORTH CAROLINA

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

NA - Not Applicable
ND - Not Detected

TABLE 4-5

SUMMARY OF SITE CONTAMINATION
OPERABLE UNIT NO. 14 (SITE 69)
REMEDIAL INVESTIGATION, CTO-0212
MCB, CAMP LEJEUNE, NORTH CAROLINA

Media	Fraction	Contaminant	Comparison Criteria	Comparison Criteria	Site Contamination						
					Min.	Max.	Max. Concentration Location	Detection Frequency	Number of Detections Above Comparison Criteria	Number of Detections Above Comparison Criteria	Distribution
					(µg/kg)	(µg/kg)					
Surface Soils	Volatiles	Methylene Chloride	NE	NE	5J	105	69-CSA-SB23-00	15/25	NA	NA	Widespread
		Acetone	NE	NE	31J	340J	69-CSA-SB09-00	5/25	NA	NA	Scattered
		1,2-Dichloroethene (total)	NE	NE	4J	4J	69-CSA-SB20-00	1/25	NA	NA	Southern Area
		2-Butanone	NE	NE	10.9J	10.9J	69-CSA-SB23-00	1/25	NA	NA	Southeast Area
		1,1,1-Trichloroethane	NE	NE	2J	2J	69-CSA-SB18-00	1/25	NA	NA	Southwest Area
		Trichloroethene	NE	NE	3J	3J	69-CSA-SB21-00	1/25	NA	NA	Southern Area
		4-Methyl-2-pentanone	NE	NE	1J	12J	69-CSA-SB11-00	6/25	NA	NA	Scattered
		Tetrachloroethene	NE	NE	2J	2J	69-CSA-SB21-00	1/25	NA	NA	Southern Area
		Xylenes (total)	NE	NE	5J	5J	69-CSA-SB23-00	1/25	NA	NA	Southeast Area
	Semivolatiles	bis(2-Ethylhexyl)phthalate	NE	NE	43J	48J	69-CSA-SB10-00	4/25	NA	NA	Central Area
		di-n-Butylphthalate	NE	NE	36J	280J	69-CSA-SB06-00	23/25	NA	NA	Widespread
	Pesticides/ PCBs	beta-BHC	NE	NE	11J	11J	69-CSA-SB25-00	1/25	NA	NA	Central Area
		4,4'-DDE	NE	NE	4.8J	4.8J	69-CSA-SB17-00	1/25	NA	NA	Southeast Central
		Endosulfan II	NE	NE	3.4J	3.4J	69-CSA-SB15-00	1/25	NA	NA	Central Area
		4,4'-DDT	NE	NE	13.3J	13.3J	69-CSA-SB17-00	1/25	NA	NA	Southeast Central
		Aroclor 1260	NE	NE	94J	94J	69-CSA-SB19-00	1/25	NA	NA	Southwest Area
	Chemical Surety Degradation Compounds	Acetophenone	NE	NE	51J	51J	69-CSA-SB17-00	1/35	NA	NA	Southeast Central
		Hydroxyacetophenone	NE	NE	120J	160J	69-CSA-SB17-00	2/35	NA	NA	Southeast Central

SUMMARY OF SITE CONTAMINATION
OPERABLE UNIT NO. 14 (SITE 69)
REMEDIAL INVESTIGATION, CTO-0212
MCB, CAMP LEJEUNE, NORTH CAROLINA

					Site Contamination						
Media	Fraction	Contaminant	Comparison Criteria	Comparison Criteria	Min.	Max.	Max. Concentration Location	Detection Frequency	Number of Detections Above Comparison Criteria	Number of Detections Above Comparison Criteria	Distribution
Surface Soils (Cont.)				Base Background (mg/kg)	(mg/kg)	(mg/kg)				Base Background	
	Inorganics	Aluminum	NE	17.7-9,570	368	3370	69-CSA-SB12-00	25/25	NA	0	Widespread
		Barium	NE	0.65-20.8	3	6.8	69-CSA-SB21-00	17/25	NA	0	Widespread
		Calcium	NE	4.25-10,700	35.8	101	69-CSA-SB19-00	8/25	NA	0	Scattered
		Chromium	NE	0.33-12.5	1.6	3.6	69-CSA-SB18-00	18/25	NA	0	Widespread
		Iron	NE	69.7-9,640	235	2360	69-CSA-SB12-00	25/25	NA	0	Widespread
		Lead	NE	0.47-142	1.1J	12.5	69-CSA-SB17-00	25/25	NA	0	Widespread
		Magnesium	NE	2.55-610	12.9	67.7	69-CSA-SB18-00	24/25	NA	0	Widespread
		Manganese	NE	0.87-66	1.3	15.5	69-CSA-SB01-00	22/25	NA	0	Widespread
		Potassium	NE	1-416	66.1	66.4	69-CSA-SB13-00	2/25	NA	0	Scattered
		Selenium	NE	0.075-1.3	1.1	1.1	69-CSA-SB21-00	1/25	NA	0	Southern Area
		Silver	NE	0.0435-4.3	0.09J	10.2J	69-CSA-SB25-00	4/25	NA	1	Central Area
		Vanadium	NE	0.305-18.2	3.9	5.3	69-CSA-SB12-00	3/25	NA	0	Scattered
		Zinc	NE	0.3-28.3	1.5	66	69-CSA-SB19-00	12/25	NA	1	Scattered
		Total Cyanide	NE	NE	1.1	2.3	69-CSA-SB15-00	12/25	NA	NA	Scattered

TABLE 4-5 (Continued)

SUMMARY OF SITE CONTAMINATION
OPERABLE UNIT NO. 14 (SITE 69)
REMEDIAL INVESTIGATION, CTO-0212
MCB, CAMP LEJEUNE, NORTH CAROLINA

					Site Contamination						
Media	Fraction	Contaminant	Comparison Criteria	Comparison Criteria	Min.	Max.	Max. Concentration Location	Detection Frequency	Number of Detections Above Comparison Criteria	Number of Detections Above Comparison Criteria	Distribution
					(µg/kg)	(µg/kg)					
Sub-surface Soil	Volatiles	Methylene chloride	NE	NE	6J	58	69-GW11-02	7/20	NA	NA	Widespread
		Acetone	NE	NE	13J	45000	69-GW12-01	8/20	NA	NA	Widespread
		1,2-Dichloroethene (total)	NE	NE	2J	2J	69-DA-HP01	1/20	NA	NA	Central Area
		1,1,1-Trichloroethane	NE	NE	2J	2J	69-GW11-02	1/20	NA	NA	Southeast of Site
		1,1,2-Trichloroethane	NE	NE	3J	3J	69-DA-HP02	1/20	NA	NA	Central Area
		Ethylbenzene	NE	NE	2J	2J	69-GW12DW-01	2/20	NA	NA	Scattered
	Semivolatiles	bis(2-Ethylhexyl)phthalate	NE	NE	53J	53J	69-GW11-02	1/10	NA	NA	Southeast of Site
		Diethylphthalate	NE	NE	260J	260J	69-GW02DW-03	1/10	NA	NA	Southern Area
		di-n-Butylphthalate	NE	NE	53J	120J	69-GW09-05	5/10	NA	NA	Scattered
	Pesticides	4,4'-DDE	NE	NE	1.2J	1.2J	69-GW10-01	1/10	NA	NA	Central Area
		Endrin	NE	NE	1.2J	1.2J	69-GW02DW-01	1/10	NA	NA	Southern Area
		4,4'-DDD	NE	NE	5.7J	5.7J	69-GW10-01	1/10	NA	NA	Central Area
		4,4'-DDT	NE	NE	1.6J	1.6J	69-GW02DW-01	1/10	NA	NA	Southern Area
				Base Background (mg/kg)	(mg/kg)	(mg/kg)				Base Background	
	Inorganics	Aluminum	NE	16.9-11,000	832	9990	69-GW09-05	10/10	NA	0	Widespread
		Arsenic	NE	0.033-15.4	1.15	2.9	69-GW09-05	2/10	NA	0	Scattered
		Barium	NE	0.65-22.6	3.8	14.6	69-GW09-05	7/10	NA	0	Widespread
		Beryllium	NE	0.01-0.31	0.36	0.36	69-GW09-05	1/10	NA	1	Northeast of Site
		Cadmium	NE	0.155-1.2	0.74	0.74	69-GW09-05	1/10	NA	0	Northeast of Site
		Calcium	NE	4.75-4,410	29.2	688	69-GW09-05	8/10	NA	0	Widespread
		Chromium	NE	0.65-66.4	1.76	17.7	69-GW09-05	8/10	NA	0	Widespread
		Copper	NE	0.47-9.5	5.1	5.1	69-GW09-05	1/10	NA	0	Northeast of Site

TABLE 4-5 (Continued)

SUMMARY OF SITE CONTAMINATION
OPERABLE UNIT NO. 14 (SITE 69)
REMEDIAL INVESTIGATION, CTO-0212
MCB, CAMP LEJEUNE, NORTH CAROLINA

Media	Fraction	Contaminant	Comparison Criteria	Comparison Criteria	Site Contamination						
					Min.	Max.	Max. Concentration Location	Detection Frequency	Number of Detections Above Comparison Criteria	Number of Detections Above Comparison Criteria	Distribution
Sub-surface Soil (Cont.)	Inorganics (Cont.)			Base Background (mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)			Base Background	
		Iron	NE	63.3-90,500	354	19900	69-GW09-05	10/10	NA	0	Widespread
		Lead	NE	0.465-21.4	1.78	6	69-GW09-05	10/10	NA	0	Widespread
		Magnesium	NE	2.85-852	26.9	574	69-GW09-05	10/10	NA	0	Widespread
		Manganese	NE	0.395-19.9	1.6	39	69-GW09-05	10/10	NA	2	Widespread
		Mercury	NE	0.01-0.68	0.04	0.07	69-GW11-02	2/10	NA	0	Scattered
		Nickel	NE	0.45-4.7	3.4	3.9	69-GW09-05	3/10	NA	0	Scattered
		Potassium	NE	1.05-1,250	149	516J	69-GW09-05	3/10	NA	0	Scattered
		Silver	NE	0.175-1	0.43J	0.43J	69-GW09-02	1/10	NA	0	Northeast of Site
		Sodium	NE	5.4-141	130	130	69-GW09-05	1/10	NA	0	Northeast of Site
		Vanadium	NE	0.34-69.4	4.4	22.6	69-GW09-05	4/10	NA	0	Scattered
		Zinc	NE	0.32-26.6	3.4	13.7	69-GW09-05	3/10	NA	0	Scattered
		Total Cyanide	NE	NE	1.2	2.6	69-GW09-05	3/10	NA	NA	Scattered
			MCL (µg/L)	NCWQS (µg/L)	(µg/L)	(µg/L)			MCL	NCWQS	
Shallow Ground-water	Volatiles	Vinyl Chloride	2	0.15	5	55J	69-GW15-01	3/32	2	2	Southern Area
		Chloroform	80	0.19	6	6	69-GW04	1/32	0	1	East Central Area
		Carbon Disulfide	NE	NE	1J	1J	69-GW10-01	1/32	NA	NA	Central Area
		1,1-Dichloroethane	NE	700	1J	1J	69-GW03-01	1/32	NA	0	Southeast Area
		1,2-Dichloroethene (total)	70	NE	2J	2,400	69-GW02-01	8/32	4	NA	Scattered
		Trans-1,2-Dichloroethene	100	70	230	230	69-GW02	1/32	1	1	Southern Area
		Trichloroethene	5	2.8	1J	150J	69-GW15-01	6/32	5	5	Southern Area
		Tetrachloroethene	NE	0.7	1J	33J	69-GW15-01	2/32	NA	2	Southern Area

TABLE 4-5 (Continued)

SUMMARY OF SITE CONTAMINATION
OPERABLE UNIT NO. 14 (SITE 69)
REMEDIAL INVESTIGATION, CTO-0212
MCB, CAMP LEJEUNE, NORTH CAROLINA

					Site Contamination						
Media	Fraction	Contaminant	Comparison Criteria	Comparison Criteria	Min.	Max.	Max. Concentration Location	Detection Frequency	Number of Detections Above Comparison Criteria	Number of Detections Above Comparison Criteria	Distribution
Shallow Ground-water (Cont.)	Volatiles (Cont.)		MCL (µg/L)	NCWQS (µg/L)	(µg/L)	(µg/L)			MCL	NCWQS	
		1,1,2,2-Tetrachloroethane	NE	NE	1J	22J	69-GW02-01	3/32	NA	NA	Scattered
		Toluene	1,000	1,000	1J	4J	69-GW03-01	2/32	0	0	Southeast Area
		Chlorobenzene	NE	50	25J	25J	69-GW03-01	1/32	NA	0	Southeast Area
	Semi-Volatiles	1,4-Dichlorobenzene	NE	NE	2J	2J	69-GW03-01	1/12	NA	NA	Southeast Area
	Pesticides/PCBs	alpha-BHC	NE	NE	0.056	0.056	69-GW03-01	1/12	NA	NA	Southeast Area
		delta-BHC	NE	NE	2.3	2.3	69-GW03-01	1/12	NA	NA	Southeast Area
	Inorganics	Aluminum	50-200(1)	NE	304	211,000	69-GW12-01	12/12	12	NA	Widespread
		Antimony	6	NE	8.59J	8.59J	69-GW06-01	1/6	1	NA	Widespread
		Arsenic	50	50	2.94J	19.9	69-GW10-01	6/12	0	0	Widespread
		Barium	2,000	2,000	29.6	850	69-GW12-01	12/12	0	0	Widespread
		Beryllium	4	NE	2.1	10.6	69-GW12-01	5/12	2	NA	Widespread
		Cadmium	5	5	3.12	11.4	69-GW12-01	3/12	1	1	Scattered
		Calcium	NE	NE	2,010	38,700	69-GW08-01	12/12	NA	NA	Widespread
		Chromium	100	50	15.1	159	69-GW12-01	10/12	1	3	Widespread
		Cobalt	NE	NE	25.9	25.9	69-GW12-01	1/12	NA	NA	Southeast of Site
		Copper	1,000 (1)	1,000	16.5	70.8	69-GW12-01	3/12	0	0	Scattered
		Iron	300 (1)	300	1,610	99,500J	69-GW04-01	12/12	12	12	Widespread
		Lead	15 (2)	15	4.4	188	69-GW12-01	11/12	5	5	Widespread
		Magnesium	NE	NE	371	13,200	69-GW12-01	12/12	NA	NA	Widespread
		Manganese	50 (1)	50	13	912	69-GW08-01	12/12	9	9	Widespread
		Mercury	2	1.10	0.068	0.936	69-GW12-01	6/12	0	0	Widespread
		Nickel	100	100	16.7	99.8	69-GW12-01	4/12	0	0	Scattered

TABLE 4-5 (Continued)

SUMMARY OF SITE CONTAMINATION
OPERABLE UNIT NO. 14 (SITE 69)
REMEDIAL INVESTIGATION, CTO-0212
MCB, CAMP LEJEUNE, NORTH CAROLINA

Media	Fraction	Contaminant	Comparison Criteria	Comparison Criteria	Site Contamination						
					Min.	Max.	Max. Concentration Location	Detection Frequency	Number of Detections Above Comparison Criteria	Number of Detections Above Comparison Criteria	Distribution
Shallow Ground-water (Cont.)	Inorganics (Cont.)		MCL (μg/L)	NCWQS (μg/L)	(μg/L)	(μg/L)			MCL	NCWQS	
		Potassium	NE	NE	1,410J	7,610	69-GW12-01	10/12	NA	NA	Widespread
		Selenium	50	50	3.81J	5.28J	69-GW12-01	3/12	0	0	Scatterd
		Sodium	NE	NE	4,130	14,100	69-GW02-01	12/12	NA	NA	Widespread
		Vanadium	NE	NE	17.2	210	69-GW12-01	10/12	NA	NA	Widespread
		Zinc	5,000 (1)	2,100	52.1	9,120J	69-GW04-01	10/12	1	1	Widespread
Castle Hayne Aquifer	Volatiles	Vinyl Chloride	2	0.015	8.37J	8.37J	69-GW02-DW-01	1/18	1	1	Southern Area
		1,2-Dichloroethene (total)	70	NE	788	2,500	69-GW15IW-01	2/18	2	NA	Southern Area
		Trans-1,2-Dichloroethene	100	70	8	8	69-GW02DW	1/18	0	0	Southern Area
		Trichloroethene	5	2.8	29.4	2,600	69-GW15IW-01	2/18	2	2	Southern Area
		1,1,2-Trichloroethane	5	NE	13	13	69-GW15IW	1/18	1	NA	Cetral Area
	Inorganics	Aluminum	50-200 (1)	NE	3,030	4,680J	69-GW12DW-01	2/2	2	NA	Southeast Area
		Arsenic	50	50	3.54J	3.54J	69-GW12DW-01	1/2	0	0	Southeast of Site
		Barium	2,000	2,000	42.3	58	69-GW12DW-01	2/2	0	0	Southeast Area
		Beryllium	4	NE	0.89	0.89	69-GW12DW-01	1/2	0	NA	Southeast of Site
		Calcium	NE	NE	59,300	180,000	69-GW12DW-01	2/2	NA	NA	Southeast Area
		Chromium	100	50	20.7	20.7	69-GW12DW-01	1/2	0	0	Southeast of Site
		Iron	300 (1)	300	5,820	10,900	69-GW12DW-01	2/2	2	2	Southeast Area
		Lead	15 (2)	15	3.1	3.1	69-GW02DW-01	1/2	0	0	Southern Area
		Magnesium	NE	NE	2,590	4,890	69-GW12DW-01	2/2	NA	NA	Southeast Area
		Manganese	50 (1)	50	53.7	114	69-GW12DW-01	2/2	2	2	Southeast Area
		Mercury	2	1.10	0.174	0.174	69-GW02DW-01	1/2	0	0	Southern Area
		Potassium	NE	NE	1,660	1,850	69-GW02DW-01	2/2	NA	NA	Southeast Area

TABLE 4-5 (Continued)

SUMMARY OF SITE CONTAMINATION
OPERABLE UNIT NO. 14 (SITE 69)
REMEDIAL INVESTIGATION, CTO-0212
MCB, CAMP LEJEUNE, NORTH CAROLINA

					Site Contamination						
Media	Fraction	Contaminant	Comparison Criteria	Comparison Criteria	Min.	Max.	Max. Concentration Location	Detection Frequency	Number of Detections Above Comparison Criteria	Number of Detections Above Comparison Criteria	Distribution
			MCL (µg/L)	NCWQS (µg/L)	(µg/L)	(µg/L)			MCL	NCWQS	
Castle Hayne Aquifer (Cont.)	Inorganics (Cont.)	Sodium	NE	NE	10,900	33,000	69-GW02DW-01	2/2	NA	NA	Southeast Area
		Zinc	5,000 (1)	2,100	31.1	31.1	69-GW02DW-01	1/2	0	0	Southern Area
			AWQC (µg/L)	NCWQS (µg/L)	(µg/L)	(µg/L)			AWQC	NCWQS	
Surface Water On-Site and Drainage Areas	Volatiles	Vinyl Chloride	2	525	8J	8J	69-OS-SW01	1/7	1	0	Southern Area
		Acetone	NE	NE	3J	9J	69-DA-SW04	2/7	NA	NA	N and S of Site
		1,2-Dichloroethene (total)	NE	NE	13	55	69-OS-SW01	2/7	NA	NA	Southern Area
		Chloroform	5.7	NE	2J	2J	69-OS-SW01	1/7	0	NA	Southern Area
		Trichloroethene	2.7	NE	4J	4J	69-OS-SW01	1/7	NA	NA	Southern Area
		Toluene	6800	NE	1J	1J	69-OS-SW02 and 69-DA-SW01	2/7	0	NA	Widespread
		Ethylbenzene	3100	NE	1J	1J	69-DA-SW01	1/7	0	NA	Northeast of Site
		Xylenes (total)	NE	NE	10	10	69-DA-SW04	1/7	NA	NA	Southeast of Site
	Semi-Volatiles	di-n-Butylphthalate	2700	NE	1J	1J	69-DA-SW01	1/7	0	NA	Northeast of Site

TABLE 4-5 (Continued)

SUMMARY OF SITE CONTAMINATION
OPERABLE UNIT NO. 14 (SITE 69)
REMEDIAL INVESTIGATION, CTO-0212
MCB, CAMP LEJEUNE, NORTH CAROLINA

Media	Fraction	Contaminant	Comparison Criteria	Comparison Criteria	Site Contamination Min.	Site Contamination Max.	Site Contamination Max. Concentration Location	Site Contamination Detection Frequency	Site Contamination Number of Detections Above Comparison Criteria	Site Contamination Number of Detections Above Comparison Criteria	Site Contamination Distribution
Surface Water On-Site and Drainage Areas (Cont.)	Inorganics		AWQC (µg/L)	NCWQS (µg/L)	(µg/L)	(µg/L)			AWQC	NCWQS	
		Aluminum	NE	NE	487	29,200	69-DA-SW02	7/7	NA	NA	Widespread
		Arsenic	0.018	NE	4.1	32.8	69-DA-SW03	2/7	2	NA	Southern Area
		Barium	1,000	NE	45.1	373	69-DA-SW02	7/7	0	NA	Widespread
		Beryllium	NE	.117	1.6	6.0	69-DA-SW02	2/7	NA	2	N and S of Site
		Calcium	NE	NE	3,080	73,000	69-DA-SW01	7/7	NA	NA	Widespread
		Chromium	NE	NE	23.8	23.8	69-DA-SW02	1/7	NA	NA	North of Site
		Copper	NE	NE	22.8	35.9	69-DA-SW03	3/7	NA	NA	Scattered
		Iron	300	NE	1,090	38,400	69-DA-SW03	7/7	7	NA	Widespread
		Lead	NE	NE	3.1	85.8	69-DA-SW02	6/7	NA	NA	Widespread
		Magnesium	4	NE	885	143,000	69-DA-SW01	7/7	7	NA	Widespread
		Manganese	50	NE	73.4	421	69-DA-SW02	7/7	7	NA	Widespread
		Mercury	0.14	NE	0.43	0.43	69-DA-SW02	1/7	1	NA	North of Site
		Nickel	610	NE	17.8	17.8	69-DA-SW02	1/7	0	NA	North of Site
		Potassium	NE	NE	365	37,600	69-DA-SW01	6/7	NA	NA	Widespread
		Silver	NE	NE	0.74J	2.3J	69-DA-SW04	3/7	NA	NA	N and S of Site
		Sodium	NE	NE	4,900	1,460,000	69-DA-SW01	7/7	NA	NA	Widespread
		Vanadium	NE	NE	23.3	24	69-DA-SW02	2/7	NA	NA	N and S of Site
		Zinc	NE	NE	96	4,370	69-OS-SW01	7/7	NA	NA	Widespread

TABLE 4-5 (Continued)

SUMMARY OF SITE CONTAMINATION
OPERABLE UNIT NO. 14 (SITE 69)
REMEDIAL INVESTIGATION, CTO-0212
MCB, CAMP LEJEUNE, NORTH CAROLINA

Media	Fraction	Contaminant	Comparison Criteria	Comparison Criteria	Site Contamination						
					Min.	Max.	Max. Concentration Location	Detection Frequency	Number of Detections Above Comparison Criteria	Number of Detections Above Comparison Criteria	Distribution
New River Surface Water	Inorganics		AWQC (µg/L)	NCWQS (µg/L)	(µg/L)	(µg/L)			AWQC	NCWQS	
		Aluminum	NE	NE	554	1,840	69-NR1-SW06	3/3	NA	NA	N and E of Site
		Barium	1,000	NE	11.7JB	15.2JB	69-NR1-SW06	3/3	0	NA	N and E of Site
		Calcium	NE	NE	95,700	110,000	69-NR1-SW06 & 69-NR2-SW06	3/3	NA	NA	N and E of Site
		Iron	300	NE	682	1,330	69-NR2-SW06	3/3	3	NA	N and E of Site
		Magnesium	NE	NE	267,000	308,000	69-NR1-SW06	3/3	NA	NA	N and E of Site
		Manganese	50	NE	19.2J	21.7J	69-NR2-SW06	3/3	0	NA	N and E of Site
		Potassium	NE	NE	84,900	111,000	69-NR1-SW06	3/3	NA	NA	N and E of Site
		Silver	NE	NE	3.5JB	4.5JB	69-NR1-SW06	2/3	NA	NA	N and E of Site
		Sodium	NE	NE	3,080,000	5,830,000	69-NR2-SW06	3/3	NA	NA	N and E of Site
		Thallium	1.7	NE	11.3JB	11.3JB	69-NR2-SW06	1/3	1	NA	East of Site
Unnamed Tributary Surface Water	Inorganics	Aluminum	NE	NE	881	3,490	69-UT3-SW06	3/3	NA	NA	N and W of Site
		Barium	1,000	NE	15.2JB	23B	69-UT1-SW06	3/3	0	NA	N and W of Site
		Cadmium	NE	NE	3JB	3JB	69-UT1-SW06	1/3	NA	NA	West of Site
		Calcium	NE	NE	1,380B	92,300	69-UT3-SW06	3/3	NA	NA	N and W of Site
		Cobalt	NE	NE	8JB	8JB	69-UT1-SW06	1/3	NA	NA	West of Site
		Copper	NE	NE	7JB	7JB	69-UT1-SW06	1/3	NA	NA	West of Site
		Iron	300	NE	740	1,840	69-UT3-SW06	3/3	3	NA	N and W of Site
		Lead	NE	NE	2B	2B	69-UT2-SW06	1/3	NA	NA	West of Site
		Magnesium	NE	NE	846B	257,000	69-UT3-SW06	3/3	NA	NA	N and W of Site
		Manganese	50	NE	9JB	17.7J	69-UT2-SW06	3/3	0	NA	N and W of Site

TABLE 4-5 (Continued)

SUMMARY OF SITE CONTAMINATION
OPERABLE UNIT NO. 14 (SITE 69)
REMEDIAL INVESTIGATION, CTO-0212
MCB, CAMP LEJEUNE, NORTH CAROLINA

					Site Contamination						
Media	Fraction	Contaminant	Comparison Criteria	Comparison Criteria	Min.	Max.	Max. Concentration Location	Detection Frequency	Number of Detections Above Comparison Criteria	Number of Detections Above Comparison Criteria	Distribution
Unnamed Tributary Surface Water (Cont.)	Inorganics (Cont.)		AWQC (µg/L)	NCWQS (µg/L)	(µg/L)	(µg/L)			AWQC	NCWQS	
		Potassium	NE	NE	385B	86,000	69-UT3-SW06	3/3	NA	NA	N and W of Site
		Sodium	NE	NE	4,790JB	2,220,000	69-UT3-SW06	3/3	NA	NA	N and W of Site
		Vanadium	NE	NE	4.2JB	10JB	69-UT1-SW06	2/3	NA	NA	N and W of Site
		Zinc	NE	NE	18B	18B	69-UT1-SW06	1/3	NA	NA	West of Site
Everett Creek Surface Water	Inorganics	Aluminum	NE	NE	445	501	69-EC3-SW06	2/3	NA	NA	Southeast of Site
		Barium	1,000	NE	10.4JB	22.2JB	69-EC1-SW06	3/3	0	NA	South of Site
		Calcium	NE	NE	26,400	85,200	69-EC1-SW06	3/3	NA	NA	South of Site
		Copper	NE	NE	2.6JB	2.6JB	69-EC1-SW06	1/3	NA	NA	Southwest of Site
		Iron	300	NE	490	667	69-EC1-SW06	3/3	3	NA	South of Site
		Lead	NE	NE	1.4B	2.3J	69-EC3-SW06	2/3	NA	NA	Southeast of Site
		Magnesium	NE	NE	73,800	229,000	69-EC1-SW06	3/3	NA	NA	South of Site
		Manganese	50	NE	14.3JB	32.5	69-EC1-SW06	3/3	0	NA	South of Site
		Potassium	NE	NE	22,600	88,700	69-EC1-SW06	3/3	NA	NA	South of Site
		Silver	NE	NE	3.2J	4.1J	69-EC3-SW06	2/3	NA	NA	Southeast of Site
		Sodium	NE	NE	727,000	2,130,000	69-EC1-SW06	3/3	NA	NA	South of Site

TABLE 4-5 (Continued)

SUMMARY OF SITE CONTAMINATION
OPERABLE UNIT NO. 14 (SITE 69)
REMEDIAL INVESTIGATION, CTO-0212
MCB, CAMP LEJEUNE, NORTH CAROLINA

					Site Contamination						
Media	Fraction	Contaminant	Comparison Criteria	Comparison Criteria	Min.	Max.	Max. Concentration Location	Detection Frequency	Number of Detections Above Comparison Criteria	Number of Detections Above Comparison Criteria	Distribution
			NOAA ER-L (µg/kg)	NOAA ER-M (µg/kg)	(µg/kg)	(µg/kg)			NOAA ER-L	NOAA ER-M	
Sediment On-Site and Drainage Areas	Volatiles	Methylene Chloride	NE	NE	8J	48	69-DA-SD04-06	5/7	NA	NA	Widespread
		Acetone	NE	NE	9J	850J	69-OS-SD02-06	3/7	NA	NA	Southern Area
		1,2-Dichloroethene (total)	NE	NE	9J	9J	69-OS-SD01-06	1/7	NA	NA	Southern Area
		2-Butanone	NE	NE	36J	36J	69-DA-SD01-06	1/7	NA	NA	Northeast of Site
		4-Methyl-2pentenone	NE	NE	9J	17	69-OS-SD02-06	3/7	NA	NA	Scattered
		Toluene	NE	NE	18J	18J	69-DA-SD04-06	1/7	NA	NA	Southeast of Site
	Semi-Volatiles	di-n-Butylphthalate	NE	NE	110J	110J	69-OS-SD03-06 and 69-OS-SD02-06	2/7	NA	NA	Southeast Area
	Pesticides/PCBs	alpha-BHC	NE	NE	3.1J	3.1J	69-OS-SD02-06	1/7	NA	NA	Southeast Area
		beta-BHC	NE	NE	23.4J	23.4J	69-OS-SD02-06	1/7	NA	NA	Southeast Area
		delta-BHC	NE	NE	54.5J	54.5J	69-OS-SD02-06	1/7	NA	NA	Southeast Area
		4,4'-DDE	2.2	27	13.3J	13.3J	69-DA-SD02-06	1/7	1	0	Northeast of Site
		4,4'-DDD	2	20	1.5J	13.9J	69-DA-SD04-06	3/7	2	0	N and S of Site
		4,4'-DDT	1.58	46.1	2.1J	6.6J	69-DA-SD04-06	2/7	2	0	Southeast Area
		Aroclor 1254	22.7(3)	180(3)	79J	79J	69-OS-SD01-06	1/7	1	0	Southern Area
	Chemical Surety Material	Acetophenone	NE	NE	60J	960J	69-DA-SD01-06	2/7	NA	NA	Scattered

TABLE 4-5 (Continued)

SUMMARY OF SITE CONTAMINATION
OPERABLE UNIT NO. 14 (SITE 69)
REMEDIAL INVESTIGATION, CTO-0212
MCB, CAMP LEJEUNE, NORTH CAROLINA

					Site Contamination						
Media	Fraction	Contaminant	Comparison Criteria	Comparison Criteria	Min.	Max.	Max. Concentration Location	Detection Frequency	Number of Detections Above Comparison Criteria	Number of Detections Above Comparison Criteria	Distribution
Sediment On-Site and Drainage Areas	Inorganics		NOAA ER-L (mg/kg)	NOAA ER-M (mg/kg)	(mg/kg)	(mg/kg)			NOAA ER-L	NOAA ER-M	
		Aluminum	NE	NE	1,050	23,700	69-DA-SD04-06	7/7	NA	NA	Widespread
		Barium	NE	NE	6.8	131	69-DA-SD04-06	4/7	NA	NA	Scattered
		Beryllium	NE	NE	0.94	2	69-DA-SD04-06	2/7	NA	NA	N and S of Site
		Calcium	NE	NE	107	5,600	69-DA-SD04-06	5/7	NA	NA	Widespread
		Chromium	81	370	2.9	21.5	69-DA-SD04-06	3/7	0	0	Scattered
		Copper	34	270	21.7	21.7	69-OS-SD02-06	1/7	0	0	Southeast Area
		Iron	NE	NE	369	8,930	69-DA-SD04-06	7/7	NA	NA	Widespread
		Lead	46.7	218	3.1J	45.5	69-DA-SD04-06	7/7	0	0	Widespread
		Magnesium	NE	NE	28	5,190	69-DA-SD01-06	7/7	NA	NA	Widespread
		Manganese	NE	NE	1.4	44.1	69-DA-SD04-06	6/7	NA	NA	Widespread
		Mercury	0.15	0.71	0.5	0.56	69-DA-SD01-06	2/7	2	0	N and S of Site
		Potassium	NE	NE	104	452J	69-DA-SD02-06	2/7	NA	NA	N and S of Site
		Silver	1	3.7	0.26J	74.5J	69-DA-SD01-06	3/7	2	2	Scattered
		Sodium	NE	NE	1,410	17,800	69-DA-SD01-06	2/7	NA	NA	Northeast of Site
		Zinc	150	410	15.7	551	69-DA-SD04-06	6/7	1	1	Widespread

TABLE 4-5 (Continued)

SUMMARY OF SITE CONTAMINATION
OPERABLE UNIT NO. 14 (SITE 69)
REMEDIAL INVESTIGATION, CTO-0212
MCB, CAMP LEJEUNE, NORTH CAROLINA

					Site Contamination						
Media	Fraction	Contaminant	Comparison Criteria	Comparison Criteria	Min.	Max.	Max. Concentration Location	Detection Frequency	Number of Detections Above Comparison Criteria	Number of Detections Above Comparison Criteria	Distribution
Everett Creek Sediment	Volatiles		NOAA ER-L (µg/kg)	NOAA ER-M (µg/kg)	(µg/kg)	(µg/kg)			NOAA ER-L	NOAA ER-M	
		Methylene Chloride	NE	NE	1,200J	1,200J	69-EC3-SD-03	1/5	NA	NA	Southeast of Site
		Acetone	NE	NE	240	4,600	69-EC3-SD-03	2/5	NA	NA	Southeast of Site
		Carbon Disulfide	NE	NE	35	35	69-EC3-SD-612	1/5	NA	NA	Southeast of Site
		2-Butanone	NE	NE	5,300	5,300	69-EC3-SD-03	1/5	NA	NA	Southeast of Site
	Semi-Volatiles	Bis(2-Ethylhexyl)phthalate	NE	NE	85J	130J	69-EC4-SD-6122	2/5	NA	NA	Southeast of Site
	Pesticides	4,4'-DDE	2	15	6.6J	6.6J	69-EC4-SD-6122	1/5	1	0	Southeast of Site
	Inorganics		NOAA ER-L (mg/kg)	NOAA ER-M (mg/kg)	(mg/kg)	(mg/kg)			NOAA ER-L	NOAA ER-M	
		Aluminum	NE	NE	888J	32,700	69-EC3-SD-03	5/5	NA	NA	South of Site
		Arsenic	8.2	70	4.4B	5.3B	69-EC4-SD-6122	3/5	0	0	South of Site
		Barium	NE	NE	13JB	26.4B	69-EC3-SD-03	3/5	NA	NA	South of Site
		Beryllium	NE	NE	0.13JB	0.96B	69-EC3-SD-03	5/5	NA	NA	South of Site
		Cadmium	1.2	9.6	0.52JB	5.2JB	69-EC1-SD-06	5/5	4	0	South of Site
		Calcium	NE	NE	627JB	5,500B	69-EC1-SD-06	5/5	NA	NA	South of Site
		Chromium	81	370	3.6J	43.8	69-EC3-SD-03	5/5	0	0	South of Site
		Cobalt	NE	NE	1.3B	7JB	69-EC1-SD-06	4/5	NA	NA	South of Site
		Copper	34	270	6.5JB	16.2JB	69-EC1-SD-06	3/5	0	0	South of Site
		Iron	NE	NE	4,150J	28,900	69-EC3-SD-03	5/5	NA	NA	South of Site
		Lead	46.7	218	7.5J	30.8	69-EC1-SD-06	4/5	0	0	South of Site

TABLE 4-5 *(Continued)*

SUMMARY OF SITE CONTAMINATION
OPERABLE UNIT NO. 14 (SITE 69)
REMEDIAL INVESTIGATION, CTO-0212
MCB, CAMP LEJEUNE, NORTH CAROLINA

					Site Contamination						
Media	Fraction	Contaminant	Comparison Criteria	Comparison Criteria	Min.	Max.	Max. Concentration Location	Detection Frequency	Number of Detections Above Comparison Criteria	Number of Detections Above Comparison Criteria	Distribution
Everett Creek Sediment (Cont.)	Inorganics (Cont.)		NOAA ER-L (mg/kg)	NOAA ER-M (mg/kg)	(mg/kg)	(mg/kg)			NOAA ER-L	NOAA ER-M	
		Magnesium	NE	NE	313JB	7,250	69-EC3-SD-03	5/5	NA	NA	South of Site
		Manganese	NE	NE	4.1J	85.9	69-EC3-SD-612	5/5	NA	NA	South of Site
		Mercury	0.15	0.71	0.17B	0.17B	69-EC1-SD-06	1/5	1	0	Southwest of Site
		Potassium	NE	NE	129JB	4,290	69-EC3-SD-03	5/5	NA	NA	South of Site
		Sodium	NE	NE	1,100JB	21,800	69-EC3-SD-03	5/5	NA	NA	South of Site
		Vanadium	NE	NE	7.2JB	48.8	69-EC3-SD-03	5/5	NA	NA	South of Site
		Zinc	150	410	31.8	62	69-EC1-SD-06	3/5	0	0	South of Site

TABLE 4-5 (Continued)

SUMMARY OF SITE CONTAMINATION
OPERABLE UNIT NO. 14 (SITE 69)
REMEDIAL INVESTIGATION, CTO-0212
MCB, CAMP LEJEUNE, NORTH CAROLINA

					Site Contamination						
Media	Fraction	Contaminant	Comparison Criteria	Comparison Criteria	Min.	Max.	Max. Concentration Location	Detection Frequency	Number of Detections Above Comparison Criteria	Number of Detections Above Comparison Criteria	Distribution
New River Sediment	Volatiles		NOAA ER-L (µg/kg)	NOAA ER-M (µg/kg)	(µg/kg)	(µg/kg)			NOAA ER-L	NOAA ER-M	
		Acetone	NE	NE	22	120	69-NR3-SD-612	3/5	NA	NA	N and SE of Site
	Semi-Volatiles	Bis(2-Ethylhexyl)phthalate	NE	NE	47J	92J	69-NR2-SD-062	2/5	NA	NA	East of Site
			NOAA ER-L (mg/kg)	NOAA ER-M (mg/kg)	(mg/kg)	(mg/kg)			NOAA ER-L	NOAA ER-M	
	Inorganics	Aluminum	NE	NE	3,450	16,200	69-NR1-SD-06	5/5	NA	NA	N and E of Site
		Arsenic	8.2	70	1.6B	5.6	69-NR2-SD-6122	4/5	0	0	N and E of Site
		Barium	NE	NE	4.6B	12.5B	69-NR1-SD-06	3/5	NA	NA	N and SE of Site
		Beryllium	NE	NE	0.24JB	0.37JB	69-NR2-SD-6122	4/5	NA	NA	N and E of Site
		Cadmium	1.2	96	0.53BJ	1.2J	69-NR3-SD-612	3/5	0	0	N and E of Site
		Calcium	NE	NE	376B	525JB	69-NR2-SD-062	5/5	NA	NA	N and E of Site
		Chromium	81	370	6.2	17.7	69-NR1-SD-06	5/5	0	0	N and E of Site
		Cobalt	NE	NE	0.58B	1.2B	69-NR1-SD-06 and 69-NR3-SD-612	5/5	NA	NA	N and E of Site
		Copper	34	270	1.6JB	2.5JB	69-NR3-SD-612	3/5	0	0	N and SE of Site
		Iron	NE	NE	4,320J	14,500	69-NR3-SD-612	5/5	NA	NA	N and E of Site
		Lead	46.7	218	3.6	6	69-NR1-SD-06	5/5	0	0	N and E of Site
		Magnesium	NE	NE	808JB	1,120B	69-NR1-SD-06	5/5	NA	NA	N and E of Site
		Manganese	NE	NE	13.6J	28.9	69-NR2-SD-6122	5/5	NA	NA	N and E of Site
		Potassium	NE	NE	614B	1,040B	69-NR1-SD-06	3/5	NA	NA	N and E of Site
		Sodium	NE	NE	1,240J	2,560J	69-NR3-SD-612	5/5	NA	NA	N and E of Site
		Vanadium	NE	NE	10.3B	35.3	69-NR1-SD-06	5/5	NA	NA	N and E of Site
		Zinc	150	410	7	10.7	69-NR3-SD-612	3/5	0	0	N and SE of Site

TABLE 4-5 (Continued)

SUMMARY OF SITE CONTAMINATION
OPERABLE UNIT NO. 14 (SITE 69)
REMEDIAL INVESTIGATION, CTO-0212
MCB, CAMP LEJEUNE, NORTH CAROLINA

Media	Fraction	Contaminant	Comparison Criteria	Comparison Criteria	Site Contamination						
					Min.	Max.	Max. Concentration Location	Detection Frequency	Number of Detections Above Comparison Criteria	Number of Detections Above Comparison Criteria	Distribution
Unnamed Tributary Sediment	Volatiles		NOAA ER-L (µg/kg)	NOAA ER-M (µg/kg)	(µg/kg)	(µg/kg)			NOAA ER-L	NOAA ER-M	
		Acetone	NE	NE	39J	65	69-UT3-SD-6122	3/5	NA	NA	N and W of Site
		Carbon Disulfide	NE	NE	18J	88	69-UT2-SD-06	4/5	NA	NA	N and W of Site
		Toluene	NE	NE	2J	2J	69-UT1-SD-06	1/5	NA	NA	West of Site
	Semi-Volatiles	Diethylphthalate	NE	NE	500J	500J	69-UT2-SD-612	1/5	NA	NA	Northwest of Site
		Bis(2-Ethylhexyl)phthalate	NE	NE	52J	81J	69-UT3-SD-062	2/5	NA	NA	North of Site
		Benzo(a)pyrene	430	1600	290J	2,500	69-UT2-SD-612	2/5	1	1	Northwest of Site
	Pesticides/PCBs	4,4'-DDE	2.2	27	10J	250	69-UT2-SD-612	3/5	3	2	Northwest of Site
		4,4'-DDD	2	20	14J	150	69-UT2-SD-612	3/5	3	2	N and W of Site
		PCB-1260	22.7(3)	180(3)	360	360	69-UT3-SD-6122	1/5	1	1	North of Site

TABLE 4-5 (Continued)

SUMMARY OF SITE CONTAMINATION
OPERABLE UNIT NO. 14 (SITE 69)
REMEDIAL INVESTIGATION, CTO-0212
MCB, CAMP LEJEUNE, NORTH CAROLINA

Media	Fraction	Contaminant	Comparison Criteria	Comparison Criteria	Site Contamination						
					Min.	Max.	Max. Concentration Location	Detection Frequency	Number of Detections Above Comparison Criteria	Number of Detections Above Comparison Criteria	Distribution
Unnamed Tributary Sediment (Cont.)			NOAA ER-L (mg/kg)	NOAA ER-M (mg/kg)	(mg/kg)	(mg/kg)			NOAA ER-L	NOAA ER-M	
	Inorganics	Aluminum	NE	NE	1,240	23,400	69-UT2-SD-612	5/5	NA	NA	N and Wof Site
		Arsenic	8.2	70	4.7B	7.1	69-UT3-SD-6122	4/5	0	0	N and Wof Site
		Barium	NE	NE	14.2B	23.1B	69-UT2-SD-612	2/5	NA	NA	Northwest of Site
		Beryllium	NE	NE	0.52JB	0.61JB	69-UT3-SD-6122	2/5	NA	NA	North of Site
		Cadmium	1.2	9.6	1.8JB	2.1J	69-UT3-SD-062	3/5	3	0	North of Site
		Calcium	NE	NE	264B	6,270	69-UT2-SD-06	5/5	NA	NA	N and W of Site
		Chromium	81	370	3.3	22.4	69-UT3-SD-6122	3/5	0	0	N and W of Site
		Cobalt	NE	NE	1.4B	2.1B	69-UT3-SD-6122	2/5	NA	NA	North of Site
		Copper	34	270	7.2B	24.1	69-UT2-SD-612	4/5	0	0	N and W of Site
		Iron	NE	NE	3,530	17,900	69-UT2-SD-612	5/5	NA	NA	N and W of Site
		Lead	46.7	218	1	34.1	69-UT2-SD-612	5/5	0	0	N and W of Site
		Magnesium	NE	NE	48.9B	6,670	69-UT2-SD-612	5/5	NA	NA	N and W of Site
		Manganese	NE	NE	2.9J	69.3	69-UT2-SD-612	5/5	NA	NA	N and W of Site
		Potassium	NE	NE	81.1B	2,040	69-UT3-SD-6122	3/5	NA	NA	N and W of Site
		Sodium	NE	NE	122JB	21,100	69-UT2-SD-06	5/5	NA	NA	N and W of Site
		Vanadium	NE	NE	25.8	41.1B	69-UT2-SD-612	4/5	NA	NA	N and W of Site
		Zinc	150	410	22.4	24.6	69-UT3-SD-6122	2/5	0	0	North of Site

(1) SMCL = Secondary Maximum Contaminant Level
(2) Action Level
(3) For Total PCBs
NE = No Criteria Established
NA = Not Applicable

J = Value is Estimated
B = Compounds detected in Method Blank associated with this sample.

N = North
E = East
W = West
S = South

TABLE 4-6
POSITIVE DETECTION SUMMARY
OPERABLE UNIT NO. 14 (SITE 69)
ONSITE SURFACE SOIL
MCB CAMP LEJEUNE, NORTH CAROLINA
REMEDIAL INVESTIGATION - CTO-0212
ORGANICS

Client Sample ID:		69-CSA-SB01-00	69-CSA-SB02-00	69-CSA-SB03-00	69-CSA-SB04-00	69-CSA-SB05-00
Laboratory Sample ID:		9401041-03A	9401041-04A	9401041-05A	9401041-07A	9401041-13A
Depth:		0-12"	0-12"	0-12"	0-12"	0-12"
Date Sampled:		01/07/94	01/07/94	01/07/94	01/07/94	01/07/94
Percent Solids:		93.3	94.2	92.7	93.2	92.0
	UNITS					
SEMIVOLATILES						
bis(2-Ethylhexyl)phthalate	UG/KG	ND	ND	ND	ND	43.0 J
di-n-Butylphthalate	UG/KG	ND	ND	51.0 J	36.0 J	200.0 J
VOLATILES						
Methylene chloride	UG/KG	47.0 J	48.0	9.0 J	10.0 J	ND
Acetone	UG/KG	ND	ND	ND	31.0 J	150.0 J
1,2-Dichloroethene(total)	UG/KG	ND	ND	ND	ND	ND
2-Butanone	UG/KG	ND	ND	ND	ND	10.9 J
1,1,1-Trichloroethane	UG/KG	ND	ND	ND	ND	ND
Trichloroethene	UG/KG	ND	ND	ND	ND	ND
4-Methyl-2-pentanone	UG/KG	ND	ND	ND	ND	12.0 J
Tetrachloroethene	UG/KG	ND	ND	ND	ND	ND
Xylenes (total)	UG/KG	ND	ND	ND	ND	ND
PESTICIDE/PCBS						
beta-BHC	UG/KG	ND	ND	ND	ND	ND
4,4'-DDE	UG/KG	ND	ND	ND	ND	ND
Endosulfan II	UG/KG	ND	ND	ND	ND	ND
4,4'-DDT	UG/KG	ND	ND	ND	ND	ND
Aroclor 1260	UG/KG	ND	ND	ND	ND	ND
CHEMICAL SURETY						
Acetophenone	UG/KG	ND	ND	ND	ND	ND
Hydroxyacetophenone	UG/KG	ND	ND	ND	ND	ND

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

TABLE 4-6
POSITIVE DETECTION SUMMARY
OPERABLE UNIT NO. 14 (SITE 69)
ONSITE SURFACE SOIL
MCB CAMP LEJEUNE, NORTH CAROLINA
REMEDIAL INVESTIGATION - CTO-0212
ORGANICS

Client Sample ID:		69-CSA-SB06-00	69-CSA-SB07-00	69-CSA-SB08-00	69-CSA-SB09-00	69-CSA-SB10-00
Laboratory Sample ID:		9401041-08A	9401041-09A	9401041-14A	9401041-10A	9401041-16A
Depth:		0-12"	0-12"	0-12"	0-12"	0-12"
Date Sampled:		01/07/94	01/07/94	01/07/94	01/07/94	01/07/94
Percent Solids:		92.8	92.9	91.3	91.3	94.2
	UNITS					
SEMIVOLATILES						
bis(2-Ethylhexyl)phthalate	UG/KG	ND	47.0 J	ND	ND	48.0 J
di-n-Butylphthalate	UG/KG	280.0 J	83.0 J	37.0 J	140.0 J	170.0 J
VOLATILES						
Methylene chloride	UG/KG	ND	ND	ND	ND	6.00 J
Acetone	UG/KG	180.0 J	170.0 J	ND	340.0 J	ND
1,2-Dichloroethene(total)	UG/KG	ND	ND	ND	ND	ND
2-Butanone	UG/KG	ND	ND	ND	ND	ND
1,1,1-Trichloroethane	UG/KG	ND	ND	ND	ND	ND
Trichloroethene	UG/KG	ND	ND	ND	ND	ND
4-Methyl-2-pentanone	UG/KG	ND	11.0 J	10.0 J	ND	ND
Tetrachloroethene	UG/KG	ND	ND	ND	ND	ND
Xylenes (total)	UG/KG	ND	ND	ND	ND	ND
PESTICIDE/PCBS						
beta-BHC	UG/KG	ND	ND	ND	ND	ND
4,4'-DDE	UG/KG	ND	ND	ND	ND	ND
Endosulfan II	UG/KG	ND	ND	ND	ND	ND
4,4'-DDT	UG/KG	ND	ND	ND	ND	ND
Aroclor 1260	UG/KG	ND	ND	ND	ND	ND
CHEMICAL SURETY						
Acetophenone	UG/KG	ND	ND	ND	ND	ND
Hydroxyacetophenone	UG/KG	ND	ND	120.0 J	ND	ND

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

TABLE 4-6
POSITIVE DETECTION SUMMARY
OPERABLE UNIT NO. 14 (SITE 69)
ONSITE SURFACE SOIL
MCB CAMP LEJEUNE, NORTH CAROLINA
REMEDIAL INVESTIGATION - CTO-0212
ORGANICS

Client Sample ID:		69-CSA-SB11-00	69-CSA-SB12-00	69-CSA-SB13-00	69-CSA-SB14-00	69-CSA-SB15-00
Laboratory Sample ID:		9401043-01A	9401041-17A	9401041-18A	9401043-02A	9401043-04A
Depth:		0-12"	0-12"	0-12"	0-12"	0-12"
Date Sampled:			01/07/94	01/07/94		
Percent Solids:		86.9	89.7	92.3	90.6	87.1
	UNITS					
SEMIVOLATILES						
bis(2-Ethylhexyl)phthalate	UG/KG	ND	ND	ND	ND	ND
di-n-Butylphthalate	UG/KG	55 J	240.0 J	230.0 J	200 J	140 J
VOLATILES						
Methylene chloride	UG/KG	6 J	12.0	5.00 J	7 J	10 J
Acetone	UG/KG	ND	ND	ND	ND	ND
1,2-Dichloroethene(total)	UG/KG	ND	ND	ND	ND	ND
2-Butanone	UG/KG	ND	ND	ND	ND	ND
1,1,1-Trichloroethane	UG/KG	ND	ND	ND	ND	ND
Trichloroethene	UG/KG	ND	ND	ND	ND	ND
4-Methyl-2-pentanone	UG/KG	ND	ND	ND	ND	1 J
Tetrachloroethene	UG/KG	ND	ND	ND	ND	ND
Xylenes (total)	UG/KG	ND	ND	ND	ND	ND
PESTICIDE/PCBS						
beta-BHC	UG/KG	ND	ND	ND	ND	ND
4,4'-DDE	UG/KG	ND	ND	ND	ND	ND
Endosulfan II	UG/KG	ND	ND	ND	ND	3.4 J
4,4'-DDT	UG/KG	ND	ND	ND	ND	ND
Aroclor 1260	UG/KG	ND	ND	ND	ND	ND
CHEMICAL SURETY						
Acetophenone	UG/KG	ND	ND	ND	ND	ND
Hydroxyacetophenone	UG/KG	ND	ND	ND	ND	ND

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

TABLE 4-6
POSITIVE DETECTION SUMMARY
OPERABLE UNIT NO. 14 (SITE 69)
ONSITE SURFACE SOIL
MCB CAMP LEJEUNE, NORTH CAROLINA
REMEDIAL INVESTIGATION - CTO-0212
ORGANICS

Client Sample ID:		69-CSA-SB16-00	69-CSA-SB17-00	69-CSA-SB18-00	69-CSA-SB19-00	69-CSA-SB20-00
Laboratory Sample ID:		9401041-20A	9401043-03A	9401025-01A	9401025-02A	9401036-01A
Depth:		0-12"	0-12"	0-12"	0-12"	0-12"
Date Sampled:		01/08/94				
Percent Solids:		91.4	90.3	90.9	59.7	88.7
	UNITS					
SEMIVOLATILES						
bis(2-Ethylhexyl)phthalate	UG/KG	ND	46 J	ND	ND	ND
di-n-Butylphthalate	UG/KG	160.0 J	140 J	86 J	130 J	120 J
VOLATILES						
Methylene chloride	UG/KG	8.00 J	6 J	ND	ND	ND
Acetone	UG/KG	ND	ND	ND	ND	ND
1,2-Dichloroethene(total)	UG/KG	ND	ND	ND	ND	4 J
2-Butanone	UG/KG	ND	ND	ND	ND	ND
1,1,1-Trichloroethane	UG/KG	ND	ND	2 J	ND	ND
Trichloroethene	UG/KG	ND	ND	ND	ND	ND
4-Methyl-2-pentanone	UG/KG	2.00 J	1 J	ND	ND	ND
Tetrachloroethene	UG/KG	ND	ND	ND	ND	ND
Xylenes (total)	UG/KG	ND	ND	ND	ND	ND
PESTICIDE/PCBS						
beta-BHC	UG/KG	ND	ND	ND	ND	ND
4,4'-DDE	UG/KG	ND	4.8 J	ND	ND	ND
Endosulfan II	UG/KG	ND	ND	ND	ND	ND
4,4'-DDT	UG/KG	ND	13.3 J	ND	ND	ND
Aroclor 1260	UG/KG	ND	ND	ND	94 J	ND
CHEMICAL SURETY						
Acetophenone	UG/KG	ND	51 J	ND	ND	ND
Hydroxyacetophenone	UG/KG	ND	160 J	ND	ND	ND

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

TABLE 4-6
POSITIVE DETECTION SUMMARY
OPERABLE UNIT NO. 14 (SITE 69)
ONSITE SURFACE SOIL
MCB CAMP LEJEUNE, NORTH CAROLINA
REMEDIAL INVESTIGATION - CTO-0212
ORGANICS

Client Sample ID:		69-CSA-SB21-00	69-CSA-SB22-00	69-CSA-SB23-00	69-CSA-SB24-00	69-CSA-SB25-00
Laboratory Sample ID:		9401036-02A	9401036-03A	9401036-04A	9401025-03A	9401043-05A
Depth:		0-12"	0-12"	0-12"	0-12"	0-12"
Date Sampled:						
Percent Solids:		88	91	91.8	93.6	91
	UNITS					
SEMIVOLATILES						
bis(2-Ethylhexyl)phthalate	UG/KG	ND	ND	ND	ND	ND
di-n-Butylphthalate	UG/KG	180 J	92 J	74 J	160 J	130 J
VOLATILES						
Methylene chloride	UG/KG	ND	97	105	ND	11
Acetone	UG/KG	ND	ND	ND	ND	ND
1,2-Dichloroethene(total)	UG/KG	ND	ND	ND	ND	ND
2-Butanone	UG/KG	ND	ND	ND	ND	ND
1,1,1-Trichloroethane	UG/KG	ND	ND	ND	ND	ND
Trichloroethene	UG/KG	3 J	ND	ND	ND	ND
4-Methyl-2-pentanone	UG/KG	ND	ND	ND	ND	ND
Tetrachloroethene	UG/KG	2 J	ND	ND	ND	ND
Xylenes (total)	UG/KG	ND	ND	5 J	ND	ND
PESTICIDE/PCBS						
beta-BHC	UG/KG	ND	ND	ND	ND	11 J
4,4'-DDE	UG/KG	ND	ND	ND	ND	ND
Endosulfan II	UG/KG	ND	ND	ND	ND	ND
4,4'-DDT	UG/KG	ND	ND	ND	ND	ND
Aroclor 1260	UG/KG	ND	ND	ND	ND	ND
CHEMICAL SURETY						
Acetophenone	UG/KG	ND	ND	ND	ND	ND
Hydroxyacetophenone	UG/KG	ND	ND	ND	ND	ND

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

TABLE 4-7
POSITIVE DETECTION SUMMARY
OPERABLE UNIT NO. 14 (SITE 69)
ONSITE SURFACE SOIL
MCB CAMP LEJEUNE, NORTH CAROLINA
REMEDIAL INVESTIGATION - CTO-0212
TAL INORGANICS

Client Sample ID:		69-CSA-SB01-00	69-CSA-SB02-00	69-CSA-SB03-00	69-CSA-SB04-00	69-CSA-SB05-00
Laboratory Sample ID:		9401041-03A	9401041-04A	9401041-05A	9401041-07A	9401041-13A
Depth:		0-12"	0-12"	0-12"	0-12"	0-12"
Date Sampled:		01/07/94	01/07/94	01/07/94	01/07/94	01/07/94
Percent Solids:		93.3	94.2	92.7	93.2	92.0
	UNITS					
Aluminum	MG/KG	967.0	1370.0	2270.0	1520.0	2310.0
Barium	MG/KG	3.50	4.10	4.30	3.00	4.40
Calcium	MG/KG	ND	ND	ND	ND	ND
Chromium	MG/KG	ND	ND	1.60	ND	2.20
Iron	MG/KG	465.0	803.0	1200.0	1040.0	1170.0
Lead	MG/KG	2.80 J	2.10 J	1.10 J	2.20 J	1.20 J
Magnesium	MG/KG	31.3	12.9	54.8	29.3	60.3
Manganese	MG/KG	15.5	8.20	4.80	2.40	4.90
Potassium	MG/KG	ND	ND	ND	ND	ND
Selenium	MG/KG	ND	ND	ND	ND	ND
Silver	MG/KG	ND	ND	ND	ND	ND
Vanadium	MG/KG	ND	ND	ND	ND	ND
Zinc	MG/KG	ND	ND	ND	ND	ND
Total Cyanide	MG/KG	ND	ND	ND	ND	ND

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

TABLE 4-7
POSITIVE DETECTION SUMMARY
OPERABLE UNIT NO. 14 (SITE 69)
ONSITE SURFACE SOIL
MCB CAMP LEJEUNE, NORTH CAROLINA
REMEDIAL INVESTIGATION - CTO-0212
TAL INORGANICS

Client Sample ID:		69-CSA-SB06-00	69-CSA-SB07-00	69-CSA-SB08-00	69-CSA-SB09-00	69-CSA-SB10-00
Laboratory Sample ID:		9401041-08A	9401041-09A	9401041-14A	9401041-10A	9401041-16A
Depth:		0-12"	0-12"	0-12"	0-12"	0-12"
Date Sampled:		01/07/94	01/07/94	01/07/94	01/07/94	01/07/94
Percent Solids:		92.8	92.9	91.3	91.3	94.2
	<u>UNITS</u>					
Aluminum	MG/KG	2600.0	3100.0	1330.0	2050.0	2180.0
Barium	MG/KG	4.10	4.30	ND	3.70	3.50
Calcium	MG/KG	ND	ND	ND	69.3	ND
Chromium	MG/KG	1.70	2.30	1.70	1.90	ND
Iron	MG/KG	1400.0	1410.0	622.0	1480.0	1230.0
Lead	MG/KG	2.10 J	3.00 J	2.30 J	2.70 J	1.70 J
Magnesium	MG/KG	63.4	40.1	22.7	41.3	44.6
Manganese	MG/KG	6.50	5.60	2.90	2.70	5.50
Potassium	MG/KG	66.1	ND	ND	ND	ND
Selenium	MG/KG	ND	ND	ND	ND	ND
Silver	MG/KG	0.090 J	ND	ND	ND	ND
Vanadium	MG/KG	ND	ND	ND	ND	ND
Zinc	MG/KG	ND	3.10	ND	ND	ND
Total Cyanide	MG/KG	ND	ND	ND	ND	ND

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

TABLE 4-7
POSITIVE DETECTION SUMMARY
OPERABLE UNIT NO. 14 (SITE 69)
ONSITE SURFACE SOIL
MCB CAMP LEJEUNE, NORTH CAROLINA
REMEDIAL INVESTIGATION - CTO-0212
TAL INORGANICS

Client Sample ID:		69-CSA-SB11-00	69-CSA-SB12-00	69-CSA-SB13-00	69-CSA-SB14-00	69-CSA-SB15-00
Laboratory Sample ID:		9401043-01A	9401041-17A	9401041-18A	9401043-02A	9401043-04A
Depth:		0-12"	0-12"	0-12"	0-12"	0-12"
Date Sampled:			01/07/94	01/07/94		
Percent Solids:		86.9	89.7	92.3	90.6	87.1
	UNITS					
Aluminum	MG/KG	1130	3370.0	3020.0	1350	800
Barium	MG/KG	4.3	3.10	3.80	ND	ND
Calcium	MG/KG	39.7	ND	ND	ND	ND
Chromium	MG/KG	ND	3.60	2.80	ND	ND
Iron	MG/KG	461	2360.0	1870.0	886	298
Lead	MG/KG	1.9	1.50 J	1.50 J	3.3	1.1
Magnesium	MG/KG	33.6	63.1	52.5	28.6	ND
Manganese	MG/KG	2.3	1.90	5.20	2	1.5
Potassium	MG/KG	ND	ND	66.4	ND	ND
Selenium	MG/KG	ND	ND	ND	ND	ND
Silver	MG/KG	0.34 J	ND	ND	ND	ND
Vanadium	MG/KG	ND	5.30	4.20	ND	ND
Zinc	MG/KG	3.1	ND	ND	2.7	2.8
Total Cyanide	MG/KG	2.3	ND	ND	2.2	2.3

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

TABLE 4-7
POSITIVE DETECTION SUMMARY
OPERABLE UNIT NO. 14 (SITE 69)
ONSITE SURFACE SOIL
MCB CAMP LEJEUNE, NORTH CAROLINA
REMEDIAL INVESTIGATION - CTO-0212
TAL INORGANICS

Client Sample ID:		69-CSA-SB16-00	69-CSA-SB17-00	69-CSA-SB18-00	69-CSA-SB19-00	69-CSA-SB20-00
Laboratory Sample ID:		9401041-20A	9401043-03A	9401025-01A	9401025-02A	9401036-01A
Depth:		0-12"	0-12"	0-12"	0-12"	0-12"
Date Sampled:		01/08/94				
Percent Solids:		91.4	90.3	90.9	59.7	88.7
	UNITS					
Aluminum	MG/KG	2630.0	2540	2700	1320	986
Barium	MG/KG	3.00	ND	4.6	5.1	ND
Calcium	MG/KG	ND	ND	39.2	101	56.2
Chromium	MG/KG	2.00	1.6 J	3.6	3	2.2
Iron	MG/KG	1340.0	1690	1730	1110	671
Lead	MG/KG	1.60 J	12.5	2.5	2.6 J	2.3 J
Magnesium	MG/KG	57.2	53.3	67.7	23.5	22.8
Manganese	MG/KG	4.70	1.6	1.7	2.8	1.3
Potassium	MG/KG	ND	ND	ND	ND	ND
Selenium	MG/KG	ND	ND	ND	ND	ND
Silver	MG/KG	ND	0.1 J	ND	ND	ND
Vanadium	MG/KG	ND	ND	3.9	ND	ND
Zinc	MG/KG	ND	3.9	2.2	66	2.2
Total Cyanide	MG/KG	ND	2.2	1.1	1.7	1.1

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

TABLE 4-7
POSITIVE DETECTION SUMMARY
OPERABLE UNIT NO. 14 (SITE 69)
ONSITE SURFACE SOIL
MCB CAMP LEJEUNE, NORTH CAROLINA
REMEDIAL INVESTIGATION - CTO-0212
TAL INORGANICS

Client Sample ID:		69-CSA-SB21-00	69-CSA-SB22-00	69-CSA-SB23-00	69-CSA-SB24-00	69-CSA-SB25-00
Laboratory Sample ID:		9401036-02A	9401036-03A	9401036-04A	9401025-03A	9401043-05A
Depth:		0-12"	0-12"	0-12"	0-12"	0-12"
Date Sampled:						
Percent Solids:		88	91	91.8	93.6	91
	UNITS					
Aluminum	MG/KG	775	498	368	451	2990
Barium	MG/KG	6.8	ND	ND	ND	3.3
Calcium	MG/KG	65.2	35.8	54.6	ND	ND
Chromium	MG/KG	1.8	2.1	1.7	2.9	3.1 J
Iron	MG/KG	478	483	235	294	1870
Lead	MG/KG	4.1	1.9 J	1.1	2.1	2
Magnesium	MG/KG	18.1	17.7	17.6	16.6	57.1
Manganese	MG/KG	ND	ND	ND	2.2	2.9
Potassium	MG/KG	ND	ND	ND	ND	ND
Selenium	MG/KG	1.1	ND	ND	ND	ND
Silver	MG/KG	ND	ND	ND	ND	10.2 J
Vanadium	MG/KG	ND	ND	ND	ND	ND
Zinc	MG/KG	ND	2.4	1.5	1.5	2.7
Total Cyanide	MG/KG	1.1	1.1	1.1	1.1	2.2

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

TABLE 4-8
POSITIVE DETECTION SUMMARY
OPERABLE UNIT NO. 14 (SITE 69)
ONSITE SUBSURFACE SOIL
MCB CAMP LEJEUNE, NORTH CAROLINA
REMEDIAL INVESTIGATION - CTO-0212
ORGANICS

Client Sample ID:		69-GW09-02	69-GW09-05	69-GW10-01	69-GW10-03	69-GW11-02	69-GW11-04
Laboratory Sample ID:		9401043-08A	9401043-09A	9401052-01A	9401052-02A	9401041-01A	9401041-02A
Depth:		2-4'	8-10'	0-2'	4.0-5.5'	2-4'	6-8'
Date Sampled:		01/08/94	01/08/94	01/09/94	01/09/94	01/07/94	01/07/94
Percent Solids:		84.5	76.4	94.2	83.2	73.3	85.3
	UNITS						
SEMIVOLATILES							
bis(2-Ethylhexyl)phthalate	UG/KG	ND	ND	ND	ND	53.0 J	ND
Diethylphthalate	UG/KG	ND	ND	ND	ND	ND	ND
di-n-Butylphthalate	UG/KG	88 J	120 J	ND	ND	58.0 J	53.0 J
VOLATILES							
Methylene chloride	UG/KG	11 J	6 J	ND	ND	58.0	52.0
Acetone	UG/KG	2200 J	ND	13.0 J	3200.0 J	4100.0 J	28000.0 J
1,2-Dichloroethene (total)	UG/KG	ND	ND	ND	ND	ND	ND
1,1,1-Trichloroethane	UG/KG	ND	ND	ND	ND	2.00 J	ND
1,1,2-Trichloroethane	UG/KG	ND	ND	ND	ND	ND	ND
Ethylbenzene	UG/KG	ND	ND	2.0 J	ND	ND	ND
PESTICIDES							
4,4'-DDE	UG/KG	ND	ND	1.20 J	ND	ND	ND
Endrin	UG/KG	ND	ND	ND	ND	ND	ND
4,4'-DDD	UG/KG	ND	ND	5.70 J	ND	ND	ND
4,4'-DDT	UG/KG	ND	ND	ND	ND	ND	ND
CHEMICAL SURETY MATERIALS							
Hydroxyacetophenone	UG/KG	ND	ND	ND	ND	ND	ND

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

TABLE 4-8
POSITIVE DETECTION SUMMARY
OPERABLE UNIT NO. 14 (SITE 69)
ONSITE SUBSURFACE SOIL
MCB CAMP LEJEUNE, NORTH CAROLINA
REMEDIAL INVESTIGATION - CTO-0212
ORGANICS

Client Sample ID:		69-GW12-01	69-GW02DW-01	69-GW02DW-03	69-GW12DW-01	69-GW15 IW-01
Laboratory Sample ID:		9401025-05A	9401052-03A	9401052-04A	9401054-01A	9503185-02
Depth:		0-2'	0-2'	4-6'	0-2'	1-3'
Date Sampled:		01/20/94	01/09/94	01/09/94	01/08/94	3/23/95
Percent Solids:		81.2	89.6	86.2	76.3	84.5
	UNITS					
SEMIVOLATILES						
bis(2-Ethylhexyl)phthalate	UG/KG	ND	ND	ND	ND	ND
Diethylphthalate	UG/KG	ND	ND	260.0 J	ND	ND
di-n-Butylphthalate	UG/KG	98 J	ND	ND	ND	ND
VOLATILES						
Methylene chloride	UG/KG	ND	15.0 J	11.0 J	8.00 J	ND
Acetone	UG/KG	45000	15000.0 J	ND	1000.0 J	ND
1,2-Dichloroethene (total)	UG/KG	ND	ND	ND	ND	ND
1,1,1-Trichloroethane	UG/KG	ND	ND	ND	ND	ND
1,1,2-Trichloroethane	UG/KG	ND	ND	ND	ND	ND
Ethylbenzene	UG/KG	ND	ND	ND	2.00 J	ND
PESTICIDES						
4,4'-DDE	UG/KG	ND	ND	ND	ND	ND
Endrin	UG/KG	ND	1.20 J	ND	ND	ND
4,4'-DDD	UG/KG	ND	ND	ND	ND	ND
4,4'-DDT	UG/KG	ND	1.60 J	ND	ND	ND
CHEMICAL SURETY MATERIALS						
Hydroxyacetophenone	UG/KG	ND	ND	ND	ND	45 J

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

TABL -8
POSITIVE DETECTION SUMMARY
OPERABLE UNIT NO. 14 (SITE 69)
ONSITE SUBSURFACE SOIL
MCB CAMP LEJEUNE, NORTH CAROLINA
REMEDIAL INVESTIGATION - CTO-0212
ORGANICS

Client Sample ID:		69-GW15-01	69-DA-HP01-03	69-DA-HP02-01	69-DA-HP03-02	69-DA-HP04-02
Laboratory Sample ID:		9503202-01	9503186-01	9503186-08	9503186-06	9503186-07
Depth:		1-3'	5-7'	2-4'	4-6'	3-5'
Date Sampled:		3/26/95	3/21/95	3/22/95	3/22/95	3/22/95
Percent Solids:		N/A	82	80.3	80.3	83.1
	<u>UNITS</u>					
<u>SEMIVOLATILES</u>						
bis(2-Ethylhexyl)phthalate	UG/KG	ND	ND	ND	ND	ND
Diethylphthalate	UG/KG	ND	ND	ND	ND	ND
di-n-Butylphthalate	UG/KG	ND	ND	ND	ND	ND
<u>VOLATILES</u>						
Methylene chloride	UG/KG	ND	ND	ND	ND	ND
Acetone	UG/KG	ND	ND	ND	ND	ND
1,2-Dichloroethene (total)	UG/KG	ND	2 J	ND	ND	ND
1,1,1-Trichloroethane	UG/KG	ND	ND	ND	ND	ND
1,1,2-Trichloroethane	UG/KG	ND	ND	ND	ND	ND
Ethylbenzene	UG/KG	ND	ND	ND	ND	ND
<u>PESTICIDES</u>						
4,4'-DDE	UG/KG	ND	ND	ND	ND	ND
Endrin	UG/KG	ND	ND	ND	ND	ND
4,4'-DDD	UG/KG	ND	ND	ND	ND	ND
4,4'-DDT	UG/KG	ND	ND	ND	ND	ND
<u>CHEMICAL SURETY MATERIALS</u>						
Hydroxyacetophenone	UG/KG	ND	ND	ND	ND	ND

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

TABLE 4-8
POSITIVE DETECTION SUMMARY
OPERABLE UNIT NO. 14 (SITE 69)
ONSITE SUBSURFACE SOIL
MCB CAMP LEJEUNE, NORTH CAROLINA
REMEDIAL INVESTIGATION - CTO-0212
ORGANICS

Client Sample ID:		69-DA-HP05-02	69-DA-HP06-01	69-DA-HP07-03	69-DA-HP08-03	69-DA-HP09-03
Laboratory Sample ID:		9503186-10	9503186-02	9503186-03	9503185-05	9503186-04
Depth:		3-5'	1-3'	6-8'	4-6'	5-7'
Date Sampled:		3/21/95	3/21/95	3/21/95	3/23/95	3/21/95
Percent Solids:		81.4	84.1	83.2	83.8	82
	UNITS					
SEMIVOLATILES						
bis(2-Ethylhexyl)phthalate	UG/KG	ND	ND	ND	ND	ND
Diethylphthalate	UG/KG	ND	ND	ND	ND	ND
di-n-Butylphthalate	UG/KG	ND	ND	ND	ND	ND
VOLATILES						
Methylene chloride	UG/KG	ND	ND	ND	ND	ND
Acetone	UG/KG	ND	ND	ND	ND	ND
1,2-Dichloroethene (total)	UG/KG	ND	ND	ND	ND	ND
1,1,1-Trichloroethane	UG/KG	ND	ND	ND	ND	ND
1,1,2-Trichloroethane	UG/KG	ND	ND	ND	ND	ND
Ethylbenzene	UG/KG	ND	ND	ND	ND	ND
PESTICIDES						
4,4'-DDE	UG/KG	ND	ND	ND	ND	ND
Endrin	UG/KG	ND	ND	ND	ND	ND
4,4'-DDD	UG/KG	ND	ND	ND	ND	ND
4,4'-DDT	UG/KG	ND	ND	ND	ND	ND
CHEMICAL SURETY MATERIALS						
Hydroxyacetophenone	UG/KG	ND	ND	ND	ND	ND

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

TABLE 4-9
POSITIVE DETECTION SUMMARY
OPERABLE UNIT NO. 14 (SITE 69)
ONSITE SUBSURFACE SOIL
MCB CAMP LEJEUNE, NORTH CAROLINA
REMEDIAL INVESTIGATION - CTO-0212
TAL INORGANICS

Client Sample ID:		69-GW09-02	69-GW09-05	69-GW10-01	69-GW10-03	69-GW11-02	69-GW11-04	69-GW12-01
Laboratory Sample ID:		9401043-08A	9401043-09A	9401052-01A	9401052-02A	9401041-01A	9401041-02A	9401025-05A
Depth:		2-4'	8-10'	0-2'	4.0-5.5'	2-4'	6-8'	0-2'
Date Sampled:				01/09/94	01/09/94	01/07/94	01/07/94	
Percent Solids:		84.5	76.4	94.2	83.2	73.3	85.3	81.2
	UNITS							
Aluminum	MG/KG	2460	9990	2380.0	6080.0	1980.0	4130.0	1020
Arsenic	MG/KG	ND	2.9	ND	1.15	ND	ND	ND
Barium	MG/KG	8.7	14.6	3.80	7.06	6.50	5.60	ND
Beryllium	MG/KG	ND	0.36	ND	ND	ND	ND	ND
Cadmium	MG/KG	ND	0.74	ND	ND	ND	ND	ND
Calcium	MG/KG	ND	688	29.2	59.7	73.3	72.6	ND
Chromium	MG/KG	3.6 J	17.7	ND	7.00	3.30	6.80	2.8
Copper	MG/KG	ND	5.1	ND	ND	ND	ND	ND
Iron	MG/KG	754	19900	1450.0	3880.0	1030.0	905.0	621
Lead	MG/KG	3	6	1.78	4.28	3.20 J	4.30 J	3.2
Magnesium	MG/KG	88.6	574	63.0	150.0	94.6	139.0	26.9
Manganese	MG/KG	3.3	39	20.7	3.33	5.60	4.00	1.6
Mercury	MG/KG	0.04	ND	ND	0.070	ND	ND	ND
Nickel	MG/KG	3.9	3.9	ND	ND	ND	ND	3.4
Potassium	MG/KG	ND	516 J	ND	ND	149.0	185.0	ND
Silver	MG/KG	0.43 J	ND	ND	ND	ND	ND	ND
Sodium	MG/KG	ND	130	ND	ND	ND	ND	ND
Vanadium	MG/KG	ND	22.6	ND	11.8	ND	4.40	ND
Zinc	MG/KG	3.4	13.7	ND	ND	ND	ND	3.5
Total Cyanide	MG/KG	2.4	2.6	ND	ND	ND	ND	1.2

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

TABLE 4-9
POSITIVE DETECTION SUMMARY
OPERABLE UNIT NO. 14 (SITE 69)
ONSITE SUBSURFACE SOIL
MCB CAMP LEJEUNE, NORTH CAROLINA
REMEDIAL INVESTIGATION - CTO-0212
TAL INORGANICS

Client Sample ID:		69-GW02DW-01	69-GW02DW-03	69-GW12DW-01
Laboratory Sample ID:		9401052-03A	9401052-04A	9401054-01A
Depth:		0-2'	4-6'	0-2'
Date Sampled:		01/09/94	01/09/94	01/08/94
Percent Solids:		89.6	86.2	76.3
	UNITS			
Aluminum	MG/KG	1610.0	2610.0	832.0
Arsenic	MG/KG	ND	ND	ND
Barium	MG/KG	6.80	ND	ND
Beryllium	MG/KG	ND	ND	ND
Cadmium	MG/KG	ND	ND	ND
Calcium	MG/KG	170.0	37.5	33.6
Chromium	MG/KG	1.76	4.50	ND
Copper	MG/KG	ND	ND	ND
Iron	MG/KG	1100.0	3370.0	354.0
Lead	MG/KG	4.63	2.40	3.50
Magnesium	MG/KG	52.8	100.0	29.7
Manganese	MG/KG	2.52	1.67	1.93
Mercury	MG/KG	ND	ND	ND
Nickel	MG/KG	ND	ND	ND
Potassium	MG/KG	ND	ND	ND
Silver	MG/KG	ND	ND	ND
Sodium	MG/KG	ND	ND	ND
Vanadium	MG/KG	ND	11.8	ND
Zinc	MG/KG	ND	ND	ND
Total Cyanide	MG/KG	ND	ND	ND

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

TABLE 4-10
POSITIVE DETECTION SUMMARY
OPERABLE UNIT NO. 14 (SITE 69)
ROUND ONE GROUNDWATER
MCB CAMP LEJEUNE, NORTH CAROLINA
REMEDIAL INVESTIGATION - CTO-0212
ORGANICS

Client Sample ID:		69-GW02-01	69-GW03-01	69-GW03-02	69-GW04-01	69-GW10-01	69-GW12-01
Laboratory Sample ID:		9401128-01A	9401130-06A	AB7976	9401128-03A	9401117-04A	9401117-01A
Date Sampled:		1/22/94	1/22/94	08/25/94	1/22/94	1/20/94	1/20/94
	UNITS						
SEMIVOLATILES							
1,4-Dichlorobenzene	UG/L	ND	2.00 J	NA	ND	ND	ND
di-n-Butylphthalate	UG/L	ND	ND	NA	ND	ND	ND
VOLATILES							
Vinyl chloride	UG/L	31.0 J	ND	NA	ND	ND	ND
Acetone	UG/L	ND	ND	NA	ND	ND	470.0 R
Carbon Disulfide	UG/L	ND	ND	NA	ND	1.00 J	ND
1,1-Dichloroethene	UG/L	ND	1.00 J	NA	ND	ND	ND
1,2-Dichloroethene(total)	UG/L	2400.0	630.0	NA	32.0 J	ND	2.00 J
Trichloroethene	UG/L	23.0 J	1.00 J	NA	ND	ND	ND
Benzene	UG/L	ND	1.00 J	NA	ND	ND	ND
Tetrachloroethene	UG/L	1.00 J	ND	NA	ND	ND	ND
1,1,2,2-Tetrachloroethane	UG/L	22.0 J	ND	NA	2.00 J	ND	1.00 J
Toluene	UG/L	1.00 J	4.00 J	NA	ND	ND	ND
Chlorobenzene	UG/L	ND	25.0 J	NA	ND	ND	ND
PESTICIDE/PCBS							
alpha-BHC	UG/L	ND	NA	0.056	ND	ND	ND
beta-BHC	UG/L	ND	NA	2.3	ND	ND	ND
delta-BHC	UG/L	ND	NA	ND	ND	ND	ND
Lindane (gamma-BHC)	UG/L	ND	NA	ND	ND	ND	ND
Heptachlor	UG/L	ND	NA	ND	ND	ND	ND

UG/L - microgram per liter
J - value is estimated
NA - not available
ND - not detected
R - rejected

TABLE 4-10
POSITIVE DETECTION SUMMARY
OPERABLE UNIT NO. 14 (SITE 69)
ROUND ONE GROUNDWATER
MCB CAMP LEJEUNE, NORTH CAROLINA
REMEDIAL INVESTIGATION - CTO-0212
ORGANICS

Client Sample ID:		69-GW02-DW-01	69-GW03I-01	69-GW13-01	69-GW13I-01
Laboratory Sample ID:		9402153-01	9406061-05	9406061-03	9406061-01
Date Sampled:			6/6/94	6/6/94	6/6/94
	UNITS				
SEMIVOLATILES					
1,4-Dichlorobenzene	UG/L	ND	ND	ND	ND
di-n-Butylphthalate	UG/L	ND	ND	4 J	ND
VOLATILES					
Vinyl chloride	UG/L	8.37 J	ND	ND	ND
Acetone	UG/L	180	ND	7 J	4 J
Carbon Disulfide	UG/L	ND	ND	5 J	ND
1,1-Dichloroethene	UG/L	ND	ND	ND	ND
1,2-Dichloroethene(total)	UG/L	788	24	ND	9 J
Trichloroethene	UG/L	29.4	ND	ND	ND
Benzene	UG/L	ND	ND	ND	ND
Tetrachloroethene	UG/L	ND	ND	ND	ND
1,1,2,2-Tetrachloroethane	UG/L	ND	ND	ND	ND
Toluene	UG/L	ND	ND	ND	ND
Chlorobenzene	UG/L	ND	ND	ND	ND
PESTICIDE/PCBS					
alpha-BHC	UG/L	ND	ND	ND	ND
beta-BHC	UG/L	ND	ND	ND	0.1 J
delta-BHC	UG/L	ND	ND	ND	ND
Lindane (gamma-BHC)	UG/L	ND	ND	0.07 J	ND
Heptachlor	UG/L	ND	ND	0.068 J	ND

UG/L - microgram per liter
J - value is estimated
NA - not available
ND - not detected
R - rejected

TABLE 4-11
POSITIVE DETECTION SUMMARY
OPERABLE UNIT NO. 14 (SITE 69)
ROUND ONE GROUNDWATER
MCB CAMP LEJEUNE, NORTH CAROLINA
REMEDIAL INVESTIGATION - CTO-0212
TAL TOTAL METALS

Client Sample ID:		69-GW01-02	69-GW02-01	69-GW03-02	69-GW04-01	69-GW05-01	69-GW06-01	69-GW07-01
Laboratory Sample ID:		AB8051	9401128-01A	AB7977	9401128-03A	9401118-03A	9401118-02A	9401130-05A
Date Sampled:		08/26/94	1/22/94	08/25/94	1/22/94	1/21/94	1/21/94	1/22/94
	UNITS							
Aluminum	UG/L	3640	17500.0 J	304	45000.0 J	8100.0	10500.0	7380.0 J
Antimony	UG/L	ND	ND	ND	ND	7.90 R	8.59 J	ND
Arsenic	UG/L	ND	ND	ND	ND	5.00	10.8	ND
Barium	UG/L	60	50.1	29.6	73.9	89.6	68.7	46.5
Beryllium	UG/L	ND	ND	ND	ND	ND	2.12	ND
Cadmium	UG/L	ND	ND	ND	ND	3.12	ND	ND
Calcium	UG/L	5360	8690.0 J	5320	2430.0 J	4140.0	3380.0	4310.0 J
Chromium	UG/L	ND	35.0	ND	51.5	15.1	29.0	15.8
Cobalt	UG/L	ND	ND	ND	ND	ND	ND	ND
Copper	UG/L	ND	ND	ND	ND	ND	ND	ND
Iron	UG/L	1610	71900.0 J	10100	99500.0 J	40600.0	34200.0	19200.0 J
Lead	UG/L	4.4	12.3	ND	20.2	9.35 J	40.5	7.80
Magnesium	UG/L	2570	1930.0	371	1460.0	2600.0	2930.0	2140.0
Manganese	UG/L	41.3	102.0	92.6	151.0	148.0	66.3	13.0
Mercury	UG/L	ND	ND	ND	0.173	0.068	0.128	ND
Nickel	UG/L	ND	ND	ND	ND	ND	ND	ND
Potassium	UG/L	ND	1510.00 J	ND	1700.00 J	1860.0	1640.0	1410.00 J
Selenium	UG/L	ND	ND	ND	ND	ND	ND	ND
Sodium	UG/L	13000	14100.0	6510	9750.00	7140.0	8270.0	5570.00
Vanadium	UG/L	ND	175.0	ND	79.5	32.5	34.0	17.2
Zinc	UG/L	234	71.3 J	1990	9120.0 J	ND	56.3	ND

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

TABLE 4-11
POSITIVE DETECTION SUMMARY
OPERABLE UNIT NO. 14 (SITE 69)
ROUND ONE GROUNDWATER
MCB CAMP LEJEUNE, NORTH CAROLINA
REMEDIAL INVESTIGATION - CTO-0212
TAL TOTAL METALS

Client Sample ID:		69-GW08-01	69-GW09-01	69-GW10-01	69-GW11-01	69-GW12-01	69-GW02-DW-01	69-GW12DW-01
Laboratory Sample ID:		9401118-01A	9401117-03A	9401117-04A	9401117-02A	9401117-01A	9402153-01	9402150-01
Date Sampled:		1/21/94	1/20/94	1/20/94	1/20/94	1/20/94	2/17/94	2/18/94
	UNITS							
Aluminum	UG/L	48000.0	18400.0	21500.0	11800.0	211000.0	3030	4680 J
Antimony	UG/L	7.90 R	7.90 R	7.90 R	7.90 R	7.90 R	ND	ND
Arsenic	UG/L	7.06	3.20	19.9	2.94 J	ND	ND	3.54 J
Barium	UG/L	601.0	182.0	134.0	58.0	850.0	42.3	58
Beryllium	UG/L	4.30	2.42	2.10	ND	10.6	ND	0.89
Cadmium	UG/L	3.89	ND	ND	ND	11.4	ND	ND
Calcium	UG/L	38700.0	8720.0	5970.0	2010.0	23400.0	59300	180000
Chromium	UG/L	76.2	29.4	44.2	17.8	159.0	ND	20.7
Cobalt	UG/L	ND	ND	ND	ND	25.9	ND	ND
Copper	UG/L	21.1	ND	16.5	ND	70.8	ND	ND
Iron	UG/L	56400.0	48300.0	31600.0	6360.0	51700.0	5820	10900
Lead	UG/L	77.3	9.79 J	37.8	8.90 J	188.0	3.1	ND
Magnesium	UG/L	8080.0	3640.0	3060.0	2190.0	13200.0	2590	4890
Manganese	UG/L	912.0	204.0	265.0	43.1	476.0	53.7	114
Mercury	UG/L	0.419	ND	0.215	ND	0.936	0.174	ND
Nickel	UG/L	24.2	16.7	26.2	ND	99.8	ND	ND
Potassium	UG/L	4000.0	2320.0	2880.0	1640.0	7610.0	1850	1660
Selenium	UG/L	ND	3.81 J	ND	5.13 J	5.28 J	ND	ND
Sodium	UG/L	4790.0	9210.0	4890.0	7240.0	4130.0	33000	10900
Vanadium	UG/L	103.0	39.6	60.8	24.9	210.0	ND	ND
Zinc	UG/L	136.0	84.6	133.0	52.1	689.0	31.1	ND

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

TABLE 4-11
POSITIVE DETECTION SUMMARY
OPERABLE UNIT NO. 14 (SITE 69)
ROUND ONE GROUNDWATER
MCB CAMP LEJEUNE, NORTH CAROLINA
REMEDIAL INVESTIGATION - CTO-0212
TAL TOTAL METALS

Client Sample ID:		69-GW02DD-01	69-GW03I-01	69-GW13-01	69-GW13I-01
Laboratory Sample ID:		9406061-09	9406061-05	9406061-03	9406061-01
Date Sampled:		6/6/94	6/6/94	6/6/94	6/6/94
	UNITS				
Aluminum	UG/L	169.0	1100.0	3330.0	1690.0
Antimony	UG/L	ND	ND	ND	ND
Arsenic	UG/L	ND	2.80	7.84	3.15
Barium	UG/L	ND	26.6	130.0	22.6
Beryllium	UG/L	ND	ND	0.945	ND
Cadmium	UG/L	ND	ND	ND	ND
Calcium	UG/L	49200.0	49000.0	12600.0	76900.0
Chromium	UG/L	ND	ND	ND	9.95
Cobalt	UG/L	ND	ND	17.3	ND
Copper	UG/L	ND	ND	ND	ND
Iron	UG/L	124.0 J	1850.0	15000.0	3330.0
Lead	UG/L	ND	ND	ND	ND
Magnesium	UG/L	1000.0	2420.0	5520.0	1610.0
Manganese	UG/L	5.59	25.5	165.0	26.8
Mercury	UG/L	ND	ND	ND	ND
Nickel	UG/L	ND	ND	33.5	ND
Potassium	UG/L	3400.0	1530.0	2780.0	1740.0
Selenium	UG/L	ND	ND	ND	ND
Sodium	UG/L	30700.0	18200.0	19400.0	15400.0
Vanadium	UG/L	ND	ND	ND	12.8
Zinc	UG/L	ND	ND	566.0	1780.0

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

TABLE 4-12
POSITIVE DETECTION SUMMARY
OPERABLE UNIT NO. 14 (SITE 69)
ROUND ONE GROUNDWATER
MCB CAMP LEJEUNE, NORTH CAROLINA
REMEDIAL INVESTIGATION - CTO-0212
TAL DISSOLVED METALS

Client Sample ID:		69-GW01D-02	69-GW02-01	69-GW03D-02	69-GW04-01	69-GW05-01	69-GW06-01	69-GW07-01
Laboratory Sample ID:		AB8059	9401129-01A	AB7988	9401129-03A	9401120-03A	9401120-02A	9401131-01A
Date Sampled:		08/26/94	1/22/94	08/25/94	1/22/94	1/21/94	1/21/94	1/22/94
	UNITS							
Aluminum	UG/L	564	1070.0 J	180	970.0 J	ND	181.0	ND
Antimony	UG/L	ND	9.40 J	ND	ND	8.59 J	7.90 R	ND
Arsenic	UG/L	ND	ND	ND	ND	ND	ND	ND
Barium	UG/L	63.8	22.5	34	28.3	33.9	14.4	19.2
Beryllium	UG/L	ND	ND	ND	ND	ND	ND	ND
Calcium	UG/L	6600	9570.0 J	7190	2610.0 J	3680.0	2360.0	4220.0 J
Cobalt	UG/L	ND	ND	ND	ND	ND	ND	ND
Copper	UG/L	19.1	ND	16.3	ND	ND	ND	ND
Iron	UG/L	146	2920.0 J	13400	80.2 J	ND	708.0	ND
Lead	UG/L	ND	ND	ND	ND	ND	ND	ND
Magnesium	UG/L	3050	1180.0	511	826.0	1350.0	1750.0	1940.0
Manganese	UG/L	49.3	83.6	124	139.0	52.3	31.6	8.45
Mercury	UG/L	0.25	ND	ND	ND	ND	ND	ND
Nickel	UG/L	ND	ND	ND	ND	ND	ND	ND
Potassium	UG/L	1480	397.000 J	ND	397.000 J	ND	852.0	1120.00 J
Selenium	UG/L	ND	ND	ND	ND	ND	3.95 J	ND
Sodium	UG/L	16100	15000.0	8210	10800.0	8080.0	9310.0	6080.00
Vanadium	UG/L	ND	ND	ND	ND	ND	ND	ND
Zinc	UG/L	27	ND	2490	7670.0 J	ND	ND	ND

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

TABLE 4-12
POSITIVE DETECTION SUMMARY
OPERABLE UNIT NO. 14 (SITE 69)
ROUND ONE GROUNDWATER
MCB CAMP LEJEUNE, NORTH CAROLINA
REMEDIAL INVESTIGATION - CTO-0212
TAL DISSOLVED METALS

Client Sample ID:		69-GW08-01	69-GW09-01	69-GW10-01	69-GW11-01	69-GW12-01	69-GW02DWD-01	69-GW12DWD-01
Laboratory Sample ID:		9401120-01A	9401119-03A	9401119-04A	9401119-02A	9401119-01A	9402153-03	9402150-02
Date Sampled:		1/21/94	1/20/94	1/20/94	1/20/94	1/20/94	34382	34383
	UNITS							
Aluminum	UG/L	ND	ND	ND	352.0	1690.0	ND	ND
Antimony	UG/L	12.5 J	8.59 J	18.0 J	10.2 J	8.59 J	ND	ND
Arsenic	UG/L	ND	ND	ND	ND	ND	ND	ND
Barium	UG/L	ND	14.4	21.7	34.0	ND	19.8	23.3
Beryllium	UG/L	ND	ND	ND	ND	ND	ND	ND
Calcium	UG/L	5100.0	5670.0	3700.0	2120.0	764.0	37600	63600
Cobalt	UG/L	ND	ND	ND	ND	ND	ND	ND
Copper	UG/L	ND	ND	ND	ND	ND	ND	ND
Iron	UG/L	ND	54.3	77.6	56.5	345.0	ND	ND
Lead	UG/L	ND	ND	ND	ND	1.08 J	ND	ND
Magnesium	UG/L	634.0	1740.0	1180.0	1890.0	368.0	2130	2880
Manganese	UG/L	14.1	67.6	27.9	18.6	13.0	11.5	60.1
Mercury	UG/L	ND	ND	ND	ND	ND	ND	ND
Nickel	UG/L	ND	ND	ND	ND	ND	ND	ND
Potassium	UG/L	ND	852.0	627.0	514.0	1300.0	1670	1660
Selenium	UG/L	3.22 J	2.77 J	3.95 J	5.58 J	ND	ND	ND
Sodium	UG/L	5170.0	1030.0	5640.0	7990.0	4110.0	34700	13700
Vanadium	UG/L	ND	ND	ND	ND	ND	ND	ND
Zinc	UG/L	ND	ND	ND	ND	ND	ND	ND

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

TABLE 4-12
POSITIVE DETECTION SUMMARY
OPERABLE UNIT NO. 14 (SITE 69)
ROUND ONE GROUNDWATER
MCB CAMP LEJEUNE, NORTH CAROLINA
REMEDIAL INVESTIGATION - CTO-0212
TAL DISSOLVED METALS

Client Sample ID:		69-GW02DDD-01	69-GW03ID-01	69-GW13D-01	69-GW13ID-01
Laboratory Sample ID:		9406061-10	9406061-06	9406061-04	9406061-02
Date Sampled:		6/6/94	6/6/94	6/6/94	6/6/94
	UNITS				
Aluminum	UG/L	ND	ND	2170.0	ND
Antimony	UG/L	ND	ND	ND	ND
Arsenic	UG/L	ND	ND	3.09	3.44
Barium	UG/L	ND	20.1	141.0	ND
Beryllium	UG/L	ND	ND	0.899	ND
Calcium	UG/L	35700.0	45700.0	13900.0	65800.0
Cobalt	UG/L	ND	ND	22.6	ND
Copper	UG/L	ND	ND	ND	ND
Iron	UG/L	ND	40.7 J	14700.0	ND
Lead	UG/L	ND	ND	ND	ND
Magnesium	UG/L	1120.0	2400.0	6200.0	1380.0
Manganese	UG/L	ND	13.4	181.0	ND
Mercury	UG/L	ND	ND	ND	ND
Nickel	UG/L	ND	ND	25.6	ND
Potassium	UG/L	3540.0	2240.0	3540.0	2420.0
Selenium	UG/L	ND	ND	ND	ND
Sodium	UG/L	37000.0	22200.0	24800.0	19600.0
Vanadium	UG/L	11.6	ND	ND	ND
Zinc	UG/L	ND	ND	ND	ND

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

TABLE 4-13

SUMMARY OF ROUND ONE GROUNDWATER FIELD PARAMETERS
SITE 69
REMEDIAL INVESTIGATION CTO-0212
MCB CAMP LEJEUNE, NORTH CAROLINA

Well No.	Depth of Well (feet)(1)	Purge Volume (gallons)	Field Parameters			
Date of Measurement			Well Volume	Specific Conductance at 25 deg. C (micromhos/cm)	Temperature (deg. C)	pH (S.U.)
69GW01	23.22	8	1	212	15.8	4.04
01/22/94			2	211	16	3.88
			3	213	15	3.85
69GW02	22.60	6	1	230	17	3.79
01/22/94			2	234	17	3.80
			*Well bailed dry. Slow recharge.			
69GW03	22.53	9	1	169	16	4.66
01/22/94			2	169	16	4.79
			3	175	16	4.94
69GW04	22.36	8	1	140	13.9	3.92
01/22/94			2	137	13.9	3.71
			3	139	14.2	3.70
69GW05	23.18	2.5	1	731	14.2	5.91
01/22/94			*Well bailed dry. Slow recharge.			
69GW06	33.20	7				
01/22/94						
69GW07	22.92	5	1	70	14	4.86
01/22/94			2	73	15.5	4.72
			3	67	15.5	4.85
69GW08	22.54	12				
01/21/94						
69GW09	23.44	10	1	113	14.5	5.87
01/21/94			2	112	14.9	7.29
			3	111	15	5.56
			4	114	15	5.45
69GW10	18.62	6	1	91	13	5.78
01/21/94			2	62	19	5.35
			3	68	15	5.31

TABLE 4-13 (Continued)

SUMMARY OF ROUND ONE GROUNDWATER FIELD PARAMETERS
SITE 69
REMEDIAL INVESTIGATION CTO-0212
MCB CAMP LEJEUNE, NORTH CAROLINA

Well No.	Depth of Well (feet)$^{(1)}$	Purge Volume (gallons)	Field Parameters			
Date of Measurement			Well Volume	Specific Conductance at 25 deg. C (micromhos/cm)	Temperature (deg. C)	pH (S.U.)
69GW11	21.74	10	1	97	13	6.58
01/20/94			2	104	13	5.47
			3	102	13.5	5.05
			4	109	13.5	5.06
69GW12	15.94	2	1	300	11	6.33
			*Bailed dry. After recharge well was sampled.			
69GW02DW	50.64	11	1	392	18	9.34
02/17/94			2	375	18	8.93
			3	362	17.5	8.76
69GW12DW	59.3	27	1	287	15.5	7.42
02/18/94			2	329	16	7.59
			3	348	16	7.60
69GW02DD	127.06	17	1	319	21.5	9.94
			1.5	310	22	10.05
06/06/94			2	302	22	9.74
			2.5	311	21	9.50
			3	330	21	9.29
69-GW03DW	60.17	5.5	1	249	20	7.91
6/6/94			1.5	259	19	8.11
			2	262	20	8.13
			2.5	270	20	8.10
			3	272	20.5	8.07
69-GW13	12.28	1.5	1	199	19.5	4.40
6/6/94			2	245	19.5	4.42
			3	297	19	4.40
			4	323	19	4.36
			5	330	19	4.41

TABLE 4-13 (Continued)

SUMMARY OF ROUND ONE GROUNDWATER FIELD PARAMETERS
SITE 69
REMEDIAL INVESTIGATION CTO-0212
MCB CAMP LEJEUNE, NORTH CAROLINA

Well No. Date of Measurement	Depth of Well (feet)[1]	Purge Volume (gallons)	Field Parameters			
			Well Volume	Specific Conductance at 25 deg. C (micromhos/cm)	Temperature (deg. C)	pH (S.U.)
69-GW13DW	60.59	5	1	281	19	9.88
6/694			1.5	286	19.5	9.60
			2	290	19.5	9.49
			2.5	305	20	9.33
			3	309	19	9.24

Notes: (1) Well depth taken from top of PVC riser.

TABLE 4-14
POSITIVE DETECTION SUMMARY
OPERABLE UNIT No. 14 (SITE 69)
ROUND TWO GROUNDWATER
MCB CAMP LEJEUNE, NORTH CAROLINA
REMEDIAL INVESTIGATION - CTO-0212
TCL ORGANICS

Client Sample ID:		69GW1	60GW02	69GW02DD	69GW02DW	69GW02A	69GW3	69GW03DW	69GW4	69GW5
Laboratory Sample ID:										
Date Sampled:		2/26/95	2/24/95	2/24/95	2/24/95	2/24/95	2/25/95	2/25/95	2/25/95	2/25/95
	UNITS									
PURGEABLE HALOCARBONS 601										
Chloroform	ug/L	ND	ND	ND	ND	ND	ND	ND	6	ND
trans-1,2-Dichloroethene	ug/L	ND	230	ND	8	120	ND	ND	ND	ND
Trichloroethene	ug/L	ND	10	ND	ND	5	8	ND	ND	ND
Vinyl Chloride	ug/L	ND	5	ND	ND	ND	ND	ND	ND	ND

UG/L - microgram per liter
ND - not detected

TABLE 4-14
POSITIVE DETECTION SUMMARY
OPERABLE UNIT No. 14 (SITE 69)
ROUND TWO GROUNDWATER
MCB CAMP LEJEUNE, NORTH CAROLINA
REMEDIAL INVESTIGATION - CTO-0212
TCL ORGANICS

Client Sample ID:		69GW6	69GW7	69GW8	69GW09	69GW10	69GW11	69GW12	69GW12DW	69GW13
Laboratory Sample ID:										
Date Sampled:		2/26/95	2/26/95	2/26/95	2/21/95	2/23/95	2/22/95	2/22/95	2/23/95	2/21/95
	UNITS									
PURGEABLE HALOCARBONS 601										
Chloroform	ug/L	ND	ND	ND	ND	ND	ND	ND	ND	ND
trans-1,2-Dichloroethene	ug/L	ND	ND	ND	ND	ND	ND	ND	ND	ND
Trichloroethene	ug/L	ND	ND	ND	ND	ND	ND	ND	ND	ND
Vinyl Chloride	ug/L	ND	ND	ND	ND	ND	ND	ND	ND	ND

UG/L - microgram per liter
ND - not detected

TABLE 4-14
POSITIVE DETECTION SUMMARY
OPERABLE UNIT No. 14 (SITE 69)
ROUND TWO GROUNDWATER
MCB CAMP LEJEUNE, NORTH CAROLINA
REMEDIAL INVESTIGATION - CTO-0212
TCL ORGANICS

Client Sample ID:		69GW13DW	69GW14	69GW14DW	69GW14IW	69GW14IWA
Laboratory Sample ID:						
Date Sampled:		2/22/95	2/24/95	2/23/95	2/23/95	2/23/95
	UNITS					
PURGEABLE HALOCARBONS 601						
Chloroform	ug/L	ND	ND	ND	ND	ND
trans-1,2-Dichloroethene	ug/L	ND	ND	ND	ND	ND
Trichloroethene	ug/L	ND	ND	ND	ND	ND
Vinyl Chloride	ug/L	ND	ND	ND	ND	ND

UG/L - microgram per liter
ND - not detected

TABLE 4-15

SUMMARY OF ROUND TWO GROUNDWATER FIELD PARAMETERS
OPERABLE UNIT NO. 14 (SITE 69)
REMEDIAL INVESTIGATION CTO-0212
MCB CAMP LEJEUNE, NORTH CAROLINA

Well No.	Depth of Well (feet)$^{(1)}$	Purge Volume (gallons)	Field Parameters					
Date of Measurement			Well Volume	Specific Conductance at 25 deg. C (micromhos/cm)	Temperature (deg. C)	pH (S.U.)	Temperature (deg. C)	Turbidity (NTU)
69-GW01	23.12	3.1	1	122	22	5.79	17.1	198
2/26/95			1.9	125	21	5.57	16.4	>200
			2.9	122	20	5.64	15.2	>200
			3.9	125	21	5.66	16.2	>200
69-GW02	22.61	3	1	139	16	5.46	11.4	145
2/24/95			2	144	17	5.25	13.4	21
			3	146	17.5	5.18	13.8	114
			4	151	17.5	5.13	13.4	19.6
			5	152	17.5	5.13	14.1	10.8
			5.3	-	-	-	--	2.9
69-GW03	22.28	2.8	1.1	205	16.5	6.43	10.8	43.6
2/25/95			2.1	195	21	5.67	15.9	>200
			3.2	195	19.5	5.57	14.4	52
			4.3	193	19	5.56	13.8	8
			5.4	192	19	5.56	13.9	2.4
69-GW04	22.03	2.6	1.2	165	16.5	5.93	12.2	8.6
2/25/95			2.3	165	18	5.60	13	4.5
			3.5	155	16.5	5.39	12	6.2
			4.6	147	16	5.36	12.7	1.2
69-GW05	23.13	2.2	1.1	66	16	6.65	12	>200
2/25/95			2.3	62	19	5.85	15	54
			2.7	61	18	5.76	14.2	66
			NA	-	--	-	-	25
			NA	-	-	-	-	63
69-GW06	33.20	2.6	1.2	73	20.5	5.77	15.5	0.9
2/26/95			2.3	73	21	5.64	16.9	0.8
			3.5	74	21	5.62	17.2	0.5

TABLE 4-15 (Continued)

SUMMARY OF ROUND TWO GROUNDWATER FIELD PARAMETERS
OPERABLE UNIT NO. 14 (SITE 69)
REMEDIAL INVESTIGATION CTO-0212
MCB CAMP LEJEUNE, NORTH CAROLINA

Well No.			Field Parameters					
Date of Measurement	Depth of Well (feet)$^{(1)}$	Purge Volume (gallons)	Well Volume	Specific Conductance at 25 deg. C (micromhos/cm)	Temperature (deg. C)	pH (S.U.)	Temperature (deg. C)	Turbidity (NTU)
69-GW07	22.83	2.2	1	72	12.5	5.91	8.2	20.2
2/26/95			2	61	17	5.82	11.7	7.4
			3	66	20.5	5.99	15.5	138
			4	66	24	5.81	19.3	110
			5	67	23.5	5.84	19.3	44
			6	70	21	5.93	19.4	16.1
			6.4	-	-	-	-	15
			6.8	-	-	-	-	7.8
			7	-	-	-	-	6.8
			7.3	-	-	-	-	5.2
			7.5	-	-	-	-	4.9
69-GW08	22.03	2.3	1.1	35	17.5	6.38	13.0	9.0
2/26/95			2.2	56	18.5	6.26	14.9	10.6
			3.3	34	19	6.0	15.3	8.5
			4.3	34	19	6.09	15.5	10
			4.8	-	-	-	-	28
			5	-	-	-	-	39
			5.2	-	-	-	-	35
			5.4	-	-	-	-	21
69-GW09	23.3	2.6	1.2	117	15	5.55	25	42.8
2/21/95			2.3	120	18.5	5.49	NA	56.0
			3.5	112	17	5.49	NA	33.8
			4.6	110	17	5.52	NA	20.5
			5.8	109	17	5.51	NA	15.1
			6.9	106	17	5.50	16.8	13.1
			8.1	106	17	5.47	14.7	12.3
			8.5	-	-	-	-	12.1
			8.8	-	-	-	-	11.5
			9.2	-	-	-	-	11.2

TABLE 4-15 (Continued)

SUMMARY OF ROUND TWO GROUNDWATER FIELD PARAMETERS
OPERABLE UNIT NO. 14 (SITE 69)
REMEDIAL INVESTIGATION CTO-0212
MCB CAMP LEJEUNE, NORTH CAROLINA

Well No.			Field Parameters					
Date of Measurement	Depth of Well (feet)$^{(1)}$	Purge Volume (gallons)	Well Volume	Specific Conductance at 25 deg. C (micromhos/cm)	Temperature (deg. C)	pH (S.U.)	Temperature (deg. C)	Turbidity (NTU)
69-GW10	18.57	2	1	53	17	7.55	12.9	37
2/23/95			2	51	18.5	7.01	15.5	133
			3	72	20	6.09	16.7	44
			4	51	19	6.18	15.9	45
			5	50	19.5	5.95	16.2	67
			5.5	50	19	5.86	15.8	134
69-GW11	21.61	2.7	1.1	95	14	NA	NA	2.4
2/22/95			2.2	93	16.5	NA	NA	2.2
			3.3	90	16.5	4.20	12.8	0
			4.4	93	16.5	4.07	13.0	0
69-GW12	15.80	2.1	1.2	137	16.5	5.50	12.7	NA
2/22/95			2.4	139	16	4.49	12.3	129
			3.6	124	15	5.45	11.1	>200
69-GW13	14.92	1.9	1	64	13	5.58	11.1	25.6
2/21/95			2	52	13	5.65	10.9	53.8
			3	52	15	5.78	13.2	82.2
			4	56	15	5.74	12.3	86
			5	65	13	5.74	11.3	148
			6	59	12.5	5.57	10.1	152
			7	63	12.5	5.66	11.5	148
			8	64	12	5.53	9.7	113
			9	63	12	5.57	11.6	81
			10	63	12	5.52	10.3	71
			11	60	12	5.52	9.9	59
			12	-	-	-	-	54
			13	-	-	-	-	54
69-GW14	16.03	1.8	1.1	90	16.5	5.25	12.8	>200
2/24/95			2.2	85	16	5.24	12.7	98
			3.3	91	16	5.10	12.4	111
			4.4	86	16.5	5.30	12.5	59
			5.6	83	15.5	5.28	12.2	46
			6.7	81	16.5	5.06	12.7	38
			7.8	83	17	5.04	12.7	29

TABLE 4-15 (Continued)

SUMMARY OF ROUND TWO GROUNDWATER FIELD PARAMETERS
OPERABLE UNIT NO. 14 (SITE 69)
REMEDIAL INVESTIGATION CTO-0212
MCB CAMP LEJEUNE, NORTH CAROLINA

Well No.			Field Parameters					
Date of Measurement	Depth of Well (feet)$^{(1)}$	Purge Volume (gallons)	Well Volume	Specific Conductance at 25 deg. C (micromhos/cm)	Temperature (deg. C)	pH (S.U.)	Temperature (deg. C)	Turbidity (NTU)
69-GW02DW	50.71	4	1	387	22	6.79	18.8	5.4
2/24/95			2	366	21	6.72	16.7	5.3
			3	361	20.5	6.84	16.5	6.3
			4	359	20.5	6.83	16.4	3.4
69-GW03IW	62.70	5.8	1	287	18	7.70	13.5	1.5
2/25/95			2.1	327	19	7.41	14.5	0.1
			3.1	305	19	7.32	14.4	1.6
69-GW12DW	58.75	9.1	1	341	16	7.36	12.7	2.6
2/23/95			2	352	16.5	7.20	14.2	0.4
			3	352	16.5	7.29	14.3	0.9
69-GW13IW	83.25	8.3	1.1	398	18	7.45	13.7	1.4
2/22/95			2.2	398	18	7.15	14.5	3.9
			3.3	398	18	7.19	15.0	3.2
69-GW14IW	63.07	6.3	1	217	21	8.71	18.6	46
2/23/95			2	213	20.5	8.51	17.5	69
			3	213	20.5	9.15	16.6	53
			4	207	20.5	9.08	17.7	38
			5	208	20	9.12	17.8	29
69-GW02DD	130.65	16.4	1	461	21.5	7.01	18.1	6.1
2/24/95			2	477	21	6.82	17.6	2.1
			3	477	21	6.67	17.9	1.7
69-GW14DW	127.20	16.1	1	385	19.5	7.81	16.5	1.6
2/23/95			2	408	19.5	7.47	16.6	0.69
			3	413	19.5	7.63	16.8	0.41

(1) Measurements taken from top of the PVC casing.

TABLE 4-16
COMPARISON OF VOLATILE ORGANIC RESULTS IN SOUTHERN AND EASTERN WELLS
OPERABLE UNIT NO. 14 (SITE 69)
REMEDIAL INVESTIGATION, CTO-0212
MCB CAMP LEJEUNE, NORTH CAROLINA

Volatile Organic Compounds	69-GW02				69-GW02DW				69-GW02DD				69-GW03				69-GW03IW			
	1/22/94	1/28/95	2/20/95	3/25/95	1/22/94	1/28/95	2/20/95	3/25/95	6/6/94	1/28/95	2/20/95	3/25/95	1/22/94	1/27/95	2/20.95	3/25/95	6/6/94	1/27/95	2/20/95	3/25/95
Vinyl Chloride	31J	4J	5	ND	8.37J	ND	ND	ND	ND	NA	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
1,1-Dichloroethene	ND	ND	ND	ND	ND	ND	ND	ND	ND	NA	ND	ND	1J	ND	ND	ND	ND	ND	ND	ND
1,2-Dichloroethene (Total)	2400	600	230	11	788	6J	8	54	ND	NA	ND	3J	630	440	ND	250	24	5J	ND	ND
Trichloroethene	23J	33	10	ND	29.4	18	ND	ND	ND	NA	ND	ND	1J	48	8	7J	ND	30	ND	ND
1,1,2-Trichloroethane	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Benzene	ND	2J	ND	ND	ND	2J	ND	ND	ND	NA	ND	ND	1J	3J	ND	ND	ND	2J	ND	ND
Tetrachloroethene	1J	ND	NA	ND	ND	ND	NA	ND	ND	NA	NA	ND	ND	1J	NA	ND	ND	ND	NA	ND
1,1,2,2-Tetra-Chloroethane	22J	ND	ND	ND	ND	ND	ND	ND	ND	NA	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Chloroform	ND	ND	ND	ND	ND	ND	ND	ND	ND	NA	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Toluene	1J	1J	NA	ND	ND	1J	NA	ND	ND	NA	NA	ND	4J	3J	NA	ND	ND	1J	NA	ND
Chlorobenzene	ND	ND	NA	ND	ND	ND	NA	ND	ND	NA	NA	ND	25J	6J	NA	4J	ND	ND	NA	ND
Xylenes (Total)	ND	2J	NA	ND	ND	1J	NA	ND	ND	NA	NA	ND	ND	2J	NA	ND	ND	1J	NA	ND

ND - Not Detected
NA - Not Analyzed

TABLE 4-16 (Continued)
COMPARISON OF VOLATILE ORGANIC RESULTS IN SOUTHERN AND EASTERN WELLS
OPERABLE UNIT NO. 14 (SITE 69)
REMEDIAL INVESTIGATION, CTO-0212
MCB CAMP LEJEUNE, NORTH CAROLINA

Volatile Organic Compounds	69-GW13				69-GW13IW				69-GW14			69-GW14IW			69-GW14DW			69-GW15	69-GW15IW
	6/6/94	1/27/95	2/20/95	3/26/95	6/6/95	1/27/95	2/20/95	3/26/95	1/26/95	2/20/95	3/26/95	1/26/95	2/20/95	3/26/95	1/26/95	2/20/95	3/26/95	3/27/95	3/27/95
Vinyl Chloride	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	55J	97
1,1-Dichloroethene	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	3J
1,2-Dichloroethene (Total)	ND	6	ND	ND	9J	21	ND	11	ND	ND	6J	11	ND	ND	14	ND	ND	190J	2500
Trichloroethene	ND	39	ND	ND	ND	65	ND	ND	58	ND	1J	62	ND	ND	78	ND	ND	150J	2600
1,1,2-Trichloroethane	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	13
Benzene	ND	2J	ND	ND	ND	4J	ND	ND	2J	ND	ND	2J	ND	ND	2J	ND	ND	ND	ND
Tetrachloroethene	ND	ND	NA	ND	ND	ND	NA	ND	ND	NA	ND	ND	NA	ND	ND	NA	ND	33J	14
1,1,2,2-Tetra-Chloroethane	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	3000	4J
Chloroform	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Toluene	ND	1J	NA	ND	ND	2J	NA	ND	2J	NA	ND	2J	NA	ND	1J	NA	ND	ND	ND
Chlorobenzene	ND	ND	NA	ND	ND	ND	NA	ND	ND	NA	ND	ND	NA	ND	ND	NA	ND	85	ND
Xylenes (Total)	ND	2J	NA	ND	ND	2J	NA	ND	2J	NA	ND	2J	NA	ND	2J	NA	ND	ND	ND

ND - Not Detected
NA - Not Analyzed

TABLE 4-16A

CASTLE HAYNE GROUNDWATER INVESTIGATION RESULTS
OPERABLE UNIT NO. 14 (SITE 69)
REMEDIAL INVESTIGATION, CTO-0212
MCB CAMP LEJEUNE, NORTH CAROLINA

Contaminant	North Carolina WQS	GW15BCH-01	GW15BCH-01D	GW02BCH-01	GW03BCH-01	GW15DW-02	GW03DW-04	GW02DD-04
Acetone	700	ND	ND	ND	ND	14	ND	ND
Methylene Chloride	5	4J	6J	4J	8J	5J	3J	ND
1,2-Dichloroethene	NS	ND	ND	ND	ND	8J	ND	ND
Chloroform	0.19	ND	ND	3J	3J	ND	ND	ND
Bromodichloromethane	NS	ND	ND	ND	3J	ND	ND	ND
Trichloroethene	2.8	ND	ND	ND	ND	8J	ND	ND
Dibromochloromethane	NS	ND	ND	ND	4J	ND	ND	ND
Bromoform	0.19	ND	ND	ND	2J	ND	ND	ND

Notes:

NS - denotes no standard
ND - denotes not detected above the contract required detection level
J - estimated value
All results are shown in micrograms per liter (µg/L).

TABLE 4-16B

VOC LEVELS IN THE UPPER AND INTERMEDIATE ZONES OF THE CASTLE HAYNE AQUIFER
OPERABLE UNIT NO. 14 (SITE 69)
REMEDIAL INVESTIGATION, CTO-0212
MCB CAMP LEJEUNE, NORTH CAROLINA

	Sampling Date	03/95	03/95	04/96	04/96	02/95	03/95	03/95	03/95	09/95	09/95	04/96	09/95
	Well No.	GW02DW	GW02DD	GW02DD	GW03DW	GW12DW	GW13DW	GW14IW	GW14DW	GW15UW	GW15IW	GW15DW	GW15DW
Contaminant	Depth (bgs)	50'	125'	125'	60'	58'	60'	60'	125'	37'	60'	120'	120'
Vinyl Chloride		ND	ND	ND	ND	ND	ND	ND	ND	1,600	180	ND	ND
Trichloroethene		ND	ND	ND	ND	ND	ND	ND	ND	320	3,000	8J	185
1,1-DCE		NE	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
1,2-DCE		54	3J	ND	ND	ND	11	ND	ND	2,300	54	8J	8.85
1,1,2-TCE		ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Tetrachloroethene		ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
1,1,2,2-Tetrachloroethene		ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Chlorobenzene		ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND

Notes:

All concentrations are given in micrograms per liter (µg/L).
J - estimate value
ND - denotes not detected above the contract required detection level

TABLE 4-17
POSITIVE DETECTION SUMMARY
OPERABLE UNIT NO. 14 (*SITE 69*)
ONSITE AND DRAINAGE AREA SURFACE WATER
MCB CAMP LEJEUNE, NORTH CAROLINA
REMEDIAL INVESTIGATION - CTO-0212
ORGANICS

Client Sample ID:		69-0S-SW01	69-0S-SW02	69-0S-SW03	69-DA-SW01	69-DA-SW02	69-DA-SW03	69-DA-SW04
Laboratory Sample ID:		9401042-01A	9401040-02A	9401040-01A	9401053-01A	9401053-02A	9401053-04A	9401053-03A
Date Sampled:		01/08/94	01/07/94	01/07/94	01/08/94	01/08/94	01/09/94	01/09/94
	UNITS							
SEMIVOLATILES								
di-n-Butylphthalate	UG/L	ND	ND	ND	1.00 J	ND	ND	ND
VOLATILES								
Vinyl chloride	UG/L	8.00 J	ND	ND	ND	ND	ND	ND
Acetone	UG/L	ND	ND	ND	3.00 J	ND	ND	9.00 J
1,2-Dichloroethene(total)	UG/L	55.0	13.0	ND	ND	ND	ND	ND
Chloroform	UG/L	2.00 J	ND	ND	ND	ND	ND	ND
Trichloroethene	UG/L	4.00 J	ND	ND	ND	ND	ND	ND
Toluene	UG/L	ND	1.00 J	ND	1.00 J	ND	ND	ND
Ethylbenzene	UG/L	ND	ND	ND	1.00 J	ND	ND	ND
Xylenes (total)	UG/L	ND	ND	ND	10.0	ND	ND	ND

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

TABLE 4-18
POSITIVE DETECTION SUMMARY
OPERABLE UNIT NO. 14 (SITE 69)
ONSITE AND DRAINAGE AREA SURFACE WATER
MCB CAMP LEJEUNE, NORTH CAROLINA
REMEDIAL INVESTIGATION - CTO-0212
TAL METALS

Client Sample ID:		69-0S-SW01	69-0S-SW02	69-0S-SW03	69-DA-SW01	69-DA-SW02	69-DA-SW03	69-DA-SW04
Laboratory Sample ID:		9401042-01A	9401040-02A	9401040-01A	9401053-01A	9401053-02A	9401053-04A	9401053-03A
Date Sampled:		01/08/94	01/07/94	01/07/94	01/08/94	01/08/94	01/09/94	01/09/94
	UNITS							
Aluminum	UG/L	972.0	2210.0	487.0	4720.0	29200.0	9780.0	801.0
Arsenic	UG/L	ND	4.10	ND	ND	ND	32.8	ND
Barium	UG/L	45.1	66.6	54.1	152.0	373.0	245.0	55.5
Beryllium	UG/L	ND	ND	ND	ND	6.00	1.60	ND
Calcium	UG/L	5770.0	3080.0	5870.0	73000.0	41300.0	21300.0	28400.0
Chromium	UG/L	ND	ND	ND	ND	23.8	ND	ND
Copper	UG/L	ND	22.8	ND	ND	26.3	35.9	ND
Iron	UG/L	1910.0	3820.0	1090.0	2770.0	13500.0	38400.0	8370.0
Lead	UG/L	ND	40.1	3.50	10.3	85.8	52.4	3.10
Magnesium	UG/L	1460.0	885.0	2400.0	143000.0	38100.0	3840.0	4670.0
Manganese	UG/L	339.0	73.4	156.0	147.0	421.0	129.0	157.0
Mercury	UG/L	ND	ND	ND	ND	0.430	ND	ND
Nickel	UG/L	ND	ND	ND	ND	17.8	ND	ND
Potassium	UG/L	365.0	365.0	ND	37600.0	11200.0	1980.0	580.0
Silver	UG/L	ND	ND	ND	0.910 J	0.740 J	ND	2.30 J
Sodium	UG/L	6440.0	4900.0	6820.0	1460000.0	228000.0	6530.0	8260.0
Vanadium	UG/L	ND	ND	ND	ND	24.0	23.3	ND
Zinc	UG/L	4370.0	1970.0	1560.0	112.0	96.0	1400.0	296.0

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

TABLE 4-19
POSITIVE DETECTION SUMMARY
OPERABLE UNIT NO. 14 (SITE 69)
NEW RIVER SURFACE WATER
MCB CAMP LEJEUNE, NORTH CAROLINA
REMEDIAL INVESTIGATION CTO-0212
TOTAL METALS

	Sample No:	69-NR1-SW-06		69-NR2-SW-06		69-NR3-SW-06	
	Depth:	N/A		N/A		N/A	
	Date Sampled:	08/20/92		08/20/92		08/20/92	
	Lab Id:	00424-09		00424-12		00424-15	
	UNITS						
ALUMINUM	UG/L	1840		1630		554	
BARIUM	UG/L	15.2	JB	13.8	JB	11.7	JB
CALCIUM	UG/L	110000		110000		95700	
IRON	UG/L	1200		1330		682	
MAGNESIUM	UG/L	308000		304000		267000	
MANGANESE	UG/L	21.6	J	21.7	J	19.2	J
POTASSIUM	UG/L	111000		102000		84900	
SILVER	UG/L	4.5	JB	3.5	JB	ND	
SODIUM	UG/L	3080000		5830000		3360000	J
THALLIUM	UG/L	ND		11.3	JB	ND	

UG/L - microgram per liter
J - value is estimated
JB - value is estimated below the Contract Required Detection Limit (CRDL), but greater than the Instrument Detection Limit (IDL)
ND - not detected

TABLE 4-20
POSITIVE DETECTION SUMMARY
OPERABLE UNIT NO. 14 (SITE 69)
UNNAMED TRIBUTARY SURFACE WATER
MCB CAMP LEJEUNE, NORTH CAROLINA
REMEDIAL INVESTIGATION CTO-0212
TOTAL METALS

Sample No:		69-UT1-SW-06	69-UT2-SW-06	69-UT3-SW-06
Depth:		N/A	N/A	N/A
Date Sampled:		8/216/92	8/21/92	8/21/92
Lab Id:		00428-02	00425-04	00425-08
	UNITS			
ALUMINUM	UG/L	1110	881	3490
BARIUM	UG/L	23 B	15.2 JB	18 JB
CADMIUM	UG/L	3 JB	ND	ND
CALCIUM	UG/L	1380 B	16900	92300
COBALT	UG/L	8 JB	ND	ND
COPPER	UG/L	7 JB	ND	ND
IRON	UG/L	1000	740	1840
LEAD	UG/L	2 B	ND	ND
MAGNESIUM	UG/L	846 B	37300	257000
MANGANESE	UG/L	9 JB	17.7 J	16.1 J
POTASSIUM	UG/L	385 B	12900	86000
SODIUM	UG/L	4790 JB	296000	2220000
VANADIUM	UG/L	10 JB	ND	4.2 JB
ZINC	UG/L	18 B	ND	ND

UG/L - microgram per liter
B - reported value is less than Contract Required Detection Limit (CRDL), but greater than Instrument Detection Limit (IDL)
J - value is estimated
JB - value is estimated below the CRDL, but greater than the IDL
ND - not detected

TABLE 4-21
POSITIVE DETECTION SUMMARY
OPERABLE UNIT NO. 14 (SITE 69)
EVERETT CREEK SURFACE WATER
MCB CAMP LEJEUNE, NORTH CAROLINA
REMEDIAL INVESTIGATION CTO-0212
TOTAL METALS

Sample No:		69-EC1-SW-06		69-EC3-SW-06		69-EC4-SW-06	
Depth:		N/A		N/A		N/A	
Date Sampled:		9/16/92		08/20/92		08/20/92	
Lab Id:		00517-22		00424-03		00424-06	
	UNITS						
ALUMINUM	UG/L	ND		501		445	
BARIUM	UG/L	22.2	JB	11.3	J	10.4	J
CALCIUM	UG/L	85200		26400		29300	
COPPER	UG/L	2.6	JB	ND		ND	
IRON	UG/L	667		557		490	
LEAD	UG/L	ND		2.3	J	1.4	B
MAGNESIUM	UG/L	229000		73800		80200	
MANGANESE	UG/L	32.5		17.3	J	14.3	J
POTASSIUM	UG/L	88700		22600		26200	
SILVER	UG/L	ND		4.1	J	3.2	J
SODIUM	UG/L	2130000		801000		727000	

UG/L - microgram per liter

B - reported value is less than Contract Required Detection Limit (CRDL), but greater than Instrument Detection Limit (IDL)

J - value is estimated

JB - value is estimated below the CRDL, but greater than the IDL

ND - not detected

TABLE 4-22
POSITIVE DETECTION SUMMARY
OPERABLE UNIT NO. 14 (SITE 69)
ONSITE AND DRAINAGE AREA SEDIMENT
MCB CAMP LEJEUNE, NORTH CAROLINA
REMEDIAL INVESTIGATION - CTO-0212
ORGANICS

Client Sample ID:		69-DA-SD01-06	69-DA-SD02-06	69-DA-SD03-06	69-DA-SD04-06	69-0S-SD01-06
Laboratory Sample ID:		9401055-01A	9401055-02A	9401055-07A	9401055-08A	9401043-06A
Date Sampled:		1/8/94	1/8/94	1/9/94	1/9/94	1/8/94
Percent Solids		7.69	29.9	54.2	13.0	48.2
	UNITS					
SEMIVOLATILES						
di-n-Butylphthalate	UG/KG	ND	ND	ND	ND	ND
VOLATILES						
Methylene chloride	UG/KG	36.0 J	8.00 J	9.00 J	48.0	8 J
Acetone	UG/KG	ND	ND	ND	ND	9 J
1,2-Dichloroethene(total)	UG/KG	ND	ND	ND	ND	9 J
2-Butanone	UG/KG	36.0 J	ND	ND	ND	ND
4-Methyl-2-pentanone	UG/KG	14.0 J	ND	ND	ND	ND
Toluene	UG/KG	ND	ND	ND	18.0 J	ND
PESTICIDE/PCBS						
alpha-BHC	UG/KG	ND	ND	ND	ND	ND
beta-BHC	UG/KG	ND	ND	ND	ND	ND
delta-BHC	UG/KG	ND	ND	ND	ND	ND
4,4'-DDE	UG/KG	ND	13.3 J	ND	ND	ND
4,4'-DDD	UG/KG	ND	4.90 J	1.50 J	13.9 J	ND
4,4'-DDT	UG/KG	ND	ND	ND	6.60 J	ND
Aroclor 1254	UG/KG	ND	ND	ND	ND	79 J
CHEMICAL SURETY						
Acetophenone	UG/KG	960.0 J	ND	ND	ND	ND

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

TABLE 4-22
POSITIVE DETECTION SUMMARY
OPERABLE UNIT NO. 14 (SITE 69)
ONSITE AND DRAINAGE AREA SEDIMENT
MCB CAMP LEJEUNE, NORTH CAROLINA
REMEDIAL INVESTIGATION - CTO-0212
ORGANICS

Client Sample ID:		69-0S-SD02-06	69-0S-SD03-06
Laboratory Sample ID:		9401041-12A	9401041-11A
Date Sampled:		1/7/94	1/7/94
Percent Solids		59.7	82.4
	UNITS		
SEMIVOLATILES			
di-n-Butylphthalate	UG/KG	110.0 J	110.0 J
VOLATILES			
Methylene chloride	UG/KG	ND	ND
Acetone	UG/KG	850.0 J	170.0 J
1,2-Dichloroethene(total)	UG/KG	ND	ND
2-Butanone	UG/KG	ND	ND
4-Methyl-2-pentanone	UG/KG	17.0	9.00 J
Toluene	UG/KG	ND	ND
PESTICIDE/PCBS			
alpha-BHC	UG/KG	3.10 J	ND
beta-BHC	UG/KG	23.4 J	ND
delta-BHC	UG/KG	54.5 J	ND
4,4'-DDE	UG/KG	ND	ND
4,4'-DDD	UG/KG	ND	ND
4,4'-DDT	UG/KG	2.10 J	ND
Aroclor 1254	UG/KG	ND	ND
CHEMICAL SURETY			
Acetophenone	UG/KG	60.0 J	ND

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

TABLE 4-23
POSITIVE DETECTION SUMMARY
OPERABLE UNIT NO. 14 (SITE 69)
ONSITE AND DRAINAGE AREA SEDIMENT
MCB CAMP LEJEUNE, NORTH CAROLINA
REMEDIAL INVESTIGATION - CTO-0212
TAL METALS

Client Sample ID:		69-DA-SD01-06	69-DA-SD02-06	69-DA-SD03-06	69-DA-SD04-06	69-0S-SD01-06	69-0S-SD02-06	69-0S-SD03-06
Laboratory Sample ID:		9401055-01A	9401055-02A	9401055-07A	9401055-08A	9401043-06A	9401041-12A	9401041-11A
Date Sampled:		1/8/94	1/8/94	1/9/94	1/9/94		1/7/94	1/7/94
Percent Solids		7.69	29.9	54.2	13.0	48.2	59.7	82.4
	UNITS							
Aluminum	MG/KG	2900.0	10200.0	1050.0	23700.0	1570	1550.0	2300.0
Barium	MG/KG	ND	29.6	6.80	131.0	12.1	ND	ND
Beryllium	MG/KG	ND	0.940	ND	2.00	ND	ND	ND
Calcium	MG/KG	5480.0	1830.0	403.0	5600.0	107	ND	ND
Chromium	MG/KG	ND	10.9 J	ND	21.5	ND	ND	2.90
Copper	MG/KG	ND	ND	ND	ND	ND	21.7	ND
Iron	MG/KG	779.0	2050.0	369.0	8930.0	2360	534.0	571.0
Lead	MG/KG	14.2	18.3	4.00	45.5	5.3	8.20 J	3.10 J
Magnesium	MG/KG	5190.0	1210.0	51.9	886.0	28	37.2	49.5
Manganese	MG/KG	19.6	38.2	3.30	44.1	5.5	ND	1.40
Mercury	MG/KG	0.560	ND	ND	0.500	ND	ND	ND
Potassium	MG/KG	ND	452.0 J	ND	ND	ND	ND	104.0
Silver	MG/KG	74.5 J	ND	0.260 J	ND	17.7 J	ND	ND
Sodium	MG/KG	17800.0	1410.0	ND	ND	ND	ND	ND
Zinc	MG/KG	44.8	15.7	44.2	551.0	98.4	44.3	ND

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

TABLE 4-24
POSITIVE DETECTION SUMMARY
OPERABLE UNIT NO. 14 (SITE 69)
NEW RIVER SEDIMENT
MCB CAMP LEJEUNE, NORTH CAROLINA
REMEDIAL INVESTIGATION CTO-0212
ORGANICS

Sample No:		69-NR1-SD-06	69-NR2-SD-062	69-NR2-SD-6122	69-NR3-SD-06	69-NR3-SD-612
Depth:		N/A	N/A	N/A	N/A	N/A
Date Sampled:		08/20/92	9/14/92	9/14/92	08/20/92	08/20/92
Lab Id:		00424-08	00513-04	00513-05	00424-13	00424-14
	<u>UNITS</u>					
<u>VOLATILES</u>						
ACETONE	UG/KG	22			23	120
<u>SEMIVOLATILES</u>						
BIS(2-ETHYLHEXYL)PHTHALATE	UG/KG		92 J	47 J		

UG/KG - microgram per kilogram
J - value is estimated

TABLE 4-25
POSITIVE DETECTION SUMMARY
OPERABLE UNIT NO. 14 (SITE 69)
NEW RIVER SEDIMENT
MCB CAMP LEJEUNE, NORTH CAROLINA
REMEDIAL INVESTIGATION CTO-0212
TOTAL METALS

Sample No:		69-NR1-SD-06	69-NR2-SD-062	69-NR2-SD-6122	69-NR3-SD-06	69-NR3-SD-612
Depth:		N/A	N/A	N/A	N/A	N/A
Date Sampled:		08/20/92	9/14/92	9/14/92	08/20/92	08/20/92
Lab Id:		00424-08	00513-04	00513-05	00424-13	00424-14
	UNITS					
ALUMINUM	MG/KG	16200	3450	5870	6360	8100
ARSENIC	MG/KG	2		5.6	1.6 B	3.2
BARIUM	MG/KG	12.5 B			5.2 B	4.6 B
BERYLLIUM	MG/KG	0.27 B	0.24 JB	0.37 JB		0.24 B
CADMIUM	MG/KG	0.53 J		1.1 JB		1.2 J
CALCIUM	MG/KG	376 B	525 JB	444 JB	388 B	380 B
CHROMIUM	MG/KG	17.7	6.2	10.9	9.8	13.2
COBALT	MG/KG	1.2 B	0.92 B	0.81 JB	0.58 B	1.2 B
COPPER	MG/KG	1.6 J			1.6 J	2.5 J
IRON	MG/KG	5450	4320 J	11600 J	7470	14500
LEAD	MG/KG	6	4.6 J	5.7 J	3.6	4.4
MAGNESIUM	MG/KG	1120 B	808 JB	856 JB	973 B	1040
MANGANESE	MG/KG	14.5 J	17.2	28.9	13.6 J	19.5
POTASSIUM	MG/KG	1040 B	614 B	698 B		
SODIUM	MG/KG	2280 J	1710 J	1240 J	1900 J	2560 J
VANADIUM	MG/KG	35.3	10.3 B	25.4	12.5	18.1
ZINC	MG/KG	7			8.2	10.7

MG/KG - milligram per liter
B - reported value is less than Contract Required Detection Limit (CRDL), but greater than Instrument Detection Limit (IDL)
J - value is estimated
JB - value is estimated below the CRDL, but greater than the IDL

TABLE 4-26
POSITIVE DETECTION SUMMARY
OPERABLE UNIT NO. 14 (SITE 69)
UNNAMED TRIBUTARY SEDIMENT
MCB CAMP LEJEUNE, NORTH CAROLINA
REMEDIAL INVESTIGATION CTO-0212
ORGANICS

Sample No:		69-UT1-SD-06	69-UT2-SD-06	69-UT2-SD-612	69-UT3-SD-062	69-UT3-SD-6122
Depth:		N/A	N/A	N/A	N/A	N/A
Date Sampled:		8/22/92	8/20/92	8/20/92	9/14/92	9/14/92
Lab Id:		00428-01	00425-01	00425-02	00513-08	00513-09
	UNITS					
PESTICIDE/PCBs						
4,4'-DDE	UG/KG		250	250	10 J	
4,4'-DDD	UG/KG	14 J	150	150		
PCB-1260	UG/KG					360
VOLATILES						
ACETONE	UG/KG	39 J			41	65
CARBON DISULFIDE	UG/KG		88	25 J	18 J	46
TOLUENE	UG/KG	2 J				
SEMIVOLATILES						
DIETHYL PHTHALATE	UG/KG			500 J		
BIS(2-ETHYLHEXYL)PHTHALATE	UG/KG				81 J	52 J
BENZO(A)PYRENE	UG/KG		290 J	2500		

UG/KG - microgram per kilogram
J - value is estimated

TABLE 4-27
POSITIVE DETECTION SUMMARY
OPERABLE UNIT NO. 14 (SITE 69)
UNNAMED TRIBUTARY SEDIMENT
MCB CAMP LEJEUNE, NORTH CAROLINA
REMEDIAL INVESTIGATION CTO-0212
TOTAL METALS

Sample No:		69-UT1-SD-06	69-UT2-SD-06	69-UT2-SD-612	69-UT3-SD-062	69-UT3-SD-6122
Depth:		N/A	N/A	N/A	N/A	N/A
Date Sampled:		8/216/92	8/21/92	8/21/92	9/14/92	9/14/92
Lab Id:		00428-01	00425-01	00425-02	00513-08	00513-09
	UNITS					
ALUMINUM	MG/KG	1240	16700	23400	11200	14500
ARSENIC	MG/KG		4.7 B	5.2 B	5.9	7.1
BARIUM	MG/KG		14.2 B	23.1 B		
BERYLLIUM	MG/KG				0.52 JB	0.61 JB
CADMIUM	MG/KG			2.1 JB	2.1 J	1.8 JB
CALCIUM	MG/KG	264 B	6270	5750	1360 JB	1280 JB
CHROMIUM	MG/KG	3.3			17.7	22.4
COBALT	MG/KG				1.4 B	2.1 B
COPPER	MG/KG		22.8 B	24.1	7.2 B	8.5 B
IRON	MG/KG	3530	16200	17900	12100 J	15700 J
LEAD	MG/KG	1	32.8	34.1	12.8 J	19.4 J
MAGNESIUM	MG/KG	48.9 B	6660	6670	2600 J	3180 J
MANGANESE	MG/KG	2.9 J	54.4	69.3	27	26.6
POTASSIUM	MG/KG	81.1 B			1560 B	2040
SODIUM	MG/KG	122 JB	21100	16800	6740 J	7330 J
VANADIUM	MG/KG		32.3 B	41.1 B	25.8	36.8
ZINC	MG/KG				22.4	24.6

MG/KG - milligram per liter
B - reported value is less than Contract Required Detection Limit (CRDL), but greater than Instrument Detection Limit (IDL)
J - value is estimated
JB - value is estimated below the CRDL, but greater than the IDL

TABLE 4-28
POSITIVE DETECTION SUMMARY
OPERABLE UNIT NO. 14 (SITE 69)
EVERETT CREEK SEDIMENT
MCB CAMP LEJEUNE, NORTH CAROLINA
REMEDIAL INVESTIGATION CTO-0212
ORGANICS

Sample No:		69-EC3-SD-03	69-EC3-SD-612	69-EC4-SD-062	69-EC4-SD-6122
Depth:		N/A	N/A	N/A	N/A
Date Sampled:		08/20/92	08/20/92	9/14/92	9/14/92
Lab Id:		00424-01	00424-02	00513-01	00513-03
	UNITS				
PESTICIDE/PCBS					
4,4'-DDE	UG/KG				6.6 J
VOLATILES					
METHYLENE CHLORIDE	UG/KG	1200 J			
ACETONE	UG/KG	4600	240		
CARBON DISULFIDE	UG/KG		35		
2-BUTANONE	UG/KG	5300			
SEMIVOLATILES					
BIS(2-ETHYLHEXYL)PHTHALATE	UG/KG			85 J	130 J

UG/KG - microgram per kilogram
J - value is estimated

TABLE 4-29
POSITIVE DETECTION SUMMARY
OPERABLE UNIT NO. 14 (SITE 69)
EVERETT CREEK SEDIMENT
MCB CAMP LEJEUNE, NORTH CAROLINA
REMEDIAL INVESTIGATION CTO-0212
TOTAL METALS

Sample No:		69-EC1-SD-06		69-EC3-SD-03		69-EC3-SD-612		69-EC4-SD-062		69-EC4-SD-6122	
Depth:		N/A		N/A		N/A		N/A		N/A	
Date Sampled:		9/16/92		08/20/92		08/20/92		9/14/92		9/14/92	
Lab Id:		00517-21		00424-01		00424-02		00513-01		00513-03	
	UNITS										
ALUMINUM	MG/KG	8560		32700		23200		888	J	6650	
ARSENIC	MG/KG			5.3	B	4.4	B			5.3	
BARIUM	MG/KG	13	JB	26.4	B	17.7	B				
BERYLLIUM	MG/KG	0.93	B	0.96	B	0.7	B	0.13	JB	0.43	JB
CADMIUM	MG/KG	5.2	JB	2.8	J	2.2	J	0.52	JB	1.8	J
CALCIUM	MG/KG	5500	B	3020		3880		627	JB	1380	JB
CHROMIUM	MG/KG	11.7	B	43.8		29.2		3.6	J	12.1	
COBALT	MG/KG	7	JB	3.3	B	2.3	B			1.3	B
COPPER	MG/KG	16.2	JB	11.4	B	6.5	J				
IRON	MG/KG	13700		28900		28500		4150	J	12000	J
LEAD	MG/KG	30.8		25.2		11				7.5	J
MAGNESIUM	MG/KG	4990	B	7250		5810		313	JB	2000	J
MANGANESE	MG/KG	59.1		83.3		85.9		4.1	J	27.2	
MERCURY	MG/KG	0.17	B								
POTASSIUM	MG/KG	1420	B	4290		3470		129	JB	1050	B
SODIUM	MG/KG	18000		21800		16700		1100	JB	5040	J
VANADIUM	MG/KG	20.1	B	48.8		29.8	B	7.2	JB	20.4	
ZINC	MG/KG	62		57.3		31.8					

MG/KG - milligram per liter
B - reported value is less than Contract Required Detection Limit (CRDL), but greater than Instrument Detection Limit (IDL)
J - value is estimated
JB - value is estimated below the CRDL, but greater than the IDL

TABLE 4-30

COMPARISON OF INORGANIC LEVELS IN SITE 69 SURFACE SOILS TO BACKGROUND LEVELS
REMEDIAL INVESTIGATION - CTO - 0212
MCB CAMP LEJEUNE, NORTH CAROLINA

	Site 69 (mg/kg)	Site Background (mg/kg)	Base Background (mg/kg)
Aluminum	368 - 3,370	528 - 5,370	17.7 - 9,570
Barium	3 - 6.8	5.6 - 20.8	0.65 - 20.8
Calcium	35.8 - 101	28.2 - 282	4.25 - 10,700
Chromium	1.6 - 3.6	0.75 - 12.5	0.33 - 12.5
Iron	235 - 2,360	426 - 9,640	69.7 - 9,640
Lead	1.1 - 12.5	2.8 - 6.0	0.47 - 142
Magnesium	12.9 - 67.7	37.3 - 610	2.55 - 610
Manganese	1.3 - 15.5	8.3 - 15.1	0.87 - 66
Potassium	66.1 - 66.4	32.25 - 361	1 - 416
Selenium	1.1 - 1.1	0.27 - 0.3	0.075 - 1.3
Silver	0.09 - 10.2	0.045 - 4.3	0.0435 - 4.3
Vanadium	3.9 - 5.3	1.8 - 13.5	0.305 - 18.2
Zinc	1.5 - 66	3.1 - 10.8	0.3 - 28.3
Total Cyanide	1.1 - 2.3	2.2 - 2.4	0.265 - 2.4

ND = Nondetect

TABLE 4-31

COMPARISON OF INORGANIC LEVELS IN SITE 69 SUBSURFACE SOILS TO BASE BACKGROUND LEVELS
REMEDIAL INVESTIGATION - CTO - 0212
MCB CAMP LEJEUNE, NORTH CAROLINA

	Site 69 (mg/kg)	Base Background (mg/kg)
Aluminum	832 - 9,990	16.9 - 11,000
Arsenic	1.15 - 2.9	0.033 - 15.4
Barium	3.8 - 14.6	0.65 - 22.6
Beryllium	0.36 - 0.36	0.01 - 0.31
Cadmium	0.74 - 0.74	0.155 - 1.2
Calcium	29.2 - 688	4.75 - 4,410
Chromium	1.76 - 17.7	0.65 - 66.4
Copper	5.1 - 5.1	0.47 - 9.5
Iron	354 - 19,900	63.3 - 90,500
Lead	1.78 - 6	0.465 - 21.4
Magnesium	26.9 - 574	2.85 - 852
Manganese	1.6 - 39	0.395 - 19.9
Mercury	0.04 - 0.07	0.01 - 0.68
Nickel	3.4 - 3.9	0.45 - 4.7
Potassium	149 - 516	1.05 - 1,250
Silver	0.43 - 0.43	0.175 - 1.0
Sodium	130 - 130	5.4 - 141
Vanadium	4.4 - 22.6	0.34 - 69.4
Zinc	3.4 - 13.7	0.32 - 26.6
Total Cyanide	1.2 - 2.6	NA

NA = Not Analyzed

TABLE 4-32

COMPARISON OF TOTAL AND DISSOLVED METALS IN SHALLOW GROUNDWATER AT SITE 69 TO BACKGROUND LEVELS
REMEDIAL INVESTIGATION - CTO - 0212
MCB CAMP LEJEUNE, NORTH CAROLINA

	Total Metals		Dissolved Metals	
	Site 69 (µg/L)	Base Background (µg/L)	Site 69 (µg/L)	Base Background (µg/L)
Aluminum	169 - 21,100	ND	181 - 2,170	ND
Antimony	7.9R - 8.59	ND	7.9R - 18	ND
Arsenic	2.8 - 19.9	ND - 570	3.09 - 3.44	ND - 21.6
Barium	22.6 - 850	ND - 5,410	14.4 - 141	ND - 451
Beryllium	0.89 - 10.6	ND - 43.4	0.899 - 0.899	ND - 3.2
Cadmium	3.12 - 11.4	ND - 110	ND	ND - 5
Calcium	2,010 - 180,000	ND - 828,000	764 - 65,800	ND - 441,000
Chromium	9.95 - 159	ND - 895	ND	ND - 59
Cobalt	17.3 - 25. 9	ND	22.6 - 22.6	ND
Copper	16.5 - 70.8	ND - 1,030	ND	ND - 121
Iron	124 - 99,500	ND	40.7 - 16,800	ND
Lead	3.1 - 188	ND - 9,340	1.08 - 1.08	ND - 94
Magnesium	1,000 - 13,200	ND	368 - 6,200	ND
Manganese	5.59 - 912	ND - 2,110	8.45 - 181	ND - 539
Mercury	0.068 - 0.936	ND - 3.2	ND	ND - 0.6
Nickel	16.7 - 99.8	ND - 486	25.6 - 25.6	ND - 57
Potassium	1,410 - 7,610	ND	397 - 3,540	ND
Selenium	3.81 - 8.46	ND	2.77 - 5.58	ND
Sodium	4,130 - 33,000	ND - 156,000	1,030 - 37,000	ND - 183,000
Vanadium	12.8 - 210	ND - 1,700	11.6 - 11.6	ND - 43
Zinc	31.1 - 12,100	ND - 12,100	1,960 - 7,670	ND - 7,670

ND = Nondetect

TABLE 4-33
COMPARISON OF TOTAL AND DISSOLVED METALS - LOW-FLOW PURGING TECHNIQUES
OPERABLE UNIT NO. 14 (SITE 69)
REMEDIAL INVESTIGATION, CTO-0212
MCB CAMP LEJEUNE, NORTH CAROLINA

Constituent (µg/L)	69-GW01				69-GW03			
	1/7/94		8/27/94		1/7/94		8/27/94	
	Total	Dissolved	Total	Dissolved	Total	Dissolved	Total	Dissolved
Aluminum	34,200	644	3,640	564	4,700	ND	304	180
Antimony	ND	ND	ND	ND	ND	ND	ND	ND
Arsenic	10.2	ND	ND	ND	18	ND	ND	ND
Barium	192	95.1	60	63.8	83.6	35.8	29.6	34
Beryllium	1.51	ND	ND	ND	ND	ND	ND	ND
Cadmium	ND	ND	ND	ND	ND	ND	ND	ND
Calcium	10,400	10,600	5,360	6,600	7,250	7,150	5,320	7,190
Chromium	59.6	ND	ND	ND	56.7	ND	ND	ND
Cobalt	ND	ND	ND	ND	ND	ND	ND	ND
Copper	30.1	ND	ND	19.1	32.8	ND	ND	16.3
Iron	23,900	830	1,610	146	45,000	16,800	10,100	13,400
Lead	29.5	ND	4.4	ND	56.5	ND	ND	ND
Magnesium	7,200	5,520	2,570	3,050	2,550	674	371	511
Manganese	187	102	41.3	49.3	215	138	92.6	124
Mercury	ND	ND	ND	0.25	ND	ND	ND	ND
Nickel	23.9	ND	ND	ND	21	ND	ND	ND
Potassium	3,820	1,260	ND	1,480	2,380	584	ND	ND
Selenium	6.86	ND	ND	ND	8.46	ND	ND	ND
Silver	ND	ND	ND	ND	ND	ND	ND	ND
Sodium	15,000	16,100	13,000	16,100	8,490	9,510	6,510	8,210
Thallium	ND	ND	ND	ND	ND	ND	ND	ND
Vanadium	76.1	ND	ND	ND	81.8	ND	ND	ND
Zinc	119	ND	234	27	12,100	1,960	1,990	2,490
Cyanide	ND	NA	NA	NA	ND	NA	NA	NA

ND - Not Detected
NA - Not Analyzed

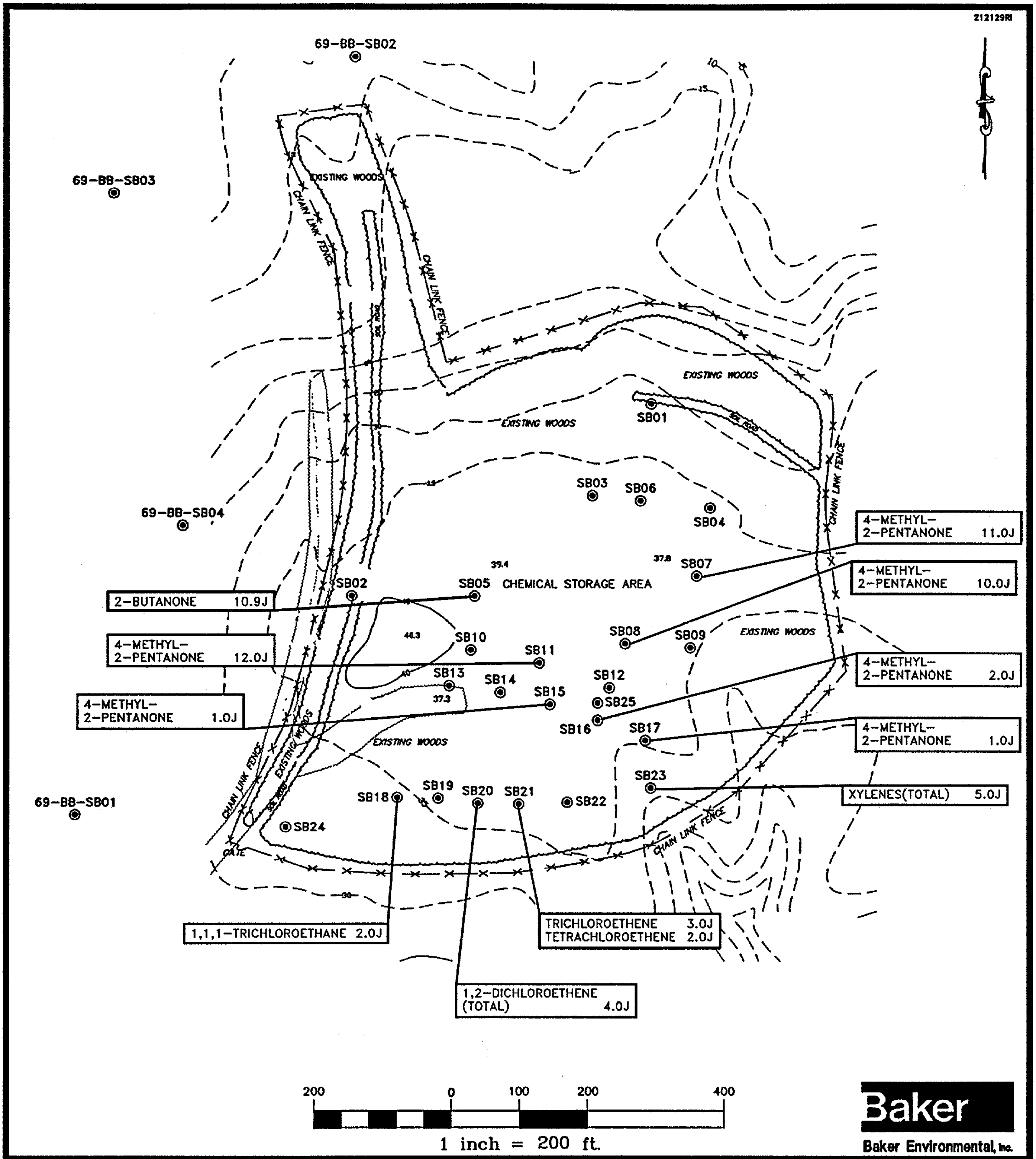
TABLE 4-34

COMPARISON OF TOTAL METALS IN "ON-SITE" AND "OFF-SITE" SURFACE WATER BODIES AT SITE 69 TO BASE UPGRADIENT LEVELS
REMEDIAL INVESTIGATION - CTO - 0212
MCB CAMP LEJEUNE, NORTH CAROLINA

	On Site (µg/L)	New River (µg/L)	Unnamed Tributary (µg/L)	Everett Creek (µg/L)	Base Upgradient (µg/L)
Aluminum	487 - 29,200	554 - 1,840	881 - 3,490	445 - 501	178 - 1,350
Arsenic	4.1 - 32.8	ND	ND	ND	ND
Barium	45.1 - 373	11.7 - 15.2	15.2 - 23	10.4 - 22.2	13.4 - 27.2
Beryllium	1.6 - 6	ND	ND	ND	ND
Cadmium	ND	ND	3 - 3	ND	ND - 3
Calcium	3,080 - 73,000	95,700 - 110,000	1,380 - 92,300	26,400 - 85,200	600 - 41,600
Chromium	23.8 - 23.8	ND	ND	ND	ND
Cobalt	ND	ND	8 - 8	ND	ND - 8
Copper	22.8 - 35.9	ND	7 - 7	2.6 - 2.6	4 - 129
Iron	1,090 - 38,400	682 - 1,330	740 - 1,840	490 - 667	413 - 1,460
Lead	3.1 - 85.8	ND	2 - 2	1.4 - 2.3	1. 17 - 10.4
Magnesium	885 - 143,000	267,000 - 308,000	846 - 257,000	73,800 - 229,000	588 - 2,410
Manganese	73.4 - 421	19.2 - 21.7	9 - 17.7	14.3 - 32.5	6.2 - 40
Mercury	0.43 - 0.43	ND	ND	ND	ND - 0.52
Nickel	17.8 - 17.8	ND	ND	ND	ND - 1,380
Potassium	36.5 - 37,600	84,900 - 111,000	385 - 86,000	22,600 - 88,700	341 - 2,210
Silver	0.74 - 2.3	3.5 - 4.5	ND	3.2 - 4.1	ND
Sodium	4,900-1,460,000	3,080,000-5,830,000	4,790-2,220,000	727,000-2,130,000	3,930 - 22,100
Thallium	ND	11.3 - 11.3	ND	ND	ND
Vanadium	23.3 - 24	ND	4.2 - 10	ND	1.9 - 10
Zinc	96 - 4,370	ND	18 - 18	ND	18 - 111

ND = Nondetect

SECTION 4.0 FIGURES



LEGEND

● SB01 SURFACE SOIL SAMPLING LOCATION

-x- FENCE

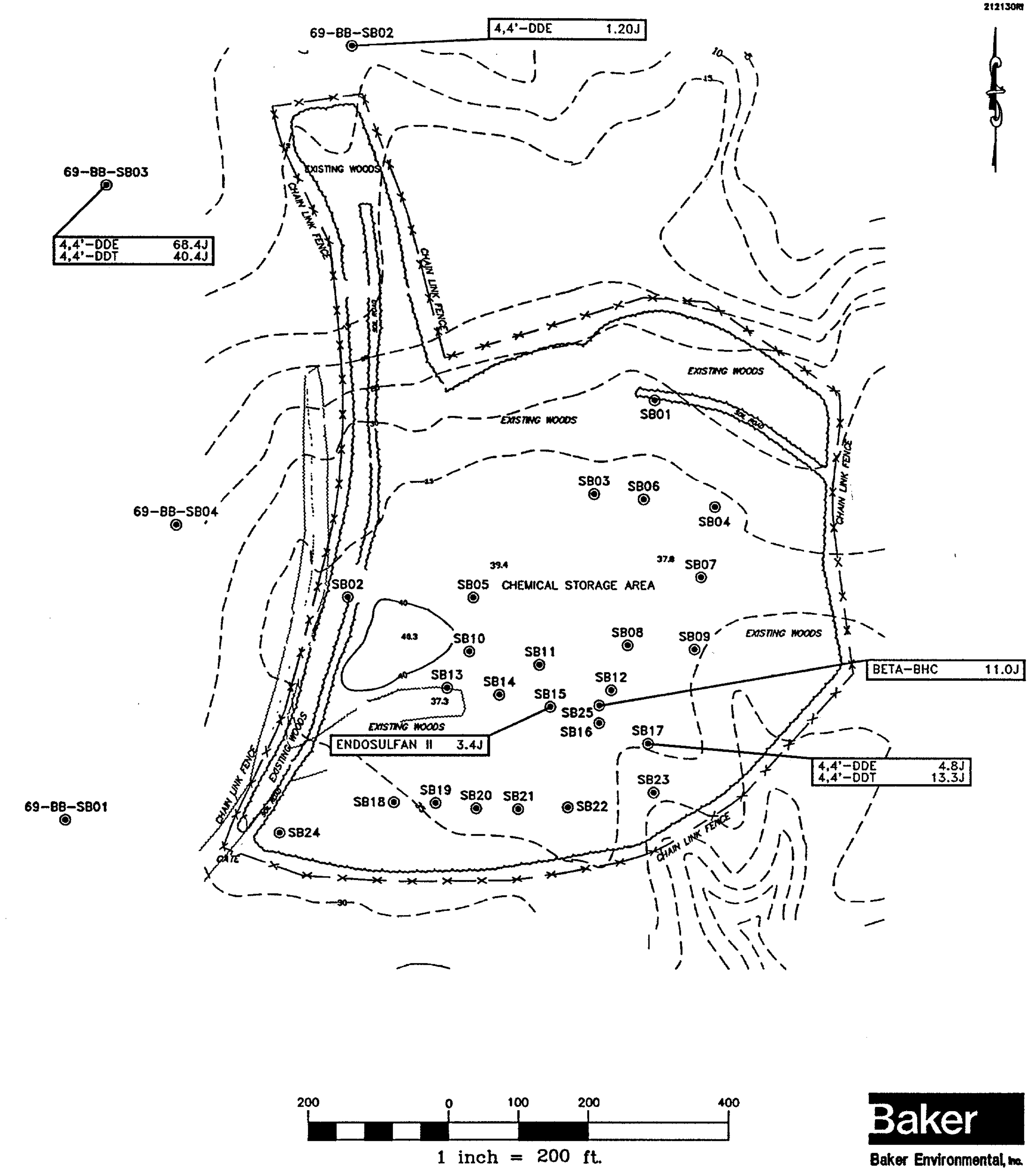
VEGETATION

TOPOGRAPHIC ELEVATION LINES (FEET, MSL)

ALL CONCENTRATIONS REPORTED IN MICROGRAMS PER KILOGRAM (ug/kg).

SOURCE: REVISED FROM LANTDIV, OCT. 1991

FIGURE 4-1
POSITIVE DETECTIONS OF VOCs IN SURFACE SOILS
SITE 69 - RIFLE RANGE CHEMICAL DUMP
REMEDIAL INVESTIGATION CTO-0212
MARINE CORPS BASE, CAMP LEJEUNE
NORTH CAROLINA



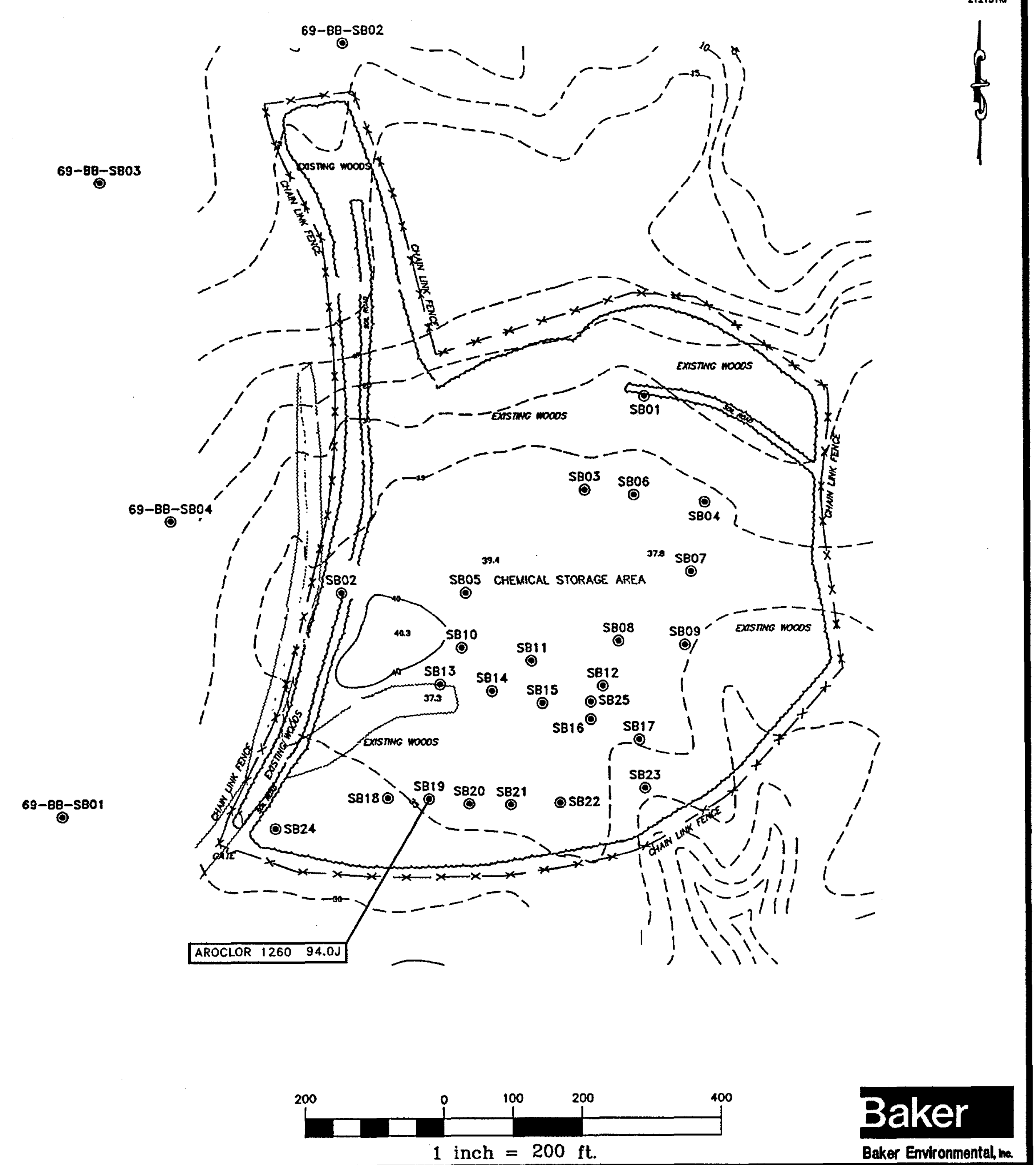
LEGEND

SB01 ◉	SURFACE SOIL SAMPLING LOCATION
✕ ✕	FENCE
〰	VEGETATION
╱	TOPOGRAPHIC ELEVATION LINES (FEET, MSL)

ALL CONCENTRATIONS REPORTED IN MICROGRAMS PER KILOGRAM (ug/kg).

SOURCE: REVISED FROM LANTDIV, OCT. 1991

FIGURE 4-2
POSITIVE DETECTIONS OF
PESTICIDES IN SURFACE SOILS
SITE 69 - RIFLE RANGE CHEMICAL DUMP
REMEDIAL INVESTIGATION CTO-0212
MARINE CORPS BASE, CAMP LEJEUNE
NORTH CAROLINA



Baker

Baker Environmental, Inc.

LEGEND

◉ SB01 SURFACE SOIL SAMPLING LOCATION

✕ FENCE

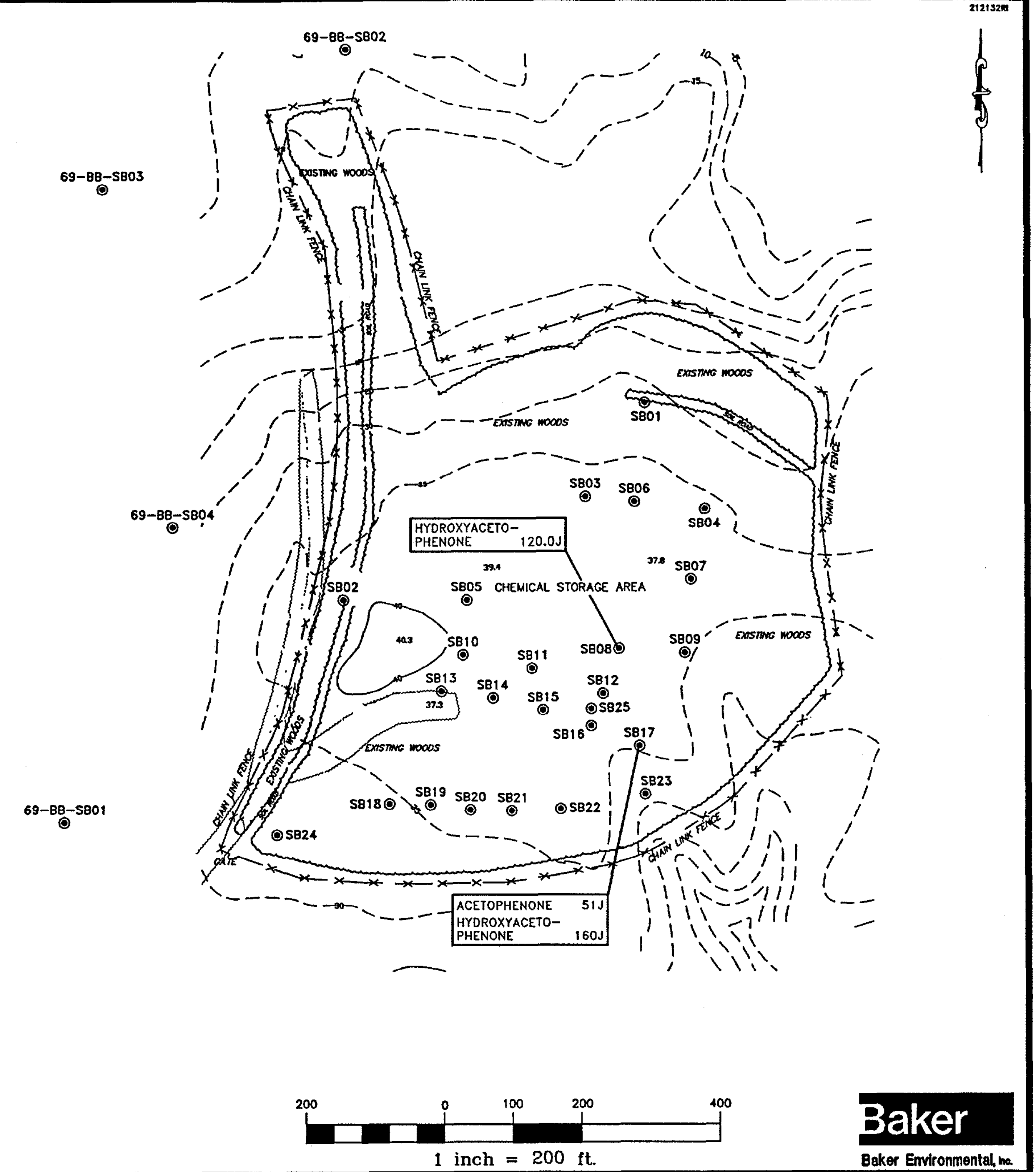
VEGETATION

TOPOGRAPHIC ELEVATION LINES (FEET, MSL)

ALL CONCENTRATIONS REPORTED IN MICROGRAMS PER KILOGRAM (ug/kg).

SOURCE: REVISED FROM LANTDIV, OCT. 1991

FIGURE 4-3
POSITIVE DETECTION OF PCBs
IN SURFACE SOILS
SITE 69 - RIFLE RANGE CHEMICAL DUMP
REMEDIAL INVESTIGATION CTO-0212
MARINE CORPS BASE, CAMP LEJEUNE
NORTH CAROLINA



HYDROXYACETO-PHENONE	120.0J

ACETOPHENONE	51J
HYDROXYACETO-PHENONE	160J

Baker

Baker Environmental, Inc.

LEGEND

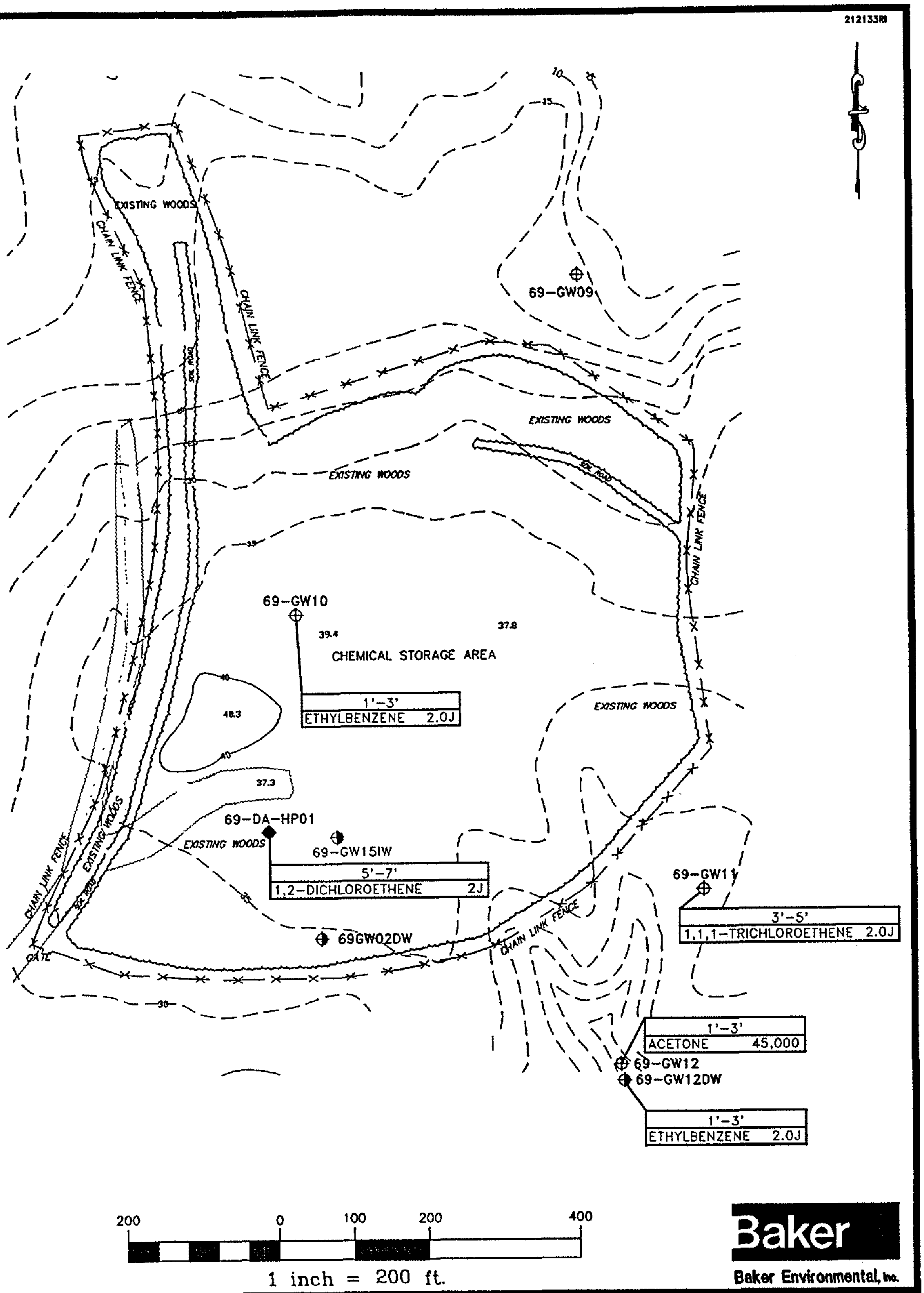
SB01 ◉	SURFACE SOIL SAMPLING LOCATION
—×— —×—	FENCE
~~	VEGETATION
/ —40—	TOPOGRAPHIC ELEVATION LINES (FEET, MSL)

ALL CONCENTRATIONS REPORTED IN MICROGRAMS PER KILOGRAM (ug/kg).

SOURCE: REVISED FROM LANTDIV, OCT. 1991

FIGURE 4-4
POSITIVE DETECTIONS OF CHEMICAL SURETY MATERIAL IN SURFACE SOILS
SITE 69 – RIFLE RANGE CHEMICAL DUMP
REMEDIAL INVESTIGATION CTO-0212
MARINE CORPS BASE, CAMP LEJEUNE
NORTH CAROLINA

212133RI



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LEGEND

69-GW09 EXISTING SHALLOW WELLS (BAKER)

69-GW02DW EXISTING DEEP WELLS (BAKER)

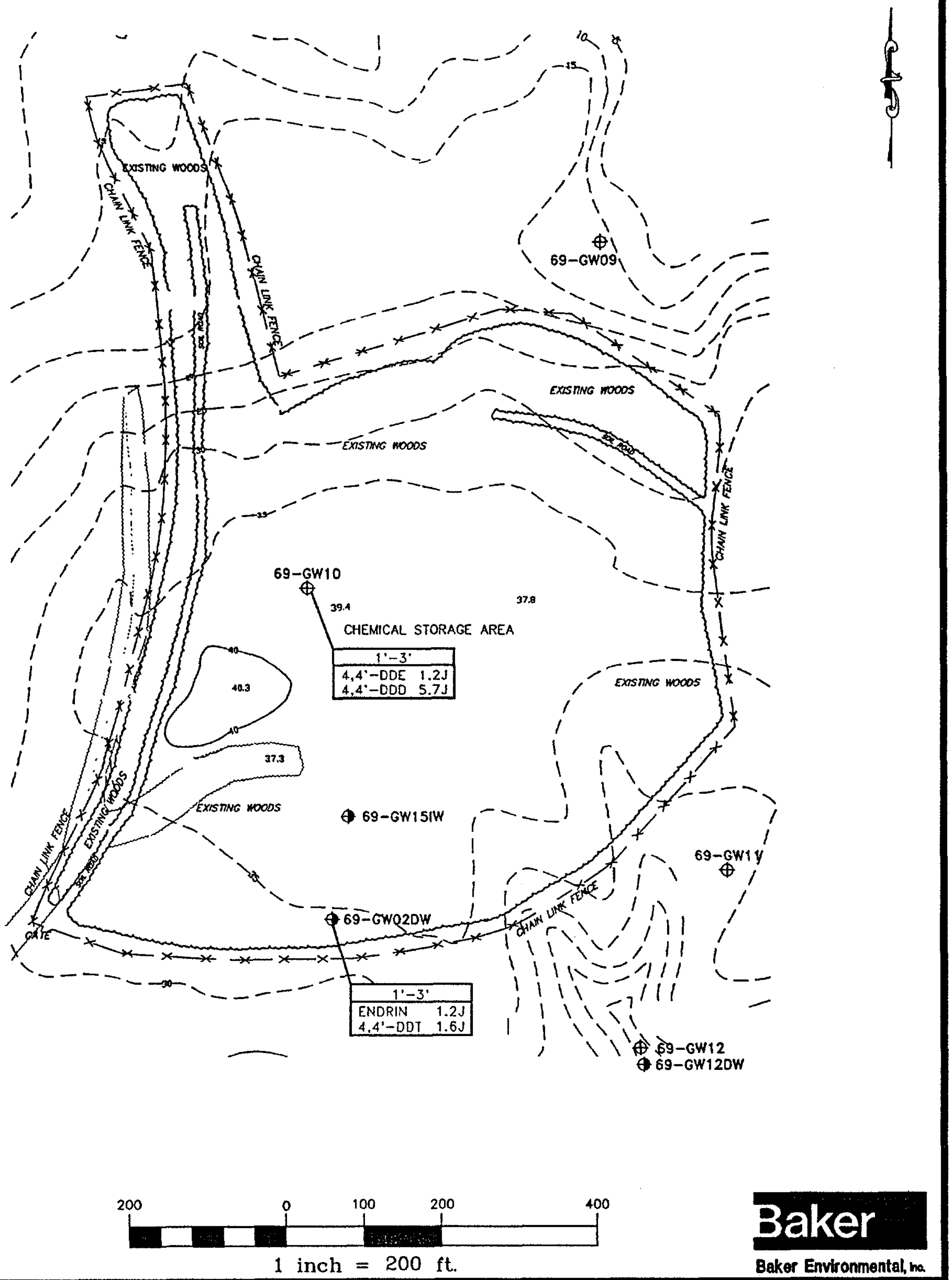
69-DA-HP01 HYDROPUNCH LOCATION

— —30— — TOPOGRAPHIC ELEVATION LINES (FEET, MSL)

ALL CONCENTRATIONS REPORTED IN MICROGRAMS PER KILOGRAM (ug/kg).

SOURCE: REVISED FROM LANTDIV, OCT. 1991

FIGURE 4-5
POSITIVE DETECTIONS OF VOCs IN SUBSURFACE SOILS
SITE 69 – RIFLE RANGE CHEMICAL DUMP
REMEDIAL INVESTIGATION CTO-0212
MARINE CORPS BASE, CAMP LEJEUNE
NORTH CAROLINA



LEGEND

69-GW09 ⊕ EXISTING SHALLOW WELLS

69-GW02DW ● EXISTING DEEP WELLS

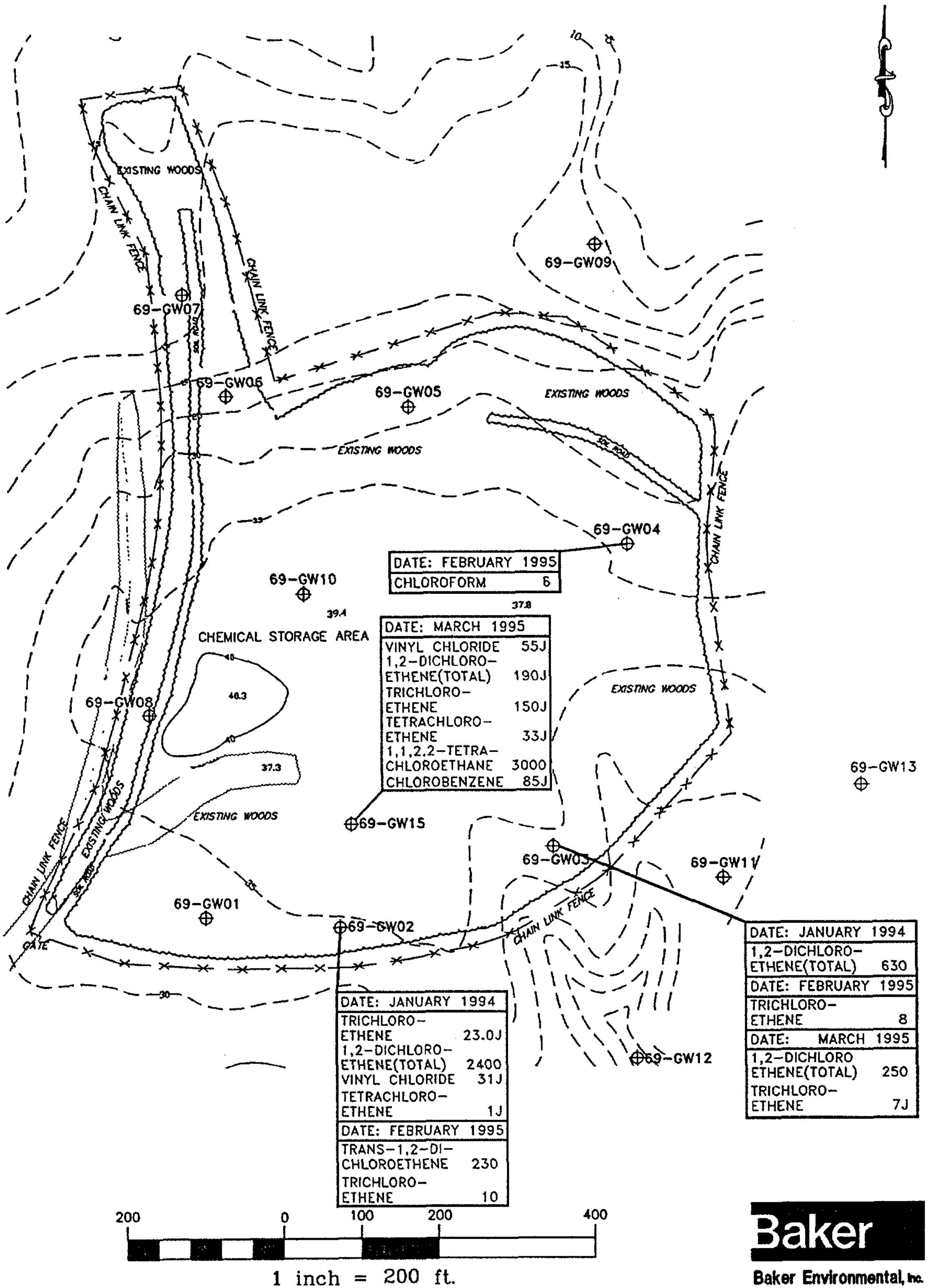
- -30- - TOPOGRAPHIC ELEVATION LINES (FEET, MSL)

ALL CONCENTRATIONS REPORTED IN MICROGRAMS PER KILOGRAM (ug/kg).

SOURCE: REVISED FROM LANTDIV, OCT. 1991

FIGURE 4-6
POSITIVE DETECTION OF PESTICIDES IN SUBSURFACE SOILS
SITE 69 – RIFLE RANGE CHEMICAL DUMP
REMEDIAL INVESTIGATION CTO-0212
MARINE CORPS BASE, CAMP LEJEUNE
NORTH CAROLINA

212135RI



DATE: FEBRUARY 1995	
CHLOROFORM	6

DATE: MARCH 1995	
VINYL CHLORIDE	55J
1,2-DICHLOROETHENE(TOTAL)	190J
TRICHLOROETHENE	150J
TETRACHLOROETHENE	33J
1,1,2,2-TETRACHLOROETHANE	3000
CHLOROBENZENE	85J

DATE: JANUARY 1994	
TRICHLOROETHENE	23.0J
1,2-DICHLOROETHENE(TOTAL)	2400
VINYL CHLORIDE	31J
TETRACHLOROETHENE	1J
DATE: FEBRUARY 1995	
TRANS-1,2-DICHLOROETHENE	230
TRICHLOROETHENE	10

DATE: JANUARY 1994	
1,2-DICHLOROETHENE(TOTAL)	630
DATE: FEBRUARY 1995	
TRICHLOROETHENE	8
DATE: MARCH 1995	
1,2-DICHLORO ETHENE(TOTAL)	250
TRICHLOROETHENE	7J

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LEGEND

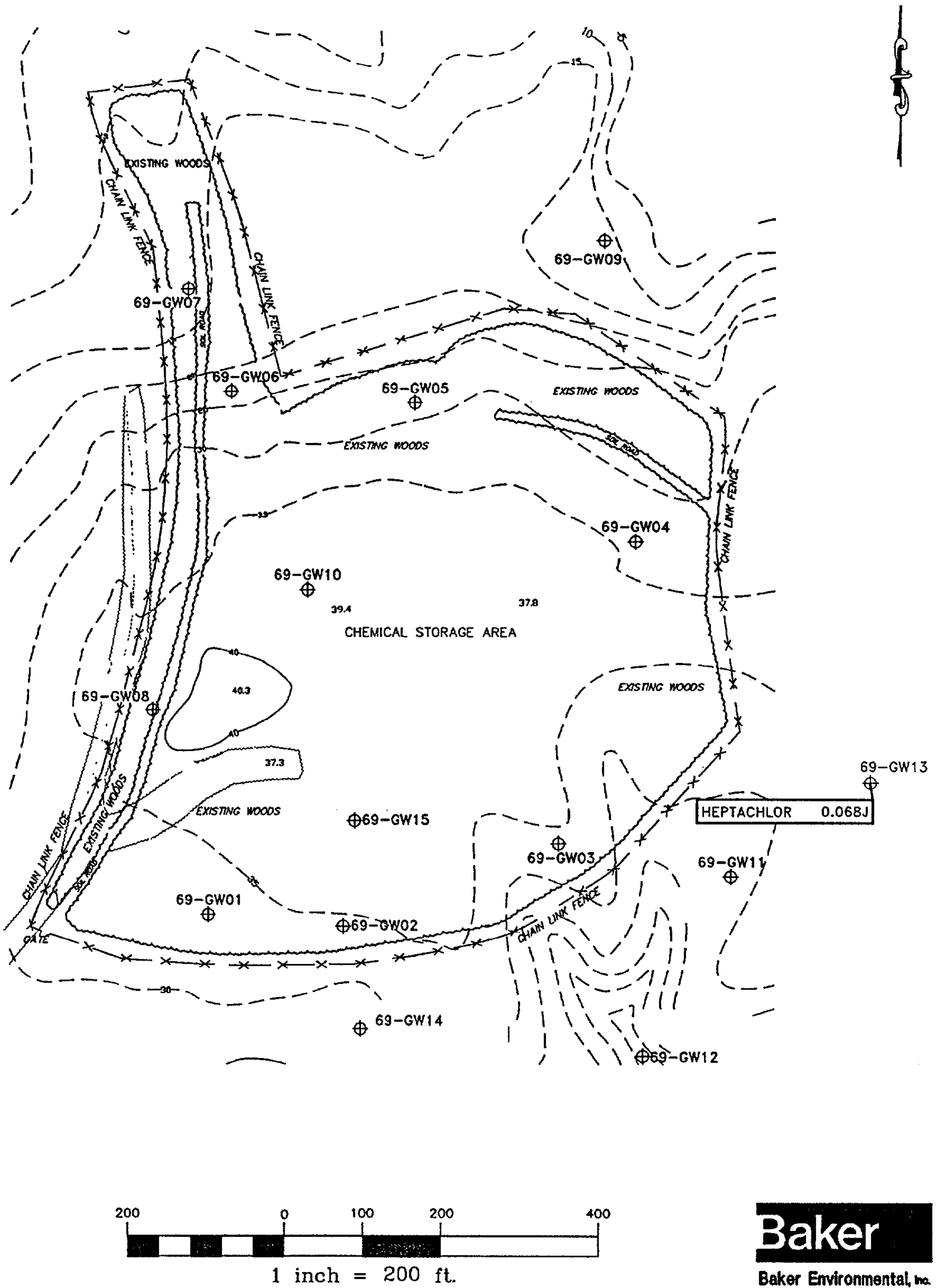
69-GW09 ⊕	EXISTING SHALLOW WELLS
--30--	TOPOGRAPHIC ELEVATION LINES (FEET, MSL)

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

SOURCE: REVISED FROM LANTDIV, OCT. 1991

FIGURE 4-7
POSITIVE DETECTIONS OF VOLATILES ABOVE FEDERAL MCLs AND/OR NCWQS IN SHALLOW WELLS
SITE 69 - RIFLE RANGE CHEMICAL DUMP
REMEDIAL INVESTIGATION CTO-0212
MARINE CORPS BASE, CAMP LEJEUNE
NORTH CAROLINA

212136RI



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LEGEND

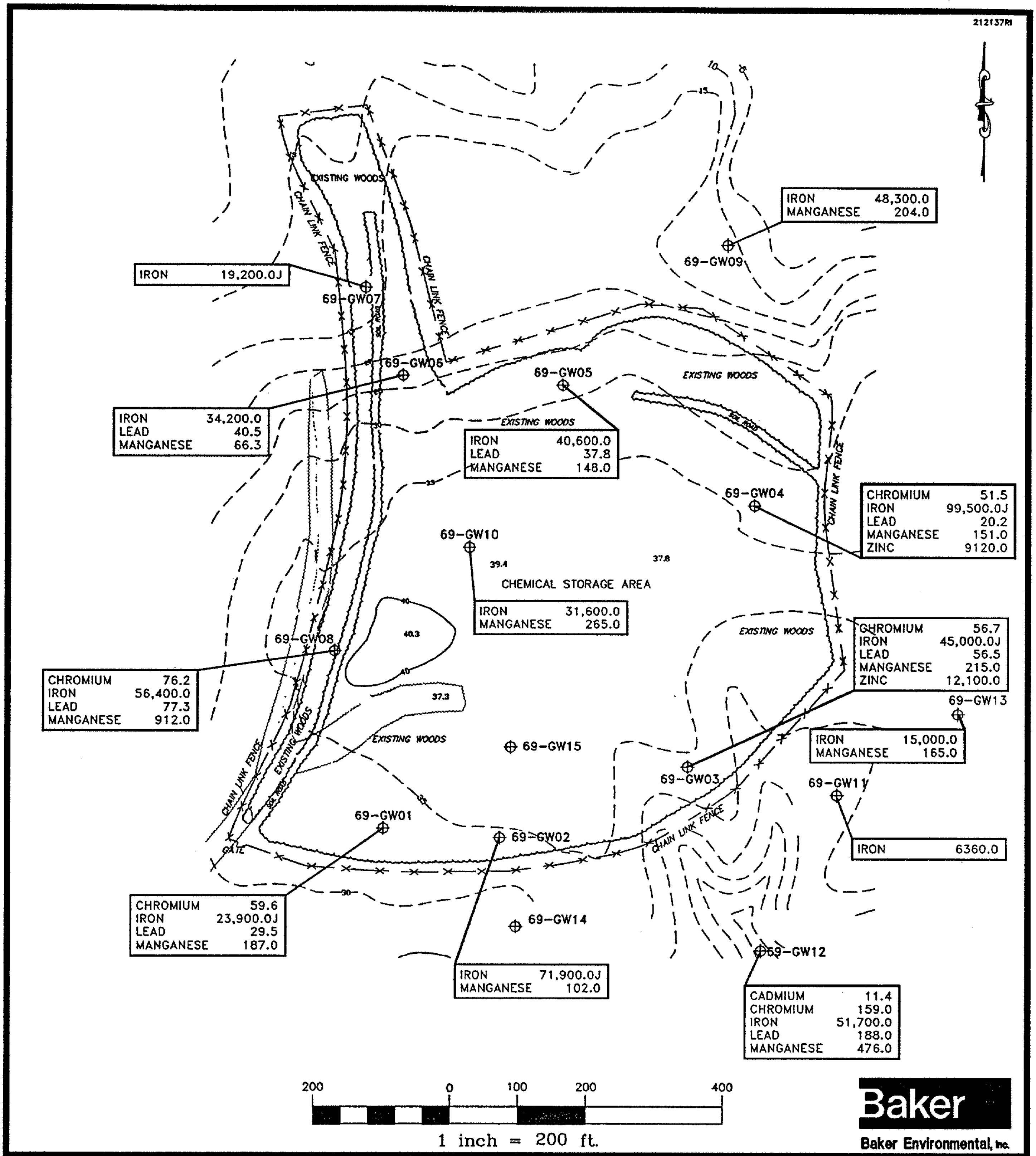
69-GW09 ⊕ EXISTING SHALLOW WELLS

—30— TOPOGRAPHIC ELEVATION LINES (FEET, MSL)

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

SOURCE: REVISED FROM LANTDIV, OCT. 1991

FIGURE 4-8
POSITIVE DETECTIONS OF PESTICIDES FOR ROUND 1 ABOVE FEDERAL MCLs AND/OR NCWQS IN SHALLOW WELLS
SITE 69 - RIFLE RANGE CHEMICAL DUMP
REMEDIAL INVESTIGATION CTO-0212
MARINE CORPS BASE, CAMP LEJEUNE
NORTH CAROLINA



Baker
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LEGEND

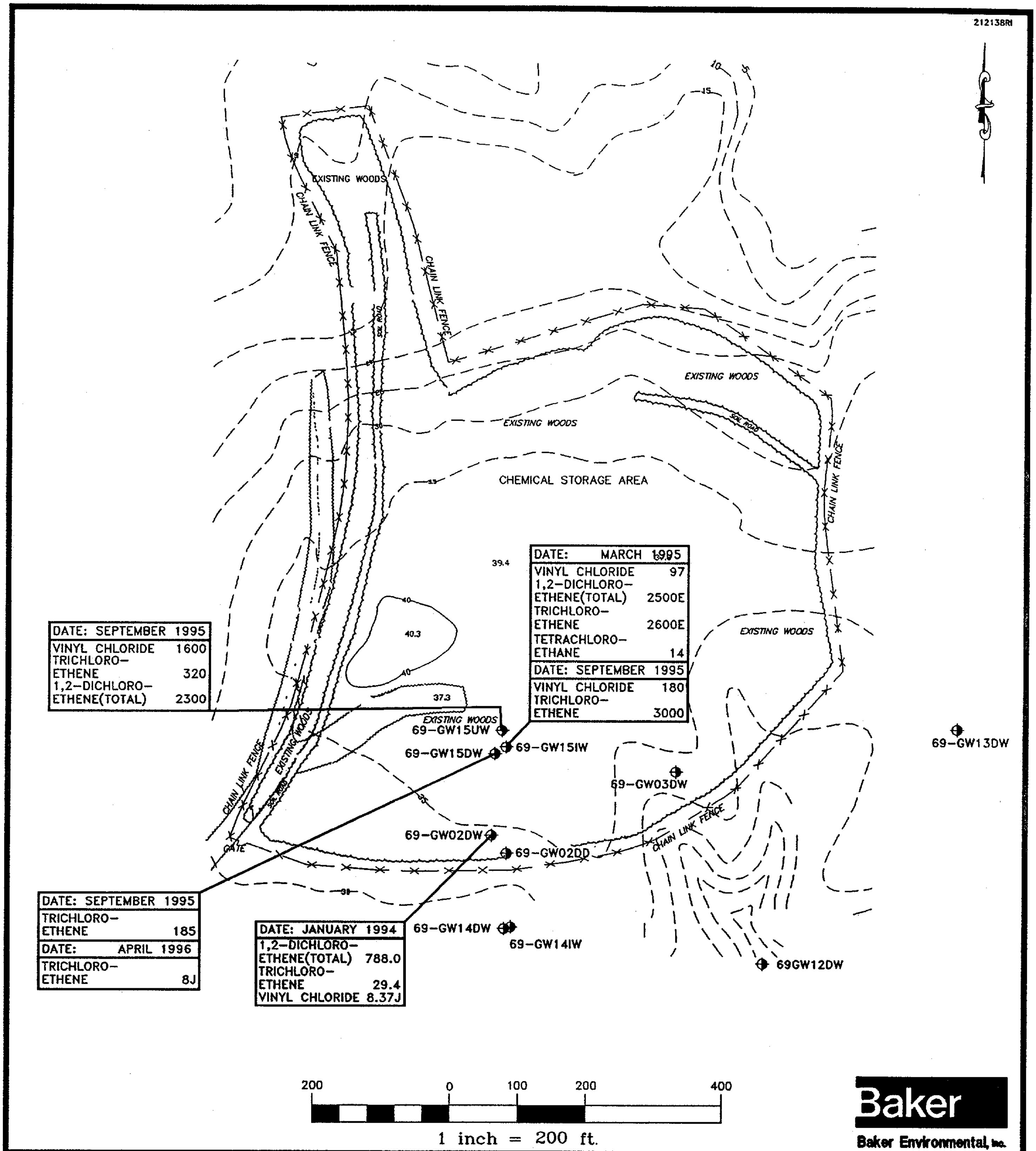
69-GW09 ⊕ EXISTING SHALLOW WELLS

--30-- TOPOGRAPHIC ELEVATION LINES (FEET, MSL)

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

SOURCE: REVISED FROM LANTDIV, OCT. 1991

FIGURE 4-9
POSITIVE DETECTIONS OF TAL METALS FOR ROUND 1 ABOVE FEDERAL MCLs AND/OR NCWQS IN SHALLOW WELLS
SITE 69 - RIFLE RANGE CHEMICAL DUMP
REMEDIAL INVESTIGATION CTO-0212
MARINE CORPS BASE, CAMP LEJEUNE
NORTH CAROLINA



DATE: SEPTEMBER 1995	
VINYL CHLORIDE	1600
TRICHLORO-ETHENE	320
1,2-DICHLORO-ETHENE(TOTAL)	2300

DATE: MARCH 1995	
VINYL CHLORIDE	97
1,2-DICHLORO-ETHENE(TOTAL)	2500E
TRICHLORO-ETHENE	2600E
TETRACHLORO-ETHANE	14
DATE: SEPTEMBER 1995	
VINYL CHLORIDE	180
TRICHLORO-ETHENE	3000

DATE: SEPTEMBER 1995	
TRICHLORO-ETHENE	185
DATE: APRIL 1996	
TRICHLORO-ETHENE	8J

DATE: JANUARY 1994	
1,2-DICHLORO-ETHENE(TOTAL)	788.0
TRICHLORO-ETHENE	29.4
VINYL CHLORIDE	8.37J

Baker

Baker Environmental, Inc.

LEGEND

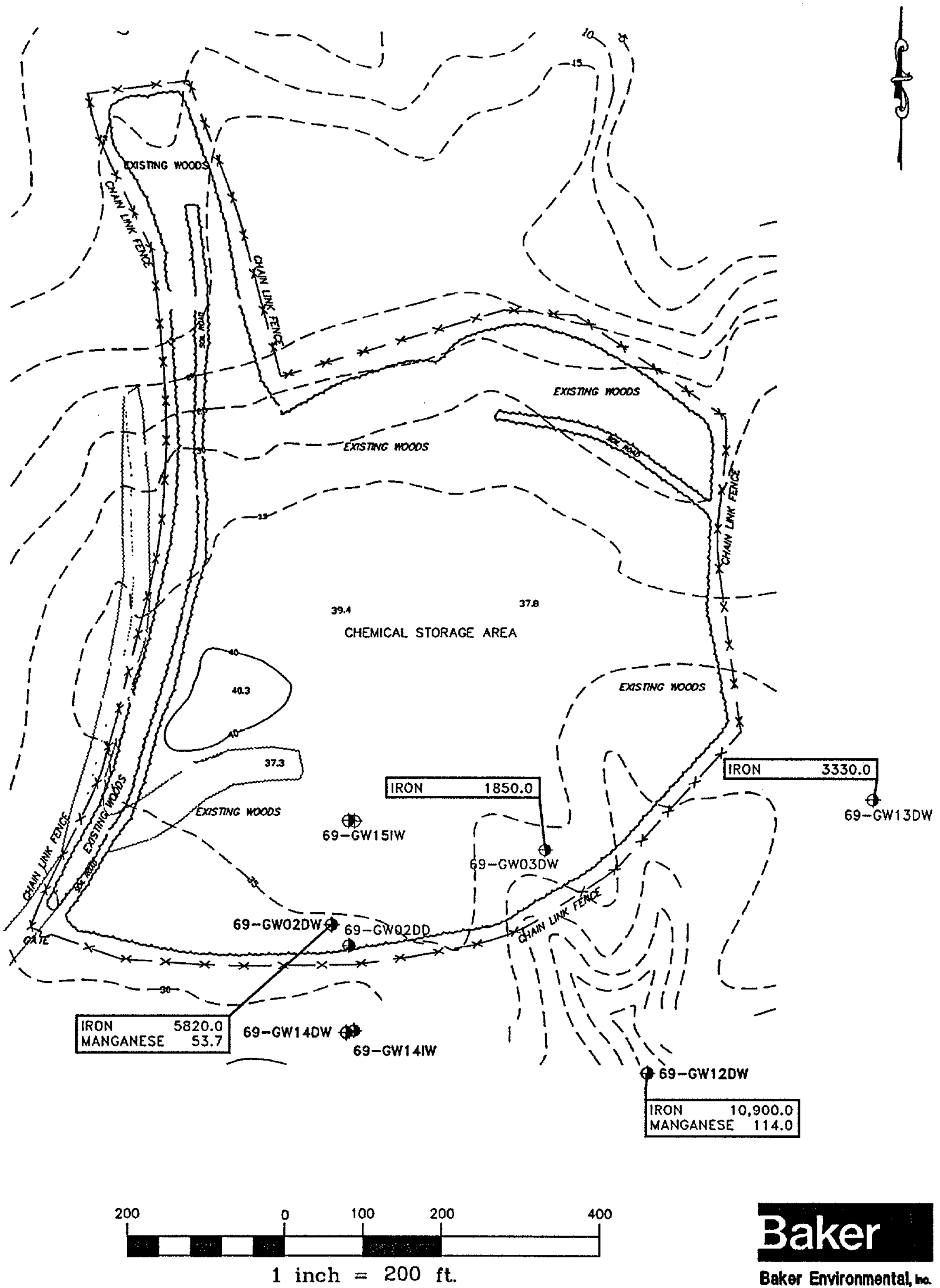
69-GW02DW ⊕ EXISTING CASTLE HAYNE WELLS

— -30- — TOPOGRAPHIC ELEVATION LINES (FEET, MSL)

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

SOURCE: REVISED FROM LANTDIV, OCT. 1991

FIGURE 4-10
POSITIVE DETECTIONS OF VOLATILES
ABOVE FEDERAL MCLs AND/OR NCWQS
IN THE CASTLE HAYNE AQUIFER
SITE 69 - RIFLE RANGE CHEMICAL DUMP
REMEDIAL INVESTIGATION CTO-0212
MARINE CORPS BASE, CAMP LEJEUNE
NORTH CAROLINA



Baker

Baker Environmental, Inc.

LEGEND

69GW02DW EXISTING DEEP WELLS

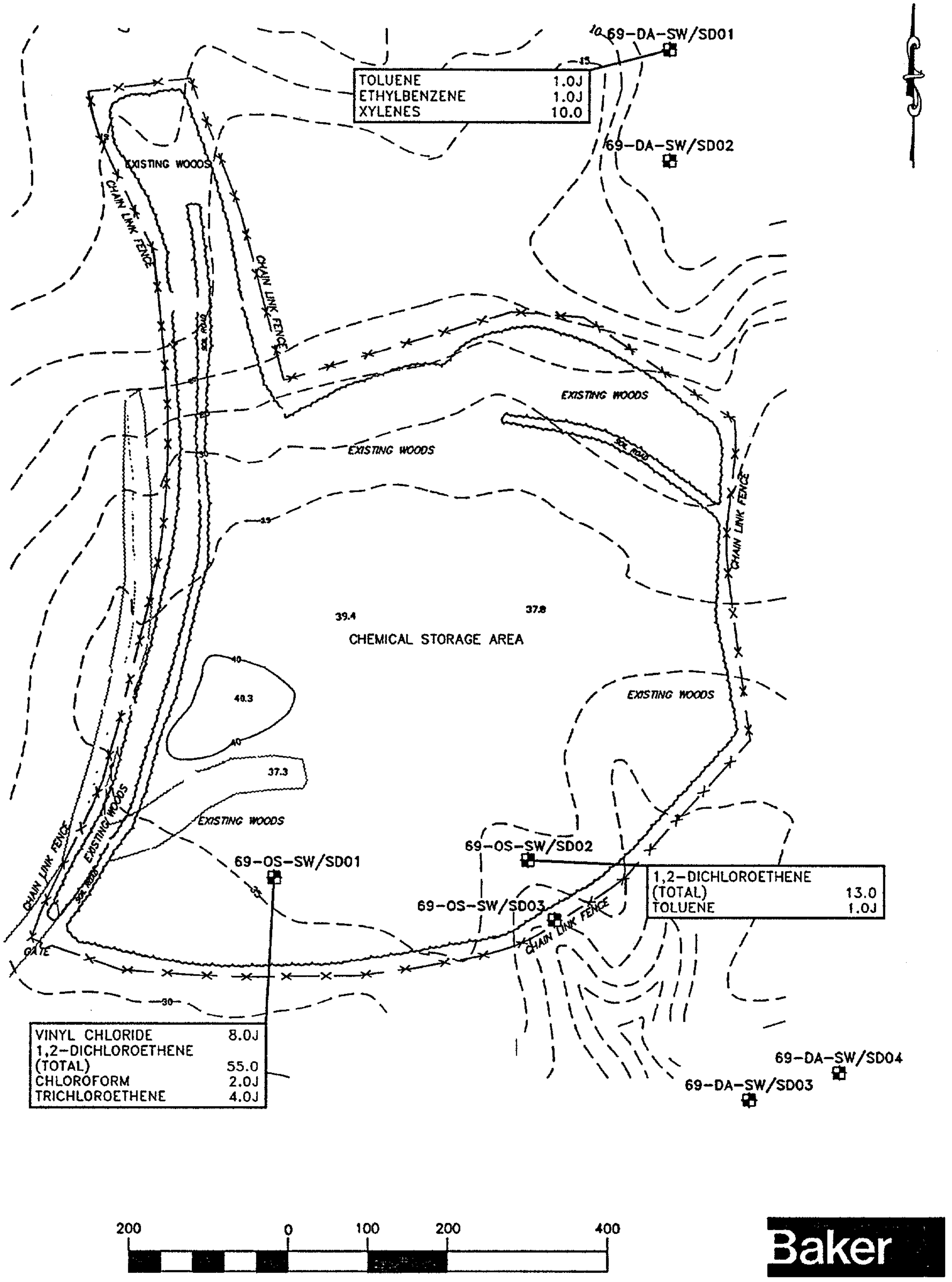
—30— TOPOGRAPHIC ELEVATION LINES (FEET, MSL)

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

SOURCE: REVISED FROM LANTDIV, OCT. 1991

FIGURE 4-11
POSITIVE DETECTIONS OF TAL METALS FOR ROUND 1 ABOVE FEDERAL MCLs AND/OR NCWQS IN DEEP WELLS
SITE 69 - RIFLE RANGE CHEMICAL DUMP
REMEDIAL INVESTIGATION CTO-0212
MARINE CORPS BASE, CAMP LEJEUNE
NORTH CAROLINA

212140RI



Baker

Baker Environmental, Inc.

LEGEND

69-DA-SW/SD01 ⊞ SURFACE WATER/SEDIMENT SAMPLE LOCATION

FENCE

VEGETATION

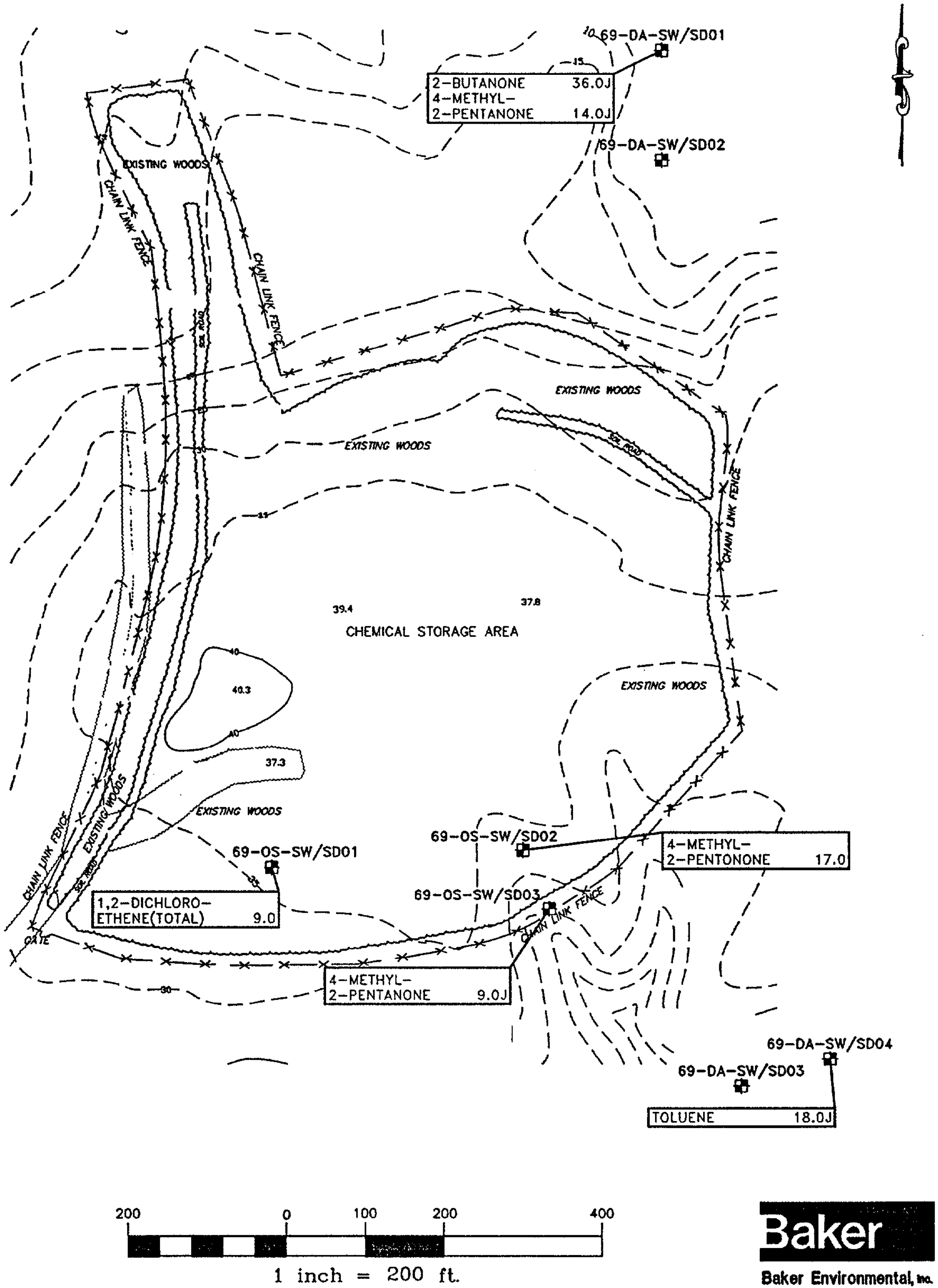
TOPOGRAPHIC ELEVATION LINES (FEET, MSL)

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

SOURCE: REVISED FROM LANTDIV, OCT. 1991

FIGURE 4-12
POSITIVE DETECTIONS OF VOLATILES
IN SURFACE WATER
SITE 69 – RIFLE RANGE CHEMICAL DUMP
REMEDIAL INVESTIGATION CTO-0212
MARINE CORPS BASE, CAMP LEJEUNE
NORTH CAROLINA

212141RI



Baker Environmental, Inc.

LEGEND

69-DA-SW/SD01 SURFACE WATER/SEDIMENT SAMPLE LOCATION

FENCE

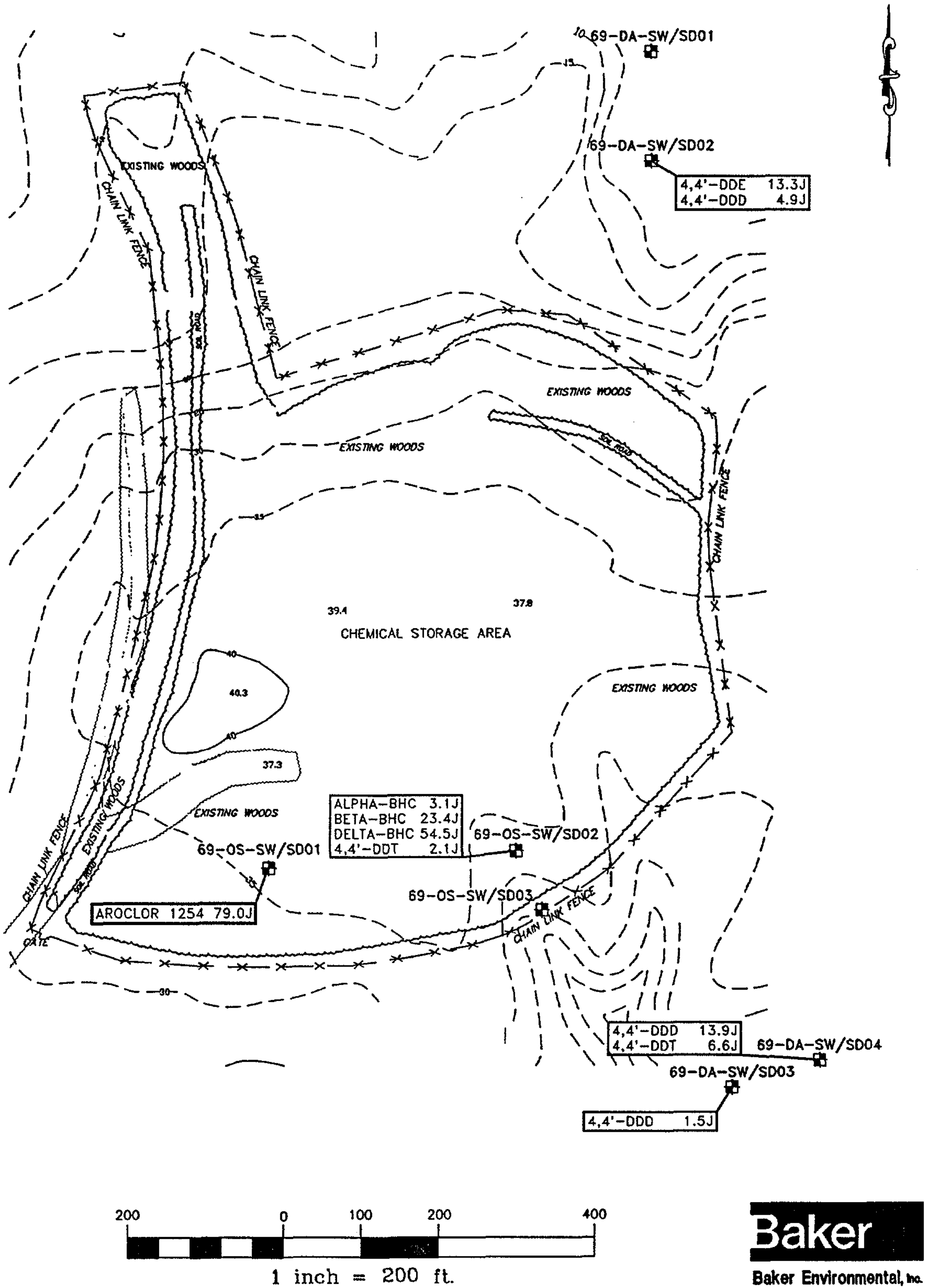
VEGETATION

TOPOGRAPHIC ELEVATION LINES (FEET, MSL)

ALL CONCENTRATIONS REPORTED IN MICROGRAMS PER KILOGRAM (ug/kg).

SOURCE: REVISED FROM LANTDIV, OCT. 1991

FIGURE 4-13
POSITIVE DETECTIONS OF VOLATILES IN SEDIMENT
SITE 69 - RIFLE RANGE CHEMICAL DUMP
REMEDIAL INVESTIGATION CTO-0212
MARINE CORPS BASE, CAMP LEJEUNE
NORTH CAROLINA



Baker

Baker Environmental, Inc.

LEGEND

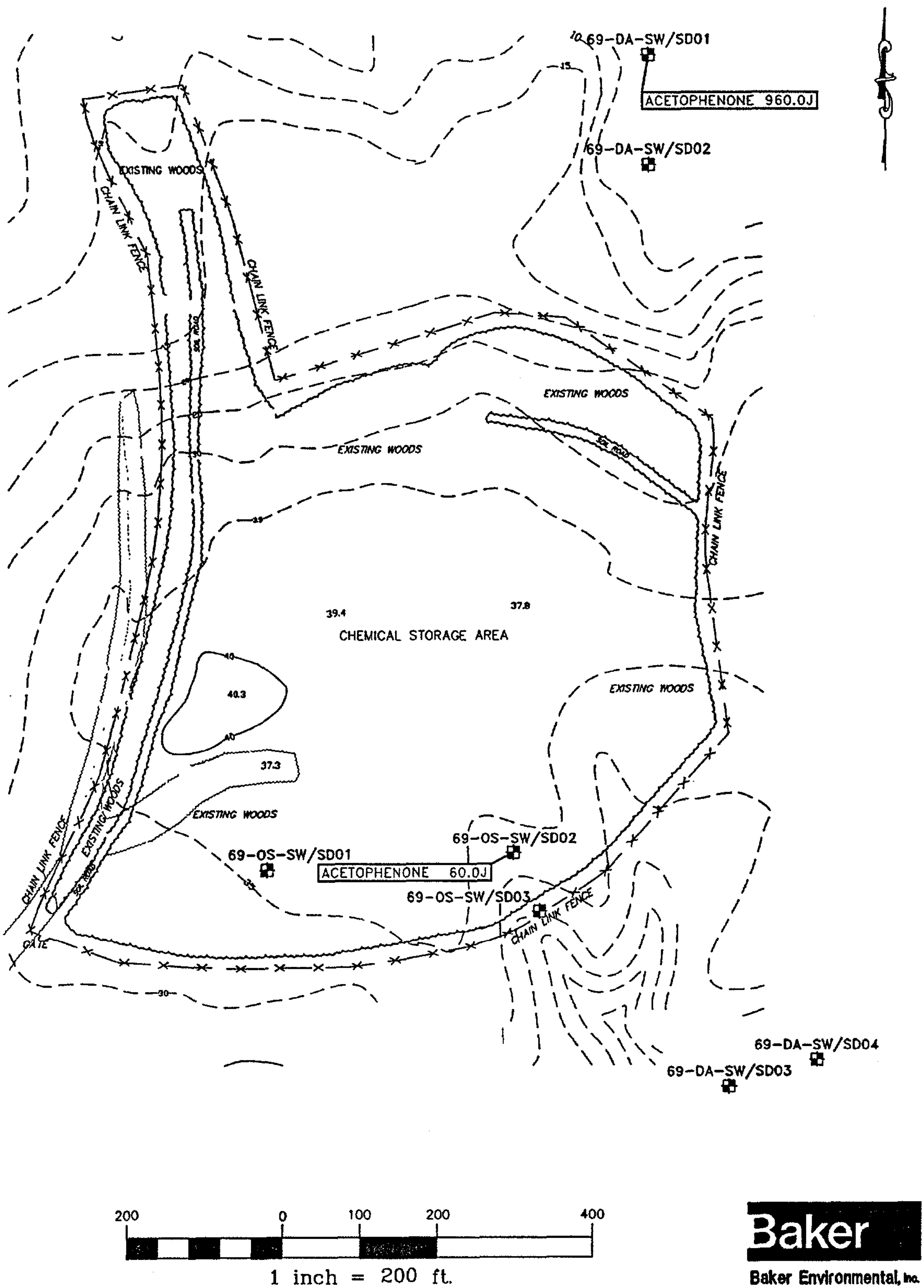
69-DA-SW/SD01 ⊞	SURFACE WATER/SEDIMENT SAMPLE LOCATION
—×— —×—	FENCE
⁓⁓	VEGETATION
/—40—_	TOPOGRAPHIC ELEVATION LINES (FEET, MSL)

ALL CONCENTRATIONS REPORTED IN MICROGRAMS PER KILOGRAM (ug/kg).

SOURCE: REVISED FROM LANTDIV, OCT. 1991

FIGURE 4-14
POSITIVE DETECTIONS OF PESTICIDES/ PCBs IN SEDIMENT
SITE 69 - RIFLE RANGE CHEMICAL DUMP REMEDIAL INVESTIGATION CTO-0212
MARINE CORPS BASE, CAMP LEJEUNE NORTH CAROLINA

212143RI



Baker

Baker Environmental, Inc.

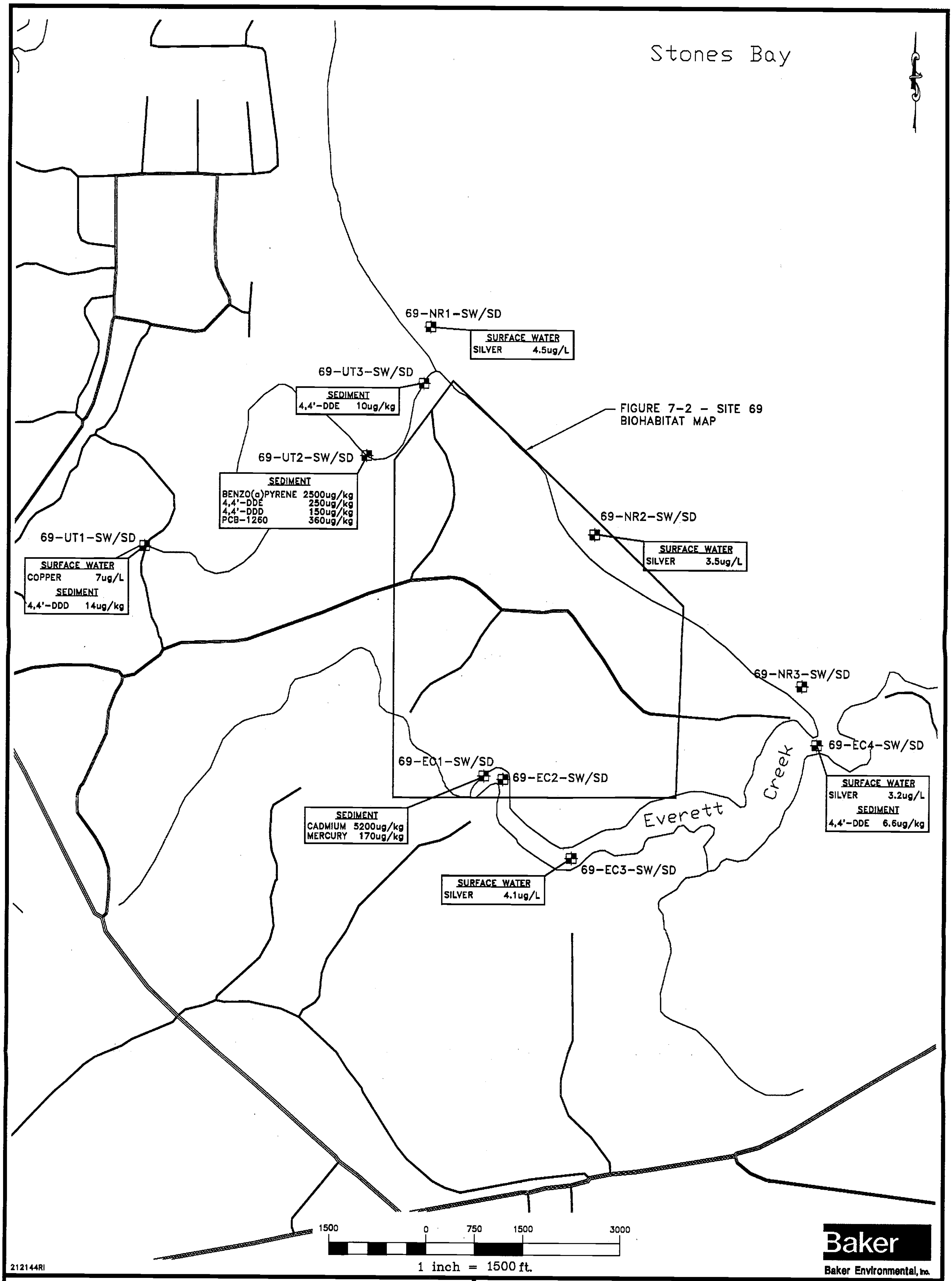
LEGEND

69-DA-SW/SD01 ▣	SURFACE WATER/SEDIMENT SAMPLE LOCATION
—×—	FENCE
⁀	VEGETATION
-- 40 --	TOPOGRAPHIC ELEVATION LINES (FEET, MSL)

ALL CONCENTRATIONS REPORTED IN MICROGRAMS PER KILOGRAM (ug/kg).

SOURCE: REVISED FROM LANTDIV, OCT. 1991

FIGURE 4-15
POSITIVE DETECTIONS OF CHEMICAL SURETY MATERIAL IN SEDIMENT
SITE 69 - RIFLE RANGE CHEMICAL DUMP
REMEDIAL INVESTIGATION CTO-0212
MARINE CORPS BASE, CAMP LEJEUNE
NORTH CAROLINA



LEGEND

UT - UNNAMED TRIBUTARY
EC - EVERETT CREEK
NR - NEW RIVER

FIGURE 4-16
POSITIVE DETECTIONS OF TCL ORGANICS AND TAL METALS IN SURFACE WATER AND SEDIMENT ABOVE AQUATIC REFERENCE VALUES AT SITE 69
REMEDIAL INVESTIGATION CTO-0212
MARINE CORPS BASE, CAMP LEJEUNE
NORTH CAROLINA

01761N122

5.0 CONTAMINANT FATE AND TRANSPORT

The potential for a contaminant to migrate and persist in an environmental medium is critical when evaluating the potential for a chemical to elicit an adverse human health or ecological effect. The environmental mobility of a chemical is influenced by its physical and chemical properties, the physical characteristics of the site, and the site chemistry. This section presents a discussion of the various physical and chemical properties of contaminants detected at OU No. 14 that impact the fate and transport of the contaminants in the environment. The basis for this discussion of contaminant fate and transport is discussed in Section 4.0, Nature and Extent of Contamination.

5.1 Chemical and Physical Properties Impacting Fate and Transport

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

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

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

Vapor pressure provides an indication of the rate at which a chemical may volatilize. It is of primary significance at environmental interfaces such as surface soil/air and surface water/air. Volatilization is not as important when evaluating groundwater and subsurface soils. Vapor pressure for monocyclic aromatics are generally higher than vapor pressures for PAHs. Contaminants with higher vapor pressures will enter the atmosphere at a quicker rate than the contaminants with low vapor pressures.

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

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

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

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

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

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

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

A scale to evaluate MI is presented by Ford and Gurba (1894):

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

5.2 Contaminant Transport Pathways

Based on the evaluation of existing conditions at Site 69, the following potential contaminant transport pathways have been identified.

- On-site atmospheric deposition of windblown dust.
- Leaching of sediment contaminants to surface water.
- Migration of contaminants in surface water.
- Leaching of soil contaminants to groundwater.
- Migration of groundwater contaminants off site.
- Groundwater infiltration from the shallow aquifer to the deep aquifer.

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

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

The following paragraphs describe the potential transport pathways listed above.

5.2.1 On-Site Deposition of Windblown Dust

Wind can act as a contaminant transport pathway agent by eroding exposed soil and exposed sediment and blowing it off site. This is influenced by: wind velocity, the grain size/density of the soil/sediment particles and the amount of vegetative cover over the soil or sediment.

A majority of the surface area of each site is vegetated (i.e., grass, trees), which would serve to retard airborne migration of site contaminants.

5.2.2 Leaching of Sediment Contaminants to Surface Water

When in contact with surface water, contaminants attached to sediment particles can disassociate from the sediment particle into surface water. This is primarily influenced by the physical and chemical properties of the contaminant, (i.e., water solubility, K_{oc}) and the physical and chemical properties of the sediment particle (i.e., grain size, f_{oc}).

Surface water sample analytical results indicate that there has not been significant leaching of sediment contaminants into surface water (Section 4.0), based on the infrequent occurrence and level of contamination.

5.2.3 Leaching of Soil Contaminants to Groundwater

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

Groundwater samples were collected from shallow and deep monitoring wells at Site 69. 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.

5.2.4 Migration of Groundwater Contaminants

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

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

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

Dispersion results from two basic processes, molecular diffusion and mechanical mixing. The kinetic activity of dissolved solutes result in diffusion of solutes from a zone of high concentration to a lower concentration. Dispersion and spreading during transport result in the dilution of contaminants (maximum concentration of contaminant decreases with distance from the plume). For simple hydrogeological systems, the spreading is reported to be proportional to the flow rate. Furthermore, dispersion in the direction of flow is often observed to be markedly greater than dispersion in the directions transverse (perpendicular) to the flow. In the absence of detailed studies to determine dispersive characteristics at all the sites, longitudinal and transverse dispersivities are estimated based on similar hydrogeological systems (Mackay, et al., 1985).

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

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

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

The soils and sediments formed or deposited on the land surface can act as a reservoir for inorganic contaminants. Soils contain surface-active mineral and humic constituents involved in reactions that affect metal retention. The surfaces of fine-grained soil particles are very active chemically; surface sites are negatively or positively charged or they are electronically neutral. Oppositely charged metallic counterions from solutions in soils (i.e., groundwater) are attracted to these charged surfaces. The relative proportions of ions attracted to these various sites depends on the degree of acidity or alkalinity of the soil, on its mineralogical composition, and on its content of organic matter. The extent of adsorption depends on either the respective charges on the adsorbing surface and the metallic cation. In addition to these adsorption reactions, precipitation of new mineral phases also may occur if the chemical composition of the soil solution becomes supersaturated with respect to the insoluble precipitates. Of the probable precipitates, the most important of these phases are hydroxides, carbonates, and sulfides. The precipitation of hydroxide minerals is important for metals such as iron and aluminum, the precipitation of carbonate minerals is significant for calcium and barium, and the precipitation of sulfide minerals dominates the soil chemistry of zinc, cadmium, and mercury. A number of precipitates may form if metals are added to soils, the concentration of metal in solution, will be controlled, at equilibrium, by the solid phase that results in the lowest value of the activity of the metallic ion in solution (Evans, 1989).

Table 5-2 presents the general processes which influence the aquatic fate of contaminants at OU No. 14.

The following paragraphs summarize the site-specific fate and transport data for some potential contaminants of concern at OU No. 14.

5.3 Fate and Transport Summary

The following paragraphs summarize the contaminant group fate and transport data for contaminants detected in media collected at OU No. 14.

5.3.1 Volatile Organic Compounds

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

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

5.3.2 Polynuclear Aromatic Hydrocarbons (PAHs)

Low water solubilities, high K_{ow} and K_{oc} indicate a strong tendency for PAHs to adsorb to soils. Of the PAHs, fluoranthene, is probably the best marker compound, since it is consistently the most abundant of the PAHs measured and provides the strongest correlation with total PAH values. Benzo(g, h, i) perylene is usually the most abundant compound in soils with low PAH values but becomes less important with increasing total PAH values. Other PAH are benzo(a)anthracene, chrysene, pyrene, benzo(g,h,i) perylene, benzo(b)fluoranthene and phenanthrene. Their mobility indices indicate that they are relatively immobile from a physical-chemical standpoint. An exception is naphthalene, which is considered only slightly immobile because of somewhat higher water solubility (Jones, et al., 1989).

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

PAHs are somewhat persistent in the environment. In general their persistence increases with increasing ring numbers. Photolysis and oxidation may be important removal mechanisms in surface waters and surficial soils, while biodegradation could be an important fate process in groundwater, surface soils or deeper soils. PAHs are ubiquitous in nature. The presence of PAHs in the soil may be the result of aerially deposited material, and the chemical and biological conditions in the soil which result in selective microbial degradation/breakdown.

5.3.3 Pesticides/Polychlorinated Biphenyls

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

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

5.3.4 Inorganics

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

The most complicated pathway for inorganic contaminants is migration in subsurface soils and groundwaters, where oxidation reduction potential (Eh) and pH play critical roles. Table 5-3 presents and assessment of relative inorganic environmental mobilities as a function of Eh and pH.

Soils at MCB Camp Lejeune are relatively neutral, therefore, inorganics in the subsurface soil should be relatively immobile.

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

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

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

SECTION 5.0 TABLES

TABLE 5-1

ORGANIC PHYSICAL AND CHEMICAL PROPERTIES
REMEDIAL INVESTIGATION CTO-0212
MCB CAMP LEJEUNE, NORTH CAROLINA

Chemical	Vapor Pressure (mm Hg)	Water Solubility (mg/L)	Octanol/Water Coefficient (log K_{ow})	Sediment Partition (log K_{oc})	Specific Gravity (g/cm^3)	Henry's Law Constant (atm-m^3/mole)	Mobility Index	Comments
Volatiles:								
Benzene	76	1780	2.13	1.92	0.879	5.55E-03	3.2	Very mobile
Bromodichloromethane	50	4500	2.10	1.79	--	2.41E-03	3.6	Very mobile
Chlorobenzene	8.8	500	2.84	2.64	1.1066	3.58E-03	1	Very mobile
1,1-Dichloroethene	500	400	1.48	2.26	1.218	1.90E-01	3.0	Very mobile
1,2-Dichloroethene	200	600	1.48	2.17	1.26	5.32E-03	2.9	Very mobile
Ethylbenzene	7	152	3.15	2.93	0.867	6.44E-03	0.1	Very mobile
Tetrachloroethene	14	150	2.6	2.6	1.626	2.87E-03	0.75	Very mobile
Toluene	22	515	2.69	2.54	0.867	5.90E-03	1.5	Very mobile
1,1,2,2-Trichloroethane	5	2900	2.56	1.92	1.60	3.83E-04	2.2	Very mobile
Trichloroethene	60	1100	2.29	2.09	1.46	1.17E-03	2.7	Very mobile
Vinyl chloride	2660	1100	0.6	1.91	0.9121	8.14E-02	4.6	Very mobile
Xylenes (total)	6	180	3.02	2.84	0.87	4.64E-03	0.19	Very mobile
Semivolatiles:								
Benzo(a)anthracene	5.0E-09	0.014	5.61	5.34	NA	1.0E-06	-15.5	Very Immobile
Benzo(b)fluoranthene	10E-06 to 10E-07	0.009	6.57	6.26	NA	1.22E-05	-14	Very Immobile
Benzo(k)fluoranthene	9.6E-11	0.0016	6.84	6.22	NA	3.87E-05	-19	Very Immobile
Benzo(a)pyrene	5.0E-09	0.0038	6.04	5.72	NA	4.9E-07	-16.4	Very Immobile
Chrysene	10E-06 to 10E-11	0.006	5.61	5.44	1.274	1.1E-06	-13.7	Very Immobile
1,4-Dichlorobenzene	6.0E-01	49	3.39	3.22	1.458	3.1E-03	-1.8	Slightly mobile
Fluoranthene	10E-06 to 10E-04	0.265	5.33	4.84	NA	6.5E-06	-9.4	Immobile
Ideno(1,2,3-cd)pyrene	1E-10	5.3E-04	6.51	6.20	1.070	6.95E-08	-19.5	Very Immobile
Pyrene	6.85	0.14	5.32	4.91	NA	5.1E-06	-11.9	Very Immobile

TABLE 5-1 (Continued)

ORGANIC PHYSICAL AND CHEMICAL PROPERTIES
REMEDIAL INVESTIGATION CTO-0212
MCB CAMP LEJEUNE, NORTH CAROLINA

Chemical	Vapor Pressure (mm Hg)	Water Solubility (mg/L)	Octanol/Water Coefficient (log K_{ow})	Sediment Partition (log K_{oc})	Specific Gravity (g/cm^3)	Henry's Law Constant (atm-m^3/mole)	Mobility Index	Comments
Pesticides/PCBs:								
Aldrin	2.31E-05	0.01	4.45	3.01	NA	1.6E-05	-11	Immobile
alpha-BHC	2.5E-05	2.0	3.46	3.81	NA	6.0E-06	-7.8	Immobile
beta-BHC	2.8E-07	0.70	3.35	3.80	NA	4.5E-07	-10	Immobile
Chlordane	1.0E-05	1.85	3.19	2.78	NA	4.8E-05	-7.9	Immobile
delta-BHC	1.7E-05	17	3.29	4.14	1.87	3.84E-07	-6.8	Immobile
Dieldrin	1.87E-04	0.1	5.6	4.31	1.75	4.57E-10	-12	Very Immobile
4,4'-DDT	1.9E-07	0.0034	6.19	4.89	NA	1.58E-05	-14	Very immobile
4,4'-DDD	10.2E-07	0.09	5.99	4.47	NA	2.2E-08	-12	Very immobile
4,4'-DDE	6.5E-06	0.04	4.28	3.66	NA	6.8E-05	-10	Immobile
Endosulfan I	9.0E-03	0.10	3.47	3.62	NA	1.0E-05	-6.5	Immobile
Endrin	2.0E-07	0.26	5.6	4.06	NA	4.0E-07	-11	Very Immobile
Heptachlor	3.0E-04	0.18	4.15	5.3	1.57	4.0E-03	-8.4	Immobile
Heptachlor Epoxide	3.0E-04	0.35	3.99	5.0	NA	3.9E-04	-7.9	Immobile
PCB-1254	7.7E-05	0.03	6.03	4.59	1.50	2.80E-03	-10	Immobile
PCB-1260	4.1E-05	0.003	4.87	6.11	1.58	7.1E-03	-12	Immobile

Notes: NA - Not Applicable

Sources:
1. Verscheuren, K. 1983. Handbook of Environmental Data on Organic Chemicals. Van Nostrand Reinhold Co., New York.
2. Lyman, et al. 1982. Handbook of Chemical Property Estimation Methods. Environmental Behavior of Organic Compounds.
3. USEPA. 1982. Aquatic Fate Process Data for Organic Priority Pollutants. Final Report.

TABLE 5-2

PROCESSES INFLUENCING FATE OF ORGANIC POLLUTANTS
REMEDIAL INVESTIGATION CTO-0212
MCB CAMP LEJEUNE, NORTH CAROLINA

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

TABLE 5-2 (Continued)

PROCESSES INFLUENCING FATE OF ORGANIC POLLUTANTS
REMEDIAL INVESTIGATION CTO-0212
MCB CAMP LEJEUNE, NORTH CAROLINA

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

TABLE 5-2 (Continued)

PROCESSES INFLUENCING FATE OF ORGANIC POLLUTANTS
REMEDIAL INVESTIGATION CTO-0212
MCB CAMP LEJEUNE, NORTH CAROLINA

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

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

Notes:

(1) Biodegradation is the only process known to transform polychlorinated biphenyls under environmental conditions, and only the lighter compounds are measurably biodegraded. There is experimental evidence that the heavier polychlorinated biphenyls (five chlorine atoms or more per molecule) can be photolyzed by ultraviolet light, but there are no data to indicate that this process is operative in the environment.

(2) Based on information for 4-nitrophenol.

(3) Based on information for PAHs as a group. Little or no information for these compounds exists.

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

TABLE 5-3

RELATIVE MOBILITIES OF INORGANICS AS A FUNCTION OF ENVIRONMENTAL CONDITIONS (Eh, pH)
REMEDIAL INVESTIGATION CTO-0212
MCB CAMP LEJEUNE, NORTH CAROLINA

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

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

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

6.0 BASELINE RISK ASSESSMENT

6.1 Introduction

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

This BRA is conducted in accordance with current USEPA Risk Assessment Guidance (USEPA, 1989a and USEPA, 1991a), and USEPA Region IV Supplemental Risk Guidance (USEPA, 1992d).

The components of the BRA include:

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

The BRA is divided into seven sections, including the introduction. Section 6.2 establishes the criteria for the selection of contaminants of potential concern (COPCs). The COPCs are chosen, for each media at each site, from an overall list of contaminants detected at the site. Section 6.3 discusses the site characteristics, identifies potential human exposure pathways, and describes potential current and future exposure scenarios. Section 6.4 presents the estimation of potential exposure, discussing the estimation of daily intakes, incremental cancer risks and hazard indices. In addition, advisory criteria for the evaluation of human health is discussed. Section 6.5 discusses the risk characterization. Section 6.6 discusses the sources of uncertainty in the BRA. Section 6.7 provides the conclusion for the potential human health impacts in the form of total site risks. Referenced tables and figures are presented after the text portion of this section.

6.2 Contaminants of Potential Concern

COPCs are site-related contaminants used to quantitatively estimate human exposures and associated potential health effects. Six environmental media were investigated during this RI: surface soils, subsurface soils, groundwater, surface water, sediments, and biota. This section presents the selection of COPCs for these media. The selection of COPCs is based on the initial round of samples collected in January 1994. Findings from additional sampling conducted in June 1994, August 1994, February 1995, and March 1995 were not included in this assessment. These investigations were performed to identify extent of contamination and did not include all media or all initial groundwater sampling points. The discussion of findings presented in Section 4.0, Nature and Extent of Contamination, was used as the basis for this section.

6.2.1 Criteria for Selecting Contaminants of Potential Concern

The criteria used in selecting the COPCs from the constituents detected during the field sampling and analytical phase of the investigation are:

- Historical information
- Prevalence
- Mobility
- Persistence
- Toxicity
- Examination of Federal and State criteria and standards
- Comparison to Risk-Based Concentrations (RBCs)
- Comparison to investigation associated field and laboratory blank data
- Comparison to background or naturally occurring levels
- Comparison to anthropogenic levels

The criteria chosen to establish the COPCs are based on the guidance in the USEPA's Risk Assessment Guidance for Superfund (USEPA, 1989a). A comparison to contaminant-specific criteria is also considered in the selection of COPCs. A brief description of the selection criteria used in choosing final COPCs is presented below. It is not required that a contaminant meet all criteria categories to be retained as a COPC.

6.2.1.1 Historical Information

Site 69 is a former disposal ground (i.e., landfill) and is approximately 6 acres in size. Various wastes have been reportedly disposed at the site including PCBs, fire retardants, pentachlorophenol, 4,4'-DDT, trichloroethylene, malathion, diazinon, lindane, calcium hypochlorite, and high-test hypochlorite.

Access to this area is restricted by a 6-foot high chain link fence with a locked entrance gate. The New River is located about one-quarter mile east of the site. Everett Creek is located about one-half mile south of the site. An unnamed tributary to the New River is situated about one-quarter mile north of the site. Both Everett Creek and the unnamed tributary drain into the New River.

The association of contaminants with site activities based on historical information is used along with the following procedures to determine retention or elimination of contaminants.

6.2.1.2 Prevalence

The frequency of positive detections in sample sets and the level at which a contaminant is detected in a given medium are factors that determine a chemical's prevalence. The judicious use of data is used in setting limits on the inclusion of infrequently detected contaminants. The occurrence of a chemical must be evaluated with respect to the number of samples taken to determine the frequency criterion which warrants the inclusion of a chemical as a COPC. Contaminants that are infrequently detected, (i.e., less than 5 percent, when at least 20 samples of a medium are available) may be artifacts in the data due to 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 the contaminant to be present.

6.2.1.3 Mobility

The physical and chemical properties of a contaminant are responsible for its transport in the environment. These properties, in conjunction with site conditions, determine whether a contaminant will tend to volatilize into the air from surface soils or surface waters, or be transported via advection or diffusion through soils, groundwaters, and surface waters. Physical and chemical properties also describe a contaminant's tendency to adsorb onto soil/sediment particles. Environmental mobility can correspond to either an increased or decreased potential to affect human health and/or the environment.

6.2.1.4 Persistence

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

6.2.1.5 Toxicity

The potential toxicity of a contaminant is an important consideration when selecting COPCs for further evaluation in the human health assessment. For example, the weight-of-evidence (WOE) classification should be considered in conjunction with concentrations detected at the site. Some effects considered in the selection of COPCs include carcinogenicity, mutagenicity, teratogenicity, systemic effects, and reproductive toxicity. Bioaccumulation and bioconcentration properties may affect the severity of the toxic response in an organism and/or subsequent receptors and are evaluated if relevant data exist.

Despite their inherent toxicity, certain inorganic contaminants are essential nutrients. Essential nutrients need not be considered for further consideration in the quantitative risk assessment if they are present in relatively low concentration (i.e., below 2 times the average base-specific background levels or slightly elevated above naturally occurring levels), or if the contaminant is toxic at doses much higher than those which could be assimilated through exposures at the site.

6.2.1.6 State and Federal Criteria and Standards

Contaminant concentrations can be compared to contaminant-specific established State and Federal criteria and standards such as Maximum Contaminant Levels (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 health 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 compiled to evaluate background levels of organic and inorganic constituents in the surface and subsurface soil. Organic contaminants were not detected in the base-specific background samples. Therefore, it is likely that all organic contaminants detected in the surface and subsurface soil, are attributable to the practices which have or are currently taking place within the areas of concern. Additionally, in order to evaluate soil concentrations, the risk-based concentrations (RBCs) for residential soil ingestion developed by USEPA (Region III) were used as guidance criteria to evaluate soil concentrations. The RBCs were used as a benchmark for evaluating site investigation data and to assist in predicting single-contaminant health risks. These values were used in conjunction with other criteria in the selection of COPCs.

A brief explanation of the criteria and standards used for the evaluation of COPCs is presented below.

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

North Carolina Water Quality Standards (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.

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

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 AWQCs for the protection of human health for potential carcinogenic substances are based on the USEPA's specified incremental cancer risk range of one additional case of cancer in an exposed population of 10,000,000 to 100,000 (i.e. the 10E-7 to 10E-5 range).

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

Region IV Sediment Screening Values - Federal sediment quality criteria for the protection of aquatic life are being developed. In the interim, the EPA 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 EPA recommends conducting sediment toxicity tests as a follow-up. If contaminant concentrations are below the ER-L, adverse effects are considered unlikely.

6.2.1.7 Risk-Based Concentrations (RBCs)

The RBCs were developed by the USEPA, Region III as benchmark concentrations for evaluating site investigation data. RBCs are not intended as stand-alone decision-making tools, but as a screening tool to be used in conjunction with other information to help in the selection of COPCs. Selecting COPCs using RBCs is accomplished by the comparison of the maximum concentrations of each contaminant detected in each medium to its corresponding RBC. The RBCs were developed using conservative default exposure scenarios suggested by the USEPA, and the latest available toxicity indices for carcinogenic and systemic chemicals. The RBC corresponds to a Hazard Quotient of 1.0 and a lifetime cancer risk of 1E-6. The RBCs represent protective environmental concentrations at which the USEPA would not typically take action (USEPA, Region III, 1994a).

6.2.1.8 Contaminant Concentrations in Blanks

The association with contaminants detected in field related blanks (i.e., trip blanks, equipment rinsates and/or field blanks) or laboratory method blanks with the same contaminants detected in analytical samples may eliminate non-site-related contaminants from the list of COPCs. Blank data should be compared with results from samples with which the blanks are associated. However, due to the difficulty in determining this association between certain blanks and data, the maximum contaminant concentrations reported in the blanks will be compared to the entire sample data set to evaluate COPCs. In accordance with the National Functional Guidelines for Organics common lab contaminants (i.e., acetone, 2-butanone, methylene chloride, toluene, and phthalate esters) should be considered attributable to site activities only if the concentrations in the sample exceed ten times the maximum amount detected in any blank. If a contaminant is not a common lab contaminant, then concentrations that are less than 5 times the concentration found in any blank are believed to be non-site-related. The elimination of a sample result will directly correlate to a reduction in the prevalence of the contaminant in that media. Consequently, a contaminant that may have been included on the basis of prevalencey would be eliminated as a COPC if elimination due to blank concentration reduces the prevalence of a contaminant to less than five percent.

The maximum concentrations of detected common laboratory contaminants in blanks are as follows:

●	Acetone	190 µg/L
●	Methylene Chloride	19.0 µg/L
●	Chloroform	10J µg/L
●	Toluene	1.0 µg/L
●	Di-n-butylphthalate	2.0 µg/L
●	bis(2-ethylhexyl)phthalate	4.0 µg/L

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

●	Bromodichloromethane	4.0 µg/L
●	Dibromochloromethane	2.0 µg/L
●	Total Xylenes	4.0 µg/L
●	Heptachlor	0.03 µg/L

When assessing soil concentrations, the Contract Required Quantitation Limits (CRQL) and percent moisture were accounted for in order to correlate solid and aqueous quantitation limits. For example, when assessing semivolatile contaminants the CRQL for solid samples is 33 to 66 times (depending on the contaminant) that of aqueous samples. Therefore, in order to assess contaminant levels in soil samples using an aqueous blank concentration, the concentration must be multiplied by 5 or 10 (noncommon or common lab contaminant) and then multiplied by 33 or 66 to correct for the variance in the CRQL. This value is then divided by the percent moisture determined for the sample.

6.2.1.9 Background Naturally Occurring Levels

Naturally occurring levels of chemicals are present under ambient conditions. In general, comparison with naturally occurring levels is applicable only to inorganic analytes, because a majority of organic contaminants are not naturally occurring. Background samples were collected from areas that are known to be uninfluenced by site contamination. An inorganic concentration was considered site-related only if it exceeded two times the mean concentration estimated for the site-specific background samples. The mean for the surface soil inorganics was estimated using 17 data points. The mean for the subsurface soil inorganics was estimated using inorganic results from six sample locations. Consequently, a 95th U.C.L. cannot statistically be estimated for these sample sets.

6.2.1.10 Anthropogenic Levels

Ubiquitous anthropogenic background concentrations result from non-site related sources such as combustion of fossil fuels (i.e., automobiles), plant synthesis, natural fires and factories. A good example of ubiquitous, anthropogenic chemicals in environmental are the PAHs. In general, anthropogenic chemicals were not eliminated as COPCs without considering other selection criteria. It is difficult to determine that such chemicals are present at the site due to operations not related to the site or the surrounding area. Omitting anthropogenic background chemicals from the risk assessment could result in the loss of important information for those potentially exposed.

The remaining sections apply the aforementioned selection criteria beginning with the prevalence of detected analytical results in each medium of interest to establish a preliminary list of COPC for Site 69. Once this task is completed, a final list of media-specific COPCs will be selected based on the remaining criteria (persistence, mobility, toxicity, ARARs, RBCs, blank concentrations, background concentrations, and anthropogenic concentrations).

6.2.2 Selection of Contaminants of Potential Concern

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

6.2.2.1 Site 69

Surface Soil

Twenty five (25) surface soil samples were analyzed for TCL VOCs. The VOCs, total 1,2-dichloroethene, 2-butanone, 1,1,1-trichloroethene, trichloroethene, and tetrachloroethane were detected in 1 of 25 samples. These contaminants are not prevalent in (present in less than five percent of the surface soil samples), therefore, are not retained as COPCs. The concentration of acetone in 5 of 25 samples (maximum concentration 340 µg/kg) is less than ten times the maximum concentration detected in the investigation associated QA/QC blanks (1900 µg/L). Methylene chloride was detected in 15 of 25 surface soil samples. Although the prevalence of this contaminant warrants retention as a COPC, the presence of this contaminant attributable to the investigation related QA/QC samples (80 µg/L) reduces the prevalence of this contaminant to less than five percent. Consequently, methylene chloride and acetone are not retained as COPCs.

Twenty five (25) surface soil samples were analyzed for TCL SVOCs. The SVOCs bis(2-ethylhexyl)phthalate (4 of 25 samples) and di-n-butylphthalate (23 of 25 samples) were detected at maximum concentrations of 48 µg/kg and 280 µg/kg, respectively. The prevalence of these contaminants warrants retention of these contaminants as COPCs. However, evaluation of sample contaminant levels to the investigation related QA/QC blanks reduces the prevalence of these contaminants to less than five percent. Therefore, these contaminants are not retained for evaluation in the risk assessment. Note that the variations in the analytical detection limits are taken into account when assessing the concentrations in the soil using aqueous blanks.

Pesticide and PCB contaminants beta-BHC, 4,4'-DDE, 4,4'-DDT, Endosulfan II, and PCB-1260 were detected in 1 of 25 surface soil samples. The prevalence of these contaminants is less than five percent, therefore, these contaminants are not retained as COPCs in the human health risk assessment.

With the exception of selenium and zinc, the maximum concentration of metals detected in the surface soil is less than two times the average base-specific background concentration for each metal. Consequently, this criteria is used to remove metals, with the exception of selenium and zinc, as COPCs. Selenium was detected in 1 of 25 surface soil samples. Although the contaminant concentration of this metal exceed two times the background concentration it is not retained as a COPC based on prevalence. Zinc was detected at a prevalency greater than five percent (12 of 25 samples). However, the prevalency of zinc concentrations greater than two times the background concentration does not warrant zinc being retained as a COPC.

Presented in Table 6-1 are the surface soil concentration ranges and frequency for the detected organic compounds. Table 6-2 presents the surface soil inorganic ranges and frequency along with a comparison to the base-specific background concentrations.

Subsurface Soil

Ten (10) subsurface soil samples were collected and submitted for VOC analysis. Consequently, for these samples the prevalence criteria cannot be statistically applied for evaluation of COPCs. The VOCs 1,1,1-trichloroethene (1 of 10 samples) and ethylbenzene (2 of 10 samples) were infrequently detected. A maximum concentration of 2 µg/kg was detected for each contaminant. Consequently, on the basis that these contaminants were infrequently detected at low concentrations, have relatively low toxic potential, and were not detected in other media, they are not retained as COPCs. The concentration of methylene chloride in 7 of 10 samples (maximum concentration 58 µg/kg) is less than ten times the maximum concentration detected in the investigation associated QA/QC blanks (80 µg/L). Acetone was detected in 8 of 10 subsurface soil samples. Although the frequent detection of this contaminant warrants retention as a COPC, the presence of this contaminant attributable to the investigation related QA/QC samples (80 µg/L) reduces the detection of this contaminant to 1 of 10 samples. Consequently, acetone and methylene chloride are not retained as a COPCs.

Ten (10) surface soil samples were analyzed for TCL SVOCs. The SVOCs bis(2-ethylhexyl)phthalate (1 of 10 samples) and di-n-butylphthalate (5 of 10 samples) were detected at maximum concentrations of 53 µg/kg and 120 µg/kg, respectively. Evaluation of sample contaminant levels to the investigation related QA/QC blanks reduced the occurrence of these contaminants in the surface soil to nondetect. Therefore, these contaminants are not retained for evaluation in the risk assessment. Note that the variations in the analytical detection limits is taken into account when assessing the concentrations in the soil using aqueous blanks.

Ten (10) subsurface soil samples were analyzed for pesticide/PCB contaminants. Pesticide contaminants 4,4'-DDE (1.2 µg/kg), 4,4'-DDD (5.7 µg/kg), 4,4'-DDT (1.6 µg/kg), and endrin (1.2 µg/kg) were detected in 1 of 10 samples. Although each of these compounds has a known carcinogenic or noncarcinogenic potential, they are not retained as COPCs due to infrequent detection at low concentrations in the subsurface soil.

Chromium and manganese were the only inorganic constituents which were frequently detected at concentrations which were greater than two-times the average base-specific concentration, therefore, these are the only inorganic analytes retained as COPCs.

Presented in Table 6-3 are the subsurface soil concentration ranges and frequency for the positively detected organic compounds. Table 6-4 presents the subsurface soil inorganic ranges and frequency along with a comparison to the base-specific background concentrations.

Groundwater

Twelve (12) groundwater samples were collected for analysis of VOCs. Although the prevalence criteria cannot be statistically applied to this sample set, the VOCs total 1,2-dichloroethene, trichloroethene, and 1,1,2,2-tetrachloroethane, warrant retention as COPCs based on their elevated detection levels and their known toxic potential. Additional VOCs, 1,4-dichlorobenzene, vinyl chloride, 1,1-dichloroethene, benzene, and toluene were infrequently detected (one or two detections) in the groundwater and/or were attributable to contaminant levels detected in the investigation associated QA/QC samples. These compounds are not warranted for retention as COPCs for the human health risk assessment. However, these compounds are retained as COPCs for comparison to North Carolina and Federal groundwater criteria and standards.

SVOCs were not detected in the twelve (12) groundwater samples collected from this site, therefore, no SVOCs warranted retention as COPCs.

Pesticide contaminants, alpha-BHC and delta-BHC were detected in 1 of the 12 groundwater samples collected at this site. These contaminants were not detected in other media. Additionally, the infrequent occurrence of these compounds at relatively low concentrations (just above the CRQL) does not warrant their retention as COPCs. These compounds were compared to North Carolina and Federal groundwater criteria.

Total inorganic constituents including arsenic, barium, beryllium, cadmium, chromium, copper, lead, manganese, mercury, nickel, selenium, vanadium, and zinc were frequently detected in twelve groundwater samples . Therefore, these inorganics are retained as COPCs for the human health risk assessment and for comparison to North Carolina and Federal groundwater standards and criteria.

Table 6-5 presents a comparison of the organic and inorganic groundwater findings to the applicable State and Federal groundwater criteria. Note, contaminants that may not be retained as COPCs for risk evaluation are retained as COPCs for comparison to criteria and standards.

Surface Water

The surface water bodies at this site, from which samples were collected as part of this investigation, included an on-site drainage area, Everett Creek, the New River, and an unnamed tributary to the New River. These surface water bodies do not support recreational activities such as swimming which would present a human health exposure pathway. Consequently, COPCs are not selected to estimate human health risks. However, in order to qualitatively evaluate the potential environmental impact to these areas analytical findings are compared to North Carolina and Federal surface water criteria. Tables 6-6 through 6-9 present the comparison of contaminants detected in these surface water bodies to North Carolina and Federal surface water standards and criteria.

Sediment

The sediment samples collected from the four surface water bodies were not used to estimate potential human health risks. Presently, an exposure pathway does not exist for human exposure to these sediments. These samples were obtained in order to assess potential impact to the environment. Therefore, Tables 6-10 through 6-13 present a qualitative comparison of contaminant levels in the sediment to NOAA sediment quality criteria.

Biota

Nineteen (19) biota samples including fish, oysters, and crabs were analyzed for full TCL organics. The VOCs, benzene (9 of 19 samples) and toluene (8 of 19) samples were retained as COPCs based on their prevalence and toxic potential. Although frequently detected, the presence of acetone and methylene chloride are dismissed as being associated with investigation related QA/QC samples.

SVOCs were not detected in the biota samples collected from Site 69. Therefore, SVOCs are not retained as COPCs.

Pesticide and PCB contaminants were detected in the biota samples. However, only 4,4'-DDE and 4,4'-DDD are prevalent in the samples and retained as COPCs.

The inorganic constituents, beryllium, cadmium, selenium, and zinc are selected as COPCs based on prevalence in the biota samples and due to the presence of these analytes in other environmental media.

6.2.2.2 Summary of COPCs

Table 6-14 presents a detailed summary of the potential COPCs identified in each environmental medium sampled at Site 69. Work sheets used in the selection of COPCs are presented in Appendix N.

6.3 Exposure Assessment

This section develops the potential human exposure pathways for each site and the rationale for their evaluation. Potential source areas and potential migration routes in conjunction with contaminant fate and transport information are combined to produce a site conceptual model. Exposure pathways to be retained for quantitative evaluation are subsequently selected, based on the conceptual site model.

6.3.1 Site Conceptual Model of Potential Exposure

A site conceptual model of potential sources, migration pathways and human receptors was developed to encompass all current and future potential routes of exposure at all three sites. Figure 6-1 presents the conceptual site model. Inputs to the site conceptual site model included qualitative descriptions of current and future land use patterns in the vicinity of the site. All available analytical data and meteorological data are considered in addition to a general understanding of the demographics of the surrounding habitats. For this information, the following list of potential receptors has been developed for inclusion in the quantitative health risk analysis:

- Current military personnel
- Future on-site residents (child and adult)
- Future construction worker

Contaminants detected in the surface and subsurface soils were discussed in Section 4.0 (Nature and Extent of Contamination) and in the selection of COPCs section. The migration of COPCs from these sources could potentially occur by the following routes:

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

The potential for a contaminant to migrate spatially and persist in environmental media are important in the estimation of potential exposure.

6.3.2 Exposure Pathways

This section describes the potential exposure pathways presented on Figure 6-1 associated with each medium and each potential human receptor group, then qualitatively evaluates each pathway for further consideration in the quantitative risk analysis. Table 6-15 present the matrices of potential human exposure scenarios for each of the three sites included under OU No. 14.

6.3.2.1 Surface Soils

Surface soil samples were collected on-site from Site 69. Potential exposures for all current and future receptors identified above to these soils may possibly occur through incidental ingestion, absorption via dermal contact, and inhalation of airborne particulates of surface soil containing COPCs. Dermal intakes will also result following dermal contact with soils containing COPCs. Incidental ingestion of soil may also occur by oral contact with hands, arms, or food items which soil particles have adhered.

Receptors most likely to be exposed via dermal contact, incidental ingestion and inhalation of air-borne particulates are the same for each area of concern due to the current and future potential land use.

6.3.2.2 Subsurface Soils

Potential exposure to subsurface soils is limited to potential site construction workers. In the event of construction in the areas of concern, workers may be exposed to subsurface soil. Therefore, future potential exposures via ingestion and dermal contact are retained for evaluation.

6.3.2.3 Groundwater

Currently the shallow groundwater in the area of the sites is not used as a potable supply for residents or base personnel. However, under a future scenario (albeit unlikely due to poor transmissivity and insufficient flow) the major potential exposure pathways for the use of on-site groundwater are ingestion, dermal contact, and the inhalation of volatile contaminants by residents while showering.

6.3.2.4 Surface Water/Sediments

The general physical characteristics of the surface water bodies included in this investigation are currently not suitable for recreational activities (i.e., swimming and wading). If recreational activities were to occur in these surface water bodies, the activity patterns (reduced duration and frequency) would limit uptake. Additionally, the exposure duration will generally be less for recreational users of a surface water body, and workers are not expected to be exposed via this pathway (USEPA, 1989a). Therefore, current and future potential exposure to surface water and sediment via ingestion and dermal contact are not retained for evaluation.

6.3.2.5 Air

A potential human exposure pathway exists in air through the inhalation of airborne particulates from surface soils containing COPCs. Airborne particulate emissions may result from the wind erosion and the entrainment of soil particles in ambient air. COPCs adhering to these airborne soil particles may be inhaled by potential future on-site residents (i.e., child and adult) and current military personnel.

Therefore, inhalation of airborne particulate emissions by potential future residents and current military personnel is retained for quantitative evaluation. Off-site receptors would be exposed to concentrations much lower than those detected in on-site air samples as a result of the dilution characteristics of ambient air and the wooded areas which separate the facility from the nearby communities. Therefore, nearby residents are not evaluated.

6.3.2.6 Biota

Recreational fishing occurs at Site 69 in the New River. However, subsistence fishing is not conducted in this area of the New River. Therefore, ingestion of fish by current fisherman is retained for quantitative evaluation.

6.3.3 Quantification of Exposure

The concentrations used in the estimation of chronic daily intakes (CDIs) must be representative of the type of exposure being considered.

Exposure to groundwaters, sediments and surface waters can occur discretely or at a number of sampling locations. These media are transitory in that concentrations change frequently over time. Averaging transitory data obtained from multiple locations is difficult and requires many more data points at discrete locations than exist within Site 69. As a result, the best way to represent groundwater, sediment, and surface water contaminants from an exposure standpoint is to use a representative exposure concentration.

Soils are less transitory than the aforementioned media and in most cases, exposure occurs over a wider area (i.e., residential exposure). Therefore, an upper confidence interval was used to represent a soil exposure concentration.

Soil data collected from each of these areas is used separately in estimating the potential human health risks under current and future exposure scenarios.

The human health assessment for future groundwater use considered groundwater data collected from all of the monitoring wells within a site and estimated risks to individuals per area of concern.

Since all the data sets originate from a skewed underlying distribution and since lognormal distribution best fits the majority of environmental data sets, the lognormal distribution was used to represent all facility media. This ensures conservatism in the estimation of chronic daily intake associated with potential exposures. Ninety-five percent upper confidence levels (95 percent U.C.L.) derived for lognormal data sets produce concentrations in excess of the 95 percent confidence interval derived assuming normality. For the sake of conservatism, the 95 percent U.C.L. for the lognormal distribution was used for each contaminant in a given data set for quantifying potential exposure. For exposure areas with limited amounts of data or extreme variability in measured data, the 95 percent U.C.L. can be greater than the maximum measured concentration, therefore, in cases where the 95 percent U.C.L. for a contaminant exceeds the maximum detected value in a given data set, the maximum result was used in the estimate of exposure of the 95 percent U.C.L. However, the true mean may still be higher than this maximum value (i.e., the 95 percent U.C.L. indicates a higher mean is possible), especially if the most contaminated portion of the site has not been sampled.

Data and frequency summaries and statistical summaries are presented in Appendices O and P, respectively.

6.3.4 Calculation of Chronic Daily Intakes (CDI)

In order to numerically estimate the risks for current and future human receptors at each site, a CDI must be estimated for each COPC in every retained exposure pathway.

Appendix S contains the specific CDI equations for each exposure scenario of interest. These equations were adopted from USEPA's Risk Assessment Guidance for Superfund, Volume I (USEPA, 1989a).

The following paragraphs present the general equations and input parameters used in the calculation of CDIs for each potential exposure pathway. Input parameters are taken from USEPA's default exposure factors guidelines where available and applicable. All inputs not defined by USEPA are derived from USEPA documents concerning exposure or best professional judgment. All exposure assessments incorporate the representative contaminant concentrations in the estimation of intakes. Therefore, only one exposure scenario is developed for each exposure route/receptor combination.

Carcinogenic risks were calculated as an incremental lifetime risk, and therefore incorporate terms describing the exposure duration (ED) in years over the course of a lifetime (70 years x 365 days/year, or 25,550 days).

Noncarcinogenic risks, on the other hand, are estimated using the concept of an average annual exposure. The intake incorporates terms describing the exposure time and/or frequency that represent the number of hours per day and the number of days per year that exposure occurs. In general, noncarcinogenic risks for many exposure routes (e.g., soil ingestion) are greater for children than adults because of the differences in body weights, similar exposure frequencies and higher ingestion rates.

Future residential exposure scenarios consider 1 to 6 year old children weighing 15 kg, and adults weighing 70 kg on average. For current/future military personnel an ED of 4 years is used to estimate a military residence. A one year ED is used for future construction worker scenarios.

6.3.4.1 Incidental Ingestion of Soil

The CDI for COPCs detected in soil is estimated for all potential human receptors and is expressed as:

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

Where:

C = Contaminant concentration in soil (mg/kg)
IR = Ingestion rate (mg/day)
CF = Conversion factor (1E-6 kg/mg)
Fi = Fraction ingested from source (dimensionless)
EF = Exposure frequency (days/year)
ED = Exposure duration (years)
BW = Body weight (kg)
AT = Averaging time (days)

The following paragraphs discuss the exposure assumptions used in the estimation of potential COPCs associated with the potential ingestion of soils.

Military Personnel

During the course of daily activities at each site, military personnel could potentially be exposed to potential COPCs by the incidental ingestion of surface soils.

The ingestion rate (IR) for residential adults (100 mg/day) is conservatively applied to evaluate ingestion of surface soils by military personnel.

An exposure frequency (EF) of 350 days/year is used to assess military personnel. It is conservatively assumed that military personnel are on base all year for the exception of two weeks (14 days vacation).

An averaging time (AT) of 70 years x 365 days/year or 25,550 days was used for exposure to potentially carcinogenic compounds while an averaging time of 1,460 days (4 years x 365 days/year) was used for noncarcinogenic exposures. An adult average body weight (BW) of 70 kg was used (USEPA, 1989a).

Future On-Site Residents

Future on-site residents could potentially be exposed to COPCs in the surficial soils during recreational activities or landscaping activities around their homes. Children and adults could potentially be exposed to COPCs in soils by incidental ingestion occurring through hand to mouth behavior.

The residential ED is divided in two parts. First, a six-year exposure duration is evaluated for young children which accounts for the period of highest soil ingestion (200 mg/day), and second a 24-year exposure is assessed for older children and adults by using a lower soil ingestion rate (100 mg/day) (USEPA, 1991a). The EFs for both receptor groups is assumed to be 350 days per year.

The BW, for a resident child is assumed to be 15 kg, representing younger individuals than those considered to be potential trespassers. The rationale is that the younger child (1 to 6 years), as a resident, will have access to affected on-site soils. The BW for the future resident adult is assumed to be 70 kg.

ATs of 25,550 days (70 years x 365 days/year) for potential carcinogens and 8,760 days (24 years x 365 days/year) for noncarcinogenic constituents is used for estimating potential CDIs for adults. An AT of 2,190 days (6 years x 365 days/year) is used to estimate potential CDIs for children potentially exposed to noncarcinogens.

Future Construction Worker

During the course of excavation activities construction workers could potentially be exposed to potential COPCs through the incidental ingestion of subsurface soil. The IR for future construction workers exposed to subsurface soils is assumed to be 480 mg/day (USEPA, 1991a). An EF of 90 days per year is used in conjunction with an ED of one year (USEPA, 1991a). An adult BW of 70 kg is used (USEPA, 1989a).

A summary of the exposure factors used in the estimation of soil CDIs associated with incidental ingestion are presented in Table 6-16.

6.3.4.2 Dermal Contact with Soil

Chronic daily intakes associated with potential dermal contact of soils containing COPCs is expressed using the following equation:

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

Where:

C = Contaminant concentration in soil (mg/kg)
CF = Conversion factor (kg/mg)
SA = Skin surface available for contact (cm^2)
AF = Soil to skin adherence factor (mg/cm^2)
ABS = Absorption factor (dimensionless)
EF = Exposure frequency (days/year)
ED = Exposure duration (years)
BW = Body weight (kg)
AT = Averaging time (days)

The following paragraphs discuss the exposure assumptions used in the estimation of potential COPCs with the potential dermal contact with soils.

Military Personnel

During the course of daily activities, there is a potential for base personnel to absorb COPCs by dermal contact.

It was assumed that military personnel have approximately 5,800 cm^2 (USEPA, 1992b) of skin surface (SA) available for dermal exposure with COPCs. Exposed body parts are the hands, head, forearms and lower legs are 25% of the total body surface area (23,000 cm^2). Thus, applying 25% to the upper-bound total body surface area results in a default of 5,800 cm^2 for military personnel.

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

Future On-Site Residents

Future on-site residents could also be potentially exposed to COPCs in on-site soil through dermal contact experienced during activities near their home.

Skin surface areas (SA) used in the on-site resident exposure scenario are developed for a reasonable worst case scenario for an individual wearing a short sleeve shirt, shorts, and shoes. The exposed skin surface area is limited to the head, hands, forearms, and lower legs. Thus, applying 25 percent of the total body surface area resulted in a default of 5,800 cm^2 for adults. The exposed skin surface for a child (2,300 cm^2) is estimated using an average of the 50th (0.866 m^2) and the 95th (1.06 m^2) percentile body surface for a six year old child multiplied by 25 percent. The child SA was calculated using information presented in Dermal Exposure Assessment: Principles and Applications (USEPA, 1992b).

Per USEPA Region IV guidance the absorption factors (ABS) factors for organics (1%) and inorganics (0.1%) were applied for this estimation of risk.

Values for ED, EF, BW, and AT are the same as those discussed for the incidental ingestion scenario presented previously.

Data on soil adherence factor (AF) are limited. A value of 1.0 mg/cm^2 (USEPA, Region IV, 1992d) is used in this assessment.

Future Construction Worker

Dermal contact with subsurface soil COPCs could potentially occur during excavation activities.

The SA used for the construction worker exposure scenario is developed for an individual wearing a short-sleeve shirt, long pants, and boots. The exposed skin surface area (4,300 cm^2) is limited to the head (1,180 cm^2), arms (2,280 cm^2), and hands (840 cm^2) (USEPA, 1992b).

The EF and ED are the same as those discussed for incidental ingestion of subsurface soil.

Data on soil AF are limited. A value of 1.0 mg/cm^2 (USEPA Region IV, 1992c) is used in this assessment.

A summary of the soil exposure assessment input parameters for dermal contact are presented in Table 6-17.

6.3.4.3 Inhalation of Fugitive Particulates

Exposure to fugitive particulates are estimated for future residents and civilian base personnel. These populations may be exposed during daily recreational or work-related activities. The chronic daily intake of contaminants associated with the inhalation of particulates is estimated using the following equation:

$$CDI = \frac{C \ x \ IR \ x \ EF \ x \ ED \ x \ 1/PEF}{BW \ x \ AT}$$

Where:

C = Contaminant concentration in soil (mg/kg)
IR = Inhalation rate (m^3/hr)
EF = Exposure frequency (days/year)
ED = Exposure duration (years)
1/PEF = Particulate emission factor (m^3/kg)
BW = Body weight (kg)
AT = Averaging time (days)

The particulate emissions factor (PEF) relates the concentration in soil with the concentration of respirable particles in the air due to fugitive dust emissions from surface contamination. This relationship is derived by Cowherd (1985). The particulate emissions from contaminated sites are due to wind erosion, and, therefore, depend on erodibility of the surface material. A default PEF obtained from USEPA, 1989a is used in this assessment.

The following paragraphs discuss the exposure assumptions used in the estimation of potential COPCs with the potential inhalation of particulates.

Military Personnel

During work related activities, there is a potential for military personnel to inhale COPCs emitted as fugitive dust. A conservative inhalation rate 20 m^3/day was used for military personnel (USEPA, 1991a). Values for ED, EF, BW, and AT are the same as those used for the incidental ingestion scenario.

Future On-Site Residents

Future on-site residents could also be potentially exposed to COPCs in on-site soil through inhalation of particulates during activities near their home.

An IR of 20 m^3/day is used to assess the on-site adult. An inhalation rate of 10 m^3/day is used to assess a child. This value was derived from a child conducting light (0.8 m^3/hr.) to moderate (2.0 m^3/hr.) activity for 8 hours per day (USEPA, 1989b). The EF, ED, BW, and AT are the same as those used for the incidental ingestion scenario.

Table 6-18 presents the exposure factors used to estimate CDIs associated with the particulate inhalation scenario.

6.3.4.4 Ingestion of Groundwater

Shallow groundwater is not currently being used as a potable supply at any of the sites. 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 deep groundwater used for potable purposes in the future. Deep groundwater from each of the sites is currently used for potable purposes. However, base supply wells are subject to routine operation, maintenance, and monitoring and those which have been determined to be contaminated have been permanently abandoned.

The CDI of contaminants associated with the future potential consumption of groundwater are estimated using the following general equation:

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

Where:

C = Contaminant concentration is groundwater (mg/L)
IR = Ingestion rate (L/day)
EF = Exposure frequency (days/year)
ED = Exposure duration (years)
BW = Body weight (kg)
AT = Averaging time (days)

The following paragraphs discuss the exposure assumptions used in the estimation of potential COPCs with the potential ingestion of groundwater.

Future On-Site Residents

Exposure to COPCs via ingestion of groundwater is retained as a potential future exposure pathway for both children and adults.

The IR of 1.0 L/day is used for the amount of water consumed by a 1 to 6 year old child with a BW of 15 kg. This ingestion rate provides a health conservative exposure estimate (for systemic, noncarcinogenic toxicants) designed to protect young children who could potentially be more affected than adolescents, or adults. This value assumes that children obtain all the tap water they drink from the same source for 350 days/year [which represents the exposure frequency (EF)]. AT of 2,190 days (6 years x 265 days/year) is used for noncarcinogenic compound exposure.

The IR for adults is 2 liters/day (USEPA, 1989a). The ED used for the estimation of adult CDIs is 30 years (USEPA, 1989b), which represents the national upper-bound (90th percentile) time at one residence. The averaging time for noncarcinogens is 10,950 days. An AT of 25,550 days (70 years x 365 days/year) is used to evaluate exposure for both children and adults to potential carcinogenic compounds.

Table 6-19 presents a summary of the input parameters for the ingestion of groundwater scenarios.

6.3.4.5 Dermal Contact with Groundwater

Shallow groundwater is not currently being used as a potable supply at any of the sites. However, there remains the possibility that upon closure of this facility residential housing could be constructed and groundwater used for residential purposes in the future.

The CDI associated with the dermal contact with groundwater is estimated using the following general equation:

$$CDI = \frac{C \; x \; SA \; x \; PC \; x \; ET \; x \; EF \; x \; ED \; x \; CF}{BW \; x \; AT}$$

Where:

C = Contaminant concentration is groundwater (mg/L)
SA = Surface area available for contact (cm^2)
PC = Dermal permeability constant (cm/hr)
ET = Exposure time (hour/day)
EF = Exposure frequency (days/year)
ED = Exposure duration (years)
CF = Conversion factor (1 L/1000 cm^3)
BW = Body weight (kg)
AT = Averaging time (days)

The following paragraphs discuss the exposure assumptions used in the estimation of potential COPCs with potential dermal contact with groundwater.

Future On-Site Residents

Children and adults could contact COPCs through dermal contact with groundwater while bathing or showering.

An EF of 350 days/year is used assuming that site groundwater would be used as the sole-source for bathing. The whole body skin SA available for dermal absorption is estimated to be 10,000 cm^2 for children and 23,000 cm^2 for adults (USEPA, 1992b). The permeability constant (PC) reflects the movement of a chemical across the skin and into the blood stream. The permeability of a chemical is an important property in evaluating actual absorbed dose, yet many compounds do not have literature PC values. For contaminants in which a PC value are not established, the PC for water (1.55E-03 cm/hr), is used (USEPA, 1992b). This value may in fact be a realistic estimate of the absorption rate of a chemical when COPC concentrations are in the part-per-billion range.

An ET of 0.25 hour/day used to conservatively estimate the duration of bathing or showering. The ED, BW, and AT were the same as those used for the ingestion of groundwater scenario.

Table 6-20 presents the exposure factors used to estimate CDIs associated with the future dermal contact with COPCs in groundwater.

6.3.4.6 Inhalation of Volatile Organics While Showering

In order to quantitatively assess the inhalation of contaminants volatilized from shower water, the model developed by Foster and Chrostowski (1986) is utilized. Contaminant concentrations in air, due to VOCs while showering, are modeled by estimating the following: the rate of chemical releases into air (generation rate), the buildup of VOCs in the shower room air while the shower was on, the decay of VOCs in the shower room after the shower is turned off, and the quantity of airborne VOCs inhaled while the shower is both on and off. The contaminant concentrations calculated to be in the air are then used as the concentration term.

The CDI associated with the inhalation of airborne (vapor phase) VOCs from groundwater while showering is estimated using the following general equation:

$$CDI = \frac{C \text{ x } IR \text{ x } ET \text{ x } EF \text{ x } ED}{BW \text{ x } AT}$$

Where:

C = Contaminant concentration in air (mg/m^3)
IR = Inhalation rate (m^3/hr)
ET = Exposure time (hr/day)
EF = Exposure frequency (days/year)
ED = Exposure duration (years)
BW = Body weight (kg)
AT_c = Averaging time carcinogen (days)
AT_{nc} = Averaging time noncarcinogen (days)

Future On-Site Residents

Both children and adults could inhale vaporized volatile organic COPCs during showering. It is assumed that showering would take place over 350 days/year, using site groundwater as the sole source, for children weighing 15 kg, and adults weighing 70 kg (USEPA, 1989a). An inhalation rate (IR) of 0.6 m^3/hr is used for both receptors (USEPA, 1989a). An exposure time (ET) of 0.25 hrs/day is used for both receptors (USEPA, 1989a). The ED and AT remained the same as for groundwater ingestion.

Table 6-21 presents the exposure factors used to estimate CDIs associated with the inhalation of VOCs from groundwater while showering.

6.3.4.7 Biota

The CDI associated with the potential ingestion of biota was expressed using the following equation:

$$CDI = \frac{C \text{ x } IR \text{ x } Fi \text{ x } EF \text{ x } ED}{BW \text{ x } AT}$$

Where:

C = Contaminant concentration in fish (mg/kg)
IR = Ingestion rate (kg/day)
Fi = Fraction ingested (dimensionless)
EF = Exposure frequency (events/year)
ED = Exposure duration (years)
BW = Body weight (kg)
AT = Averaging time (days)

Current Adults

The IR 0.054 kg/day which represents the upper 95th percentile consumption rate occurring in conjunction with recreational fishing (USEPA, 1992a). The fraction of fish ingested (Fi) from the source for adults is estimated to be 1.0 (100 percent) for the 90th percentile consumption rate. A conservative EF of 250 days/year is applied as a region-specific estimate fish consumption. The ED for adults is set at 30 years, and an AT of 25,550 days (70 years x 365 days/year) was used for exposure to carcinogenic compounds. An AT of 10,950 days (30 years x 365 days/year) is used for exposure to noncarcinogenic COPCs (USEPA, 1989a).

Table 6-22 presents a summary of the exposure factors used for the ingestion of biota scenario.

Appendix Q contains the specific CDI equations for each exposure scenario of interest.

6.4 Toxicity Assessment

Section 6.3 identified potential exposure pathways and potentially affected populations for this BRA. This section will review the available toxicological information for the potential COPCs.

6.4.1 Toxicological Evaluation

The purpose of this section is to define the toxicological values used to evaluate the potential exposure to the potential COPCs identified in Section 6.2. A toxicological evaluation characterizes the inherent toxicity of a compound. It consists of the review of scientific data to determine the nature and extent of the potential human health and environmental effects associated with potential exposure to various contaminants.

Human data from occupational exposures are often insufficient for determining quantitative indices of toxicity because of uncertainties in exposure estimates, and inherent difficulties in determining causal relationships established by epidemiological studies. For this reason, animal bioassays are conducted under controlled conditions and their results are extrapolated to humans. There are several stages to this extrapolation. First, to account for species differences, conversion factors are used to extrapolate from test animals to humans. Second, the relatively high doses administered to test animals must be extrapolated to the lower doses more typical of human exposures. For potential noncarcinogens, safety factors and modifying factors are applied to animal results when developing acceptable human doses. For potential carcinogens, mathematical models are used to extrapolate effects at high doses to effects at lower doses. Epidemiological data can be used for inferential purposes to establish the credibility of the experimentally derived indices.

The available toxicological information indicates that many of the potential COPCs have both potential carcinogenic and noncarcinogenic health effects in humans and/or experimental animals. Although the potential COPCs may potentially cause adverse health and environmental impacts, dose-response relationships and the potential for exposure must be evaluated before the risk to receptors can be determined. Dose-response relationships correlate the magnitude of the dose with the probability of toxic effects, as discussed in the following section.

6.4.2 Dose-Response Evaluation

An important component of the risk assessment is the relationship between the dose of a compound (amount to which an individual or population is potentially exposed) and the potential for adverse health effects resulting from the exposure to that dose. Dose-response relationships provide a means by which potential public health impacts may be evaluated. The published information on doses and responses is used in conjunction with information on the nature and magnitude of exposure to develop an estimate of risk.

Standard carcinogenic slope factors (CSFs) and/or reference doses (RfDs) have been developed for many of the COPCs. This section provides a brief description of these parameters.

6.4.2.1 Carcinogenic Slope Factor

CSFs are used to estimate an upper-bound lifetime probability of an individual developing cancer as a result of exposure to a particular level of a potential carcinogen (USEPA, 1989a). This factor is generally reported in units of $(mg/kg/day)^{-1}$ and is derived through an assumed low-dosage linear multistage model and an extrapolation from high to low dose-responses determined from animal studies. The value used in reporting the slope factor is the upper 95th percent confidence limit.

These slope factors are also accompanied by USEPA WOE classifications which designate the strength of the evidence that the COPC is a potential human carcinogen.

In assessing the carcinogenic potential of a chemical, the Human Health Assessment Group (HHAG) of USEPA classifies the chemical into one of the following groups, according to the weight of evidence from epidemiologic and animal studies:

Group A	-	Human Carcinogen (sufficient evidence of carcinogenicity in humans)
Group B	-	Probable Human Carcinogen (B1 - limited evidence of carcinogenicity in humans; B2 - sufficient evidence of carcinogenicity in animals with inadequate or lack of evidence in humans)
Group C	-	Possible Human Carcinogen (limited evidence of carcinogenicity in animals and inadequate or lack of human data)
Group D	-	Not Classifiable as to Human Carcinogenicity (inadequate or no evidence)
Group E	-	Evidence of Noncarcinogenicity for Humans (no evidence of carcinogenicity in adequate studies)

6.4.2.2 Reference Dose

The RfD is developed for chronic and/or subchronic human exposure to chemicals and is based solely on the noncarcinogenic effects of chemical substances. It is defined as an estimate of a daily exposure level for the human population, including sensitive populations, that is likely to be without an appreciable risk of adverse effects during a lifetime. The RfD is usually expressed as dose (mg) per unit body weight (kg) per unit time (day). It is generally derived by dividing a no-observed-(adverse)-effect-level (NOAEL or NOEL) or a lowest observed-adverse-effect-level (LOAEL) for the critical toxic effect by an appropriate "uncertainty factor (UF)". Effect levels are determined from laboratory or epidemiological studies. The UF is based on the availability of toxicity data.

UFs usually consist of multiples of 10, where each factor represents a specific area of uncertainty naturally present in the extrapolation process. These UFs are presented below and were taken from the "Risk Assessment Guidance Document for Superfund, Volume I, Human Health Evaluation Manual (Part A) (USEPA, 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:

- A MF ranging from >0 to 10 is included to reflect a qualitative professional assessment of additional uncertainties in the critical study and in the entire data base for the chemical not explicitly addressed by the preceding uncertainty factors. The default for the MF is 1.

Thus, the RfD incorporates the uncertainty of the evidence for chronic human health effects. Even if applicable human data exist, the RfD still maintains a margin of safety so that chronic human health effects are not underestimated.

Toxicity factors and the USEPA WOE classifications are presented in Table 6-23. The hierarchy (USEPA, 1989a) for choosing these values was as follows:

- Integrated Risk Information System (IRIS)
- Health Effects Assessment Summary Table (HEAST)

The IRIS data base is updated monthly and contains both verified CSFs and RfDs. The USEPA has formed the Carcinogen Risk Assessment Verification Endeavor (CRAVE) Workgroup to review and validate toxicity values used in developing CSFs. Once the slope factors have been verified via extensive peer review, they appear in the IRIS data base. Like the CSF Workgroup, the USEPA has formed a RfD Workgroup to review existing data used to derive RfDs. Once the reference doses has been verified, they also appear in IRIS.

HEAST on the other hand, provides both interim (unverified) and verified CSFs and RFDs. This document is published quarterly and incorporates any applicable changes to its data base.

6.5 Risk Characterization

This section presents and discusses the estimated incremental lifetime cancer risks (ICRs) and hazard indices (HIs) for identified potential receptor groups which could be exposed to COPCs via the exposure pathways presented in Section 6.3.

These quantitative risk calculations for potentially carcinogenic compounds estimate ICRs levels for an individual in a specified population. This unit risk refers to the cancer risk that is over and above the background cancer risk in unexposed individuals. For example, an ICR of 1E-06 indicates that, for a lifetime exposure, one additional case of cancer may occur per one million exposed individuals.

The ICR to individuals is estimated from the following relationship:

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

where CDI_i is the chronic daily intake (mg/kg/day) for compound i and CSF is the cancer slope [(mg/kg/day)-1] for contaminant i. The CSF is defined in most instances as an upper 95th percentile confidence limit of the probability of a carcinogenic response based on experimental animal data, and the CDI is defined as the exposure expressed as a mass of a substance contracted per unit body weight per unit time, averaged over a period of time (i.e., six years to a lifetime). The above equation was derived assuming that cancer is a non-threshold process and that the potential excess risk level is proportional to the cumulative intake over a lifetime.

In contrast to the above approach for potentially carcinogenic effects, quantitative risk calculations for noncarcinogenic compounds assume that a threshold toxicological effect exists. The total noncarcinogenic acceptable risk level is a HI less than or equal to 1.0. This noncancer risk level indicates a level at or below which adverse systemic effects are not expected in the exposed population. Therefore, the potential for noncarcinogenic effects are calculated by comparing CDIs with threshold levels (reference doses).

Noncarcinogenic effects are estimated by calculating the hazard index (HI) which is defined as:

$$HI = HQ_1 + HQ_2 + \ldots HQ_n$$

$$= \sum_{i=1}^{n} HQ_i$$

$$\gamma \text{ where } HQ_i = CDI_i / RfD_i$$

HQi is the hazard quotient for contaminant i, CDI_i is the chronic daily intake (mg/kg/day) of contaminant i, and RfD_i is the reference dose (mg/kg/day) of the contaminant i over a prolonged period of exposure.

6.5.1 Human Health Risks

The following paragraphs present the quantitative results of the human health evaluation for each medium at site 69.

Estimated ICRs are compared to the USEPA's acceptable target risk range of 1E-04 to 1E-06. A value of 1.0 is used for examination of the HI. The HI is calculated by comparing estimated CDIs with threshold levels below which, noncarcinogenic health effects are not expected to occur. Any HI equal to or exceeding 1.0 suggests that noncarcinogenic health effects may be possible. If the HI is less than 1.0, then systemic human health effects are considered unlikely.

6.5.1.1 Site 69

Soil

Table 6-24 presents the ICR and HI values derived for the potential exposure (dermal contact, incidental ingestion, and inhalation) of on-site surface and subsurface soil. Because of the absence of COPCs in the surface soil ICR and HI values are not estimated for current military personnel, future child residents and future adult residents. Therefore, no adverse health effects are expected from current or future exposure to surface soil.

Additionally displayed on Table 6-24 are the total ICR and HI values estimated for potential exposure to subsurface soil by a construction worker via incidental ingestion and dermal contact. The total ICR value for soil (6E-08) is less than the USEPA's lower bound target risk range (1E-06). The total HI estimated for exposure to soil is less than unity (1.0), suggesting that the occurrence of adverse systemic health effects is unlikely.

Groundwater

The ICR and HI values estimated for potential future residential receptors (children and adults) from ingestion and dermal contact of groundwater and inhalation of vapors are presented on Table 6-25. The total ICR value for future residential children (4E-04) and adults (6E-04) exceed the USEPA's upper bound risk range (1E-04), therefore, adverse health effects to future residents from ingestion, dermal contact, and inhalation are plausible. The total HI estimated for potential future residential children (28) and adults (12) exceeded unity (1.0), suggesting that adverse systemic health effects are likely. The ICR and HI values were driven by the presence of Total 1,2-dichloroethene, 1,1,2,2-tetrachloroethane, total metals arsenic and manganese.

Biota

The total ICR and HI values estimated for ingestion of fish or shellfish by current adults are presented on Table 6-26. The total ICR value (4E-05) is between the USEPA's acceptable risk range of 1E-04 to 1E-06, and the total HI value (0.7) is less than unity (1.0). These estimated values indicate that the likelihood of adverse health effects is unlikely.

6.6 Sources of Uncertainty

Uncertainties may be encountered throughout the process of performing a BRA. This section discusses the sources of uncertainty involved with the following:

- Analytical data
- Exposure Assessment
- Toxicity Assessment
- Compounds Not Qualitatively Evaluated

6.6.1 Analytical Data

The development of a BRA depends on the reliability of and uncertainties with the analytical data available to the risk assessor. Analytical data are limited by the precision and accuracy of the analytical method of analysis. For example, Contract Laboratory Program (CLP) methods have, in general, a precision of approximately plus or minus 50 percent depending on the sample media and the presence of interfering compounds. A value of 100 µg/kg could be as high as 150 µg/kg or as low as 50 µg/kg. In addition, the statistical methods used to compile and analyze the data (mean concentration, standard deviation, and detection frequencies) are subject to the uncertainty in the ability to acquire data.

Data validation serves to reduce some of the inherent uncertainty associated with the analytical data by establishing the usability of the data to the risk assessor who may or may not choose to include the data point in the estimation of risk. Data qualified as "J" (estimated) were retained for the estimation of risk at Site 69. Data can be qualified as estimated for many reasons including a slight exceedance of holding times, high or low surrogate recovery, or intra sample variability. Organic data qualified "B" (detected in blank) or "R" (unreliable) were not used in the estimation of risk due to the unusable nature of the data. Due to the comprehensive sampling and analytical program at Site 69, the loss of some data points qualified "B" or "R" did not significantly increase the uncertainty in the estimation of risk.

6.6.2 Exposure Assessment

In performing exposure assessments, uncertainties can arise from two main sources. First, the chemical concentration to which a receptor may be exposed must be estimated for every medium of interest. Second, uncertainties can arise in the estimation of contaminant intakes resulting from contact by a receptor with a particular medium.

Estimating the contaminant concentration in a given medium to which a human receptor could potentially be exposed can be as simple as deriving the 95th percent upper confidence limit of the mean for a data set. More complex methods of deriving the contaminant concentration are necessary when exposure to COPCs in a given medium occurs subsequent to release from another medium, or analytical data are not available to characterize the release. In this case, modeling is usually employed to estimate the potential human exposure.

The potential inhalation of fugitive dusts from affected soils was estimated in the BRA using USEPA's Rapid Assessment of Exposure to Particulate Emissions from Surface Contaminated Sites (Cowherd et al. 1985). The Cowherd model employs the use of a site-specific PEF for a wind erosion based on source area and vegetative cover. A conservative estimate of the PEF was derived for Site 69 by assuming that the entire area was not covered with vegetation and was unlimited in its erosion potential. Modeling results for fugitive dust emission exposure suggested that the potential risk associated with this pathway was not significant.

Groundwater samples were analyzed for total (unfiltered) and dissolved (filtered) inorganic contaminants. These samples were obtained from wells which were constructed using USEPA Region IV monitoring well design specifications. Groundwater taken from monitoring wells cannot be considered representative of potable groundwater or groundwater which is obtained from a domestic well "at the tap". The use of total inorganic analytical results overestimates the potential human health risks associated with potable use scenarios. However, for the sake of conservatism, total organic results were used to estimate the potential intake associated with groundwater use.

Currently, the shallow groundwater is not used as a potable source. Current receptors (military personnel, military dependents, and civilian base personnel) are exposed to groundwater drawn from the deep zone via ingestion, dermal contact, and inhalation. Therefore, assessing current risks to contaminants detected in the shallow aquifer for current receptors is unnecessary and if estimated may present an unlikely risk. Therefore, groundwater exposures to current receptors was not estimated for this investigation.

Current and/or future potential exposure via ingestion of surface water while swimming was not assessed. The surface water bodies included in this investigation are not sufficient in size or depth to support recreational swimming, therefore, the probability of exposure via this route is very small and estimation of risk, via this route, may unnecessarily produce an unacceptable risk.

To estimate an intake, certain assumptions must be made about exposure events, exposure durations, and the corresponding assimilation of contaminants by the receptor. Exposure factors, have been generated by the scientific community and have undergone review by the USEPA. Regardless of the validity of these exposure factors, they have been derived from a range of values generated by studies of limited number of individuals. In all instances, values used in the risk assessment, scientific judgments, and conservative assumptions agree with those of the USEPA. Conservative assumptions designed not to underestimate daily intakes were employed throughout the BRA and should error conservatively, thus adequately protecting human health and allowing the establishment of reasonable clean-up goals.

6.6.3 Sampling Strategy

Soil represents a medium of direct contact exposure and often is the main source of contaminants released into other media. The soil sampling depth should be applicable for the exposure pathways and contaminant transport routes of concern and should be chosen purposely within that depth interval. If a depth interval is chosen purposely, a random sample procedure to select a sampling point may be established. The assessment of surface exposure at all three sites is certain based on collection of samples from the shallowest depth, zero to one foot. Subsurface soil samples are important, however, if soil disturbance is likely or leaching of chemicals to groundwater is of concern.

Due to the nature of contaminants (i.e., chemical agents) at these sites, the soil investigation was limited to the surface soil. The surface soil samples at all sites were obtained directly or very near the suspected disposal areas. Therefore, these areas would be considered areas of very high concentration which would have a significant impact on exposures.

Due to the possible presence of buried chemical agents, the subsurface soil investigation did not consider potential hot spots through extensive sampling. The subsurface soil concentrations used in determining construction workers exposures were derived from subsurface soils which were considered around the site or off site. Consequently, the risk to future construction workers from ingestion and dermal contact with subsurface soils may be biased low. However, given the limited contaminants detected in the surface soil and groundwater, it does not appear as if this low bias creates a concern that needs to be addressed through additional subsurface soil sampling.

6.6.4 Toxicity Assessment

In making quantitative estimates of the toxicity of varying doses of a compound to human receptors, uncertainties arise from two sources. First, data on human exposure and the subsequent effects are usually insufficient, if they are available at all. Human exposure data usually lack adequate concentration estimations and suffer from inherent temporal variability. Therefore, animal studies are often used and therefore new uncertainties arise from the process of extrapolating animal results to humans. Second, to obtain observable effects with a manageable number of experimental animals, high doses of a compound are used over a relatively short time period. In this situation, a high dose means that experimental animal exposures are much greater than human environmental exposures. Therefore, when applying the results of the animal experiment to the human condition, the effects at the high doses must be extrapolated to approximate effects at lower doses.

In extrapolating effects from animals to humans and high doses to low doses, scientific judgment and conservative assumptions are employed. In selecting animal studies for use in dose response calculations, the following factors are considered:

- Studies are preferred where the animal closely mimics human pharmacokinets

- Studies are preferred where dose intake most closely mimics the intake route and duration for humans

- Studies are preferred which demonstrate the most sensitive response to the compound in question

For compounds believed to cause threshold effects (i.e., noncarcinogens), safety factors are employed in the extrapolation of effects from animals to humans, and from high to low doses.

The use of conservative assumptions results in quantitative indices of toxicity that are not expected to underestimate potential toxic effects, but may overestimate these effects by an order of magnitude or more.

6.6.5 Compounds Not Quantitatively Evaluated

The following contaminants are not quantitatively evaluated in the BRA for OU No. 14 because toxicity information has not been promulgated by the USEPA:

- Lead
- Vanadium

6.7 Conclusions of the BRA for Site 69

The BRA highlights the media of interest from the human health standpoint at Site 69 by identifying areas with elevated ICR and HI values. Current and future potential receptors at the site include current military personnel, future residents (i.e., children and adults), and future construction workers. The total risk from each site for the these receptors is estimated by logically summing the multiple pathways likely to affect the receptor during a given activity. The following algorithms defined the total site risk for the current and future potential receptor groups assessed in a quantitative manner. The risk associated with each site is derived using the estimated risk from multiple areas of interest.

1. Current Military Personnel
    a. Incidental ingestion of COPCs in surface soil + dermal contact with COPCs in surface soil + inhalation of airborne COPCs
2. Future Residents (Children and Adults)
    a. Incidental ingestion of COPCs in surface soil + dermal contact with COPCs in surface soil + inhalation of COPCs
    b. Ingestion of COPCs in groundwater + dermal contact with COPCs in groundwater + inhalation of volatile COPCs
3. Future Construction Worker
    a. Incidental ingestion of COPCs in on-site or off-site subsurface soil + dermal contact with COPCs in subsurface soil

The total site ICR and HI values associated with current and future receptors at this site are presented in Table 6-27. Given the absence of COPCs in the surface soil, current land use (fenced area with restricted access), and that groundwater in this area is not used for potable purposes there are no current risks posed to any population from this site. The total site ICR estimated for future residential children (4E-04) and adults (7E-04) exceeds the USEPA's upper bound risk range (1E-04). The total site ICR estimated for future construction workers (6E-08) is less than the USEPA's lower bound target risk range (1E-06). Additionally, the total site HI for future residential children (28) and adults (12) exceed unity. The total site HI estimated for the future construction worker (<0.01) does not exceed unity. The total site risk is driven by future potential exposure to shallow groundwater.

SECTION 6.0 TABLES

TABLE 6-1

ORGANIC DATA SUMMARY
ONSITE SURFACE SOIL
OPERABLE UNIT NO. 14 (SITE 69)
REMEDIAL INVESTIGATION, CTO-0212
MCB CAMP LEJEUNE, NORTH CAROLINA

Contaminant	Surface Soil	
	Range of Positive Detections	No. of Positive Detects/ No. of Samples
bis(2-ethylhexyl)phthalate	43J - 48J	4/25
di-n-Butylphthalate	36J - 280J	23/25
Methylene chloride	5J - 105	15/25
Acetone	31 - 340J	5/25
1,2-Dichloroethene (total)	4J	1/25
2-Butanone	10.9J	1/25
1,1,1-Trichloroethane	2J	1/25
Trichloroethene	3J	1/25
4-Methyl-2-Pentanone	1J - 12J	6/25
Tetrachloroethene	2J	1/25
Xylenes (total)	5J	1/25
beta-BHC	11J	1/25
4,4'-DDE	4.8J	1/25
Endosulfan II	3.4J	1/25
4,4'-DDT	13.3J	1/25
Aroclor 1260	94J	1/25
Acetophenone	51J	1/25
Hydroxyacetophenone	120J - 160J	2/25

Note: Concentrations expressed in microgram per kilogram (µg/kg).
J - Estimated value

TABLE 6-2

INORGANIC DATA SUMMARY
ONSITE SURFACE SOIL
OPERABLE UNIT NO. 14 (SITE 69)
REMEDIAL INVESTIGATION, CTO-0212
MCB CAMP LEJEUNE, NORTH CAROLINA

Inorganic	Twice the Average Base-Specific Maximum Concentration	Range of Positive Detections	No. of Positive Detects/ No. of Samples	No. of Times Exceeded Twice the Average Background Concentration
Aluminum	4,871.32	368 - 3,370	25/25	0
Arsenic	0.76	ND	0/25	NA
Barium	17.58	3 - 6.8	17/25	0
Beryllium	0.228	ND	0/25	NA
Cadmium	0.655	ND	0/25	NA
Calcium	1,598	35.8 - 101	8/25	0
Chromium	4.97	1.6 - 3.6	18/25	0
Cobalt	3.455	ND	0/25	NA
Copper	14.08	ND	0/25	NA
Iron	3,166.24	235 - 2,360	25/25	0
Lead	37.09	1.1J - 12.5	25/25	0
Magnesium	211.05	12.9 - 67.7	24/25	0
Manganese	16.84	1.3 - 15.5	22/25	0
Mercury	0.087	ND	0/25	NA
Nickel	4.05	ND	0/25	NA
Potassium	198.52	66.1 - 66.4	2/25	0
Selenium	0.674	1.1	1/25	1
Silver	0.98	0.09J - 10.2J	4/25	1
Sodium	85.412	ND	0/25	NA
Vanadium	6.76	3.9 - 5.3	3/25	0
Zinc	13.353	1.5 - 66	12/25	1

Notes: Concentrations expressed in milligram per kilogram (mg/kg).
(1) Soil background concentrations are based on reference background soil samples collected from MCB Camp Lejeune investigations.
NA - Not Applicable
ND - Not Detected
J - Estimated value

TABLE 6-3

ORGANIC DATA SUMMARY
ONSITE SUBSURFACE SOIL
OPERABLE UNIT NO. 14 (SITE 69)
REMEDIAL INVESTIGATION, CTO-0212
MCB CAMP LEJEUNE, NORTH CAROLINA

Contaminant	Subsurface Soil	
	Range of Positive Detections	No. of Positive Detects/ No. of Samples
bis(2-ethylhexyl)phthalate	53J	1/10
Diethylphthalate	260J	1/10
di-n-Butylphthalate	53J - 120J	5/10
Methylene chloride	6J - 58	7/10
Acetone	13J - 45,000	8/10
1,1,1-Trichloroethane	2J	1/10
Ethylbenzene	2J	2/10
4,4'-DDE	1.2J	1/10
Endrin	1.2J	1/10
4,4'-DDD	5.7J	1/10
4,4'-DDT	1.6J	1/10

Note: Concentrations expressed in microgram per kilogram (μg/kg).
J - Estimated value

TABLE 6-4

INORGANIC DATA SUMMARY
ONSITE SUBSURFACE SOIL
OPERABLE UNIT NO. 14 (SITE 69)
REMEDIAL INVESTIGATION, CTO-0212
MCB CAMP LEJEUNE, NORTH CAROLINA

Inorganic	Twice the Average Base-Specific Maximum Concentration	Range of Positive Detections	No. of Positive Detects/ No. of Samples	No. of Times Exceeded Twice the Average Background Concentration
Aluminum	8,946.3	832 - 9,990	10/10	1
Arsenic	0.6	1.15 - 2.9	2/10	2
Barium	11.9	3.8 - 14.6	7/10	1
Beryllium	0.2	0.36	1/10	1
Cadmium	1.0	0.74	1/10	0
Calcium	1,508.3	29.2 - 688	8/10	0
Chromium	8.7	1.76 - 17.7	8/10	1
Cobalt	1.6	ND	0/10	NA
Copper	1.6	5	1/10	1
Iron	1,778.0	354 - 19,900	10/10	3
Lead	9.1	1.78 - 6	10/10	0
Magnesium	231.2	26.9 - 574	10/10	1
Manganese	6.2	1.6 - 39	10/10	2
Mercury	0.1	0.04 - 107	2/10	0
Nickel	4.0	3.4 - 3.9	3/10	0
Potassium	228.8	149 - 516J	3/10	1
Selenium	0.8	ND	0/10	NA
Silver	1.1	0.43J	1/10	0
Sodium	40.6	130	1/10	1
Vanadium	10.1	4.9 - 22.6	4/10	3
Zinc	5.6	3.4 - 13.7	3/10	1

Notes: Concentrations expressed in milligram per kilogram (mg/kg).

(1) Soil background concentrations are based on reference background soil samples collected from MCB Camp Lejeune investigations.

ND - Not Detected

NA - Not Applicable

J - Estimated value

TABLE 6-5

GROUNDWATER DATA SUMMARY
OPERABLE UNIT NO. 14 (SITE 69)
REMEDIAL INVESTIGATION, CTO-0212
MCB CAMP LEJEUNE, NORTH CAROLINA

Contaminant	Groundwater Criteria				Frequency/Range		Comparison to Criteria			
	NCWQS(1)	MCL(2)	Federal Health Advisories(3)		No. of Positive Detects/ No. of Samples	Concentration Range	No. of Detects Above NCWQS	No. of Detects Above MCL	No. of Detects Above Health Advisories	
			10 kg Child	70 kg Adult					10 kg Child	70 kg Adult
1,4-Dichlorobenzene	75	75	10,000	40,000	1/12	2J	0	0	0	0
Vinyl chloride	0.015	2	10	50	1/12	31J	1	1	1	0
Carbon Disulfide	NE	NE	NE	NE	1/12	1J	NA	NA	NA	NA
1,1-Dichloroethene	7	7	1,000	4,000	1/12	1J	0	0	0	0
1,2-Dichloroethene (total)	70	70	2,000	6,000	4/12	2J - 2,400	1	1	1	0
Trichloroethene	2.8	5	NE	NE	2/12	1J - 23J	1	1	NA	NA
Benzene	1	5	NE	NE	1/12	1J	0	0	NA	NA
1,1,2,2-Tetrachloroethane	NE	NE	NE	NE	3/12	1J - 22J	NA	NA	NA	NA
Tetrachloroethane	0.7	5	1,000	5,000	1/12	1J	1	0	0	0
Toluene	1,000	1,000	2,000	7,000	1/12	1J - 4J	0	0	0	0
alpha-BHC	NE	NE	NE	NE	1/12	0.056	NA	NA	NA	NA
delta-BHC	NE	NE	NE	NE	1/12	2.3	NA	NA	NA	NA
Antimony	NE	6	10	15	1/6	8.59J	NA	1	0	0
Arsenic	50	50	NE	NE	6/12	2.94J-19.9	0	0	NA	NA
Barium	2,000	2,000	NE	NE	12/12	29.6-850	0	0	NA	NA
Beryllium	NE	4	4,000	20,000	5/12	2.1-10.6	NA	2	0	0
Cadmium	5	5	5	20	3/12	3.12-11.4	1	1	1	0
Chromium	50	100	200	800	10/12	15.1-159	1	0	0	0
Cobalt	NE	NE	NE	NE	1/12	25.9	NA	NA	NA	NA
Copper	1,000	1,300	NE	NE	3/12	16.5-70.8	0	0	NA	NA
Lead	15	15	NE	NE	11/12	4.4-188	7	7	NA	NA

TABLE 6-5 (Continued)

GROUNDWATER DATA SUMMARY
OPERABLE UNIT NO. 14 (SITE 69)
REMEDIAL INVESTIGATION, CTO-0212
MCB CAMP LEJEUNE, NORTH CAROLINA

Contaminant	Groundwater Criteria				Frequency/Range		Comparison to Criteria			
			Federal Health Advisories[3]						No. of Detects Above Health Advisories	
	NCWQS[1]	MCL[2]	10 kg Child	70 kg Adult	No. of Positive Detects/ No. of Samples	Concentration Range	No. of Detects Above NCWQS	No. of Detects Above MCL	10 kg Child	70 kg Adult
Manganese	50	50[4]	NE	NE	12/12	13-912	5	5	NA	NA
Mercury	1.1	2	NE	2	6/12	0.068-0.936	0	0	NA	NA
Nickel	100	100	500	1,700	4/12	16.7-99.8	0	0	0	1
Selenium	50	50	NE	NE	3/12	3.81J-5.28J	0	0	NA	NA
Vanadium	NE	NE	NE	NE	10/12	17.2-210	NA	NA	NA	NA
Zinc	2,100	5,000[4]	6,000	12,000	10/12	52.1-9120	1	1	0	0

Notes: Concentrations expressed in microgram per liter (µg/L).

[1] NCWQS = North Carolina Water Quality Standards for Groundwater

[2] MCL = Safe Drinking Water Act Maximum Contaminant Level

[3] Longer Term Health Advisories for a 10 kg Child and 70 kg Adult

[4] SMCL = Secondary Maximum Contaminant Level

NE - No Criteria Established

NA - Not Applicable

NJ - Estimated/tentative value

J - Estimated value

TABLE 6-6

SURFACE WATER DATA SUMMARY
ONSITE DRAINAGE AREA
OPERABLE UNIT NO. 14 (SITE 69)
REMEDIAL INVESTIGATION, CTO-0212
MCB CAMP LEJEUNE, NORTH CAROLINA

	Surface Water Criteria			Contaminant Frequency/Range		Comparison to Criteria		
		Federal Health AWQCs(2)					Positive Detects Above AWQC	
Contaminant	NCWQS(1)	Water & Organisms	Organisms Only	No. of Positive Detects/ No. of Samples	Contaminant Range	Positive Detects Above NCWQS	Water & Organisms	Organisms Only
Vinyl chloride	2	2.0	525	1/7	8J	1	1	0
1,2-Dichloroethene (total)	NE	NE	NE	2/7	13 - 55	NA	NA	NA
Trichloroethene	NE	NE	NE	1/7	4J	NA	NA	NA
Toluene	NE	14,300	424,000	2/7	1J	NA	0	0
Ethylbenzene	NE	1,400	3,280	1/7	1J	NA	0	0
Xylenes (total)	NE	NE	NE	1/7	10	NA	NA	NA
Arsenic	NE	0.0022	0.0175	2/7	4.1 - 32.8	NA	2	2
Barium	1,000	1,000	NE	7/7	45.1 - 373	0	0	NA
Beryllium	0.0068	0.0037	0.0641	2/7	1.6 - 6	2	2	2
Chromium	NE	50	NE	1/7	23.8	NA	0	NA
Copper	NE	1,300	NE	3/7	22.8 - 35.9	NA	0	NA
Lead	NE	50	NE	6/7	3.1 - 85.8	NA	2	NA
Manganese	50	50	100	7/7	73.4 - 421	7	7	6
Mercury	NE	0.144	0.146	1/7	0.43	NA	1	1
Nickel	25	13.4	100	1/7	17.8	0	1	0
Vanadium	NE	NE	NE	2/7	23.3 - 24	NA	NA	NA
Zinc	NE	NE	NE	7/7	96 - 4370	NA	NA	NA

Notes: Concentrations expressed in microgram per liter (µg/L).
(1) NCWQS = North Carolina Water Quality Standards for Surface Water
(2) AWQC = Ambient Water Quality Standard
(3) Insufficient data to develop criteria. Value presented is Lowest Observed Effect Level (LOEL).
NE - Not Established
NA - Not Applicable
J - Estimated value

TABLE 6-7

SURFACE WATER DATA SUMMARY
EVERETT CREEK
OPERABLE UNIT NO. 14 (SITE 69)
REMEDIAL INVESTIGATION, CTO-0212
MCB CAMP LEJEUNE, NORTH CAROLINA

Contaminant	Surface Water Criteria			Contaminant Frequency/Range		Comparison to Criteria		
	NCWQS[(1)]	Federal Health AWQCs[(2)]				Positive Detects Above NCWQS	Positive Detects Above AWQC	
		Water & Organisms	Organisms Only	No. of Positive Detects/ No. of Samples	Contaminant Range		Water & Organisms	Organisms Only
Barium	1,000	1,000	NE	3/3	10.4J - 22.2J	0	0	NA
Copper	NE	1,300	NE	1/3	2.6J	NA	0	NA
Lead	NE	50	NE	2/3	1.4B - 2.3J	NA	0	NA
Manganese	50	50	100	3/3	14.3J - 32.5	0	0	0

Notes: Concentrations expressed in microgram per liter (μg/L).

(1) NCWQS = North Carolina Water Quality Standards for Surface Water

(2) AWQC = Ambient Water Quality Standard

NE - Not established

NA - Not Applicable

J - Estimated value

TABLE 6-8

SURFACE WATER DATA SUMMARY
NEW RIVER
OPERABLE UNIT NO. 14 (SITE 69)
REMEDIAL INVESTIGATION, CTO-0212
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	
Contaminant	NCWQS(1)	Water & Organisms	Organisms Only	No. of Positive Detects/ No. of Samples	Contaminant Range		Water & Organisms	Organisms Only
Barium	1,000	1,000	NE	3/3	11.7J - 15.2J	0	0	NE
Manganese	50	50	100	3/3	19.2J - 21.7J	0	0	0
Thallium	NE	13	48	1/3	11.3J	NA	0	0

Notes: Concentrations expressed in microgram per liter (μg/L).

(1) NCWQS = North Carolina Water Quality Standards for Surface Water

(2) AWQC = Ambient Water Quality Standard

NE - Not Established

NA - Not Applicable

J - Estimated value

TABLE 6-9

SURFACE WATER DATA SUMMARY
UNNAMED TRIBUTARY
OPERABLE UNIT NO. 14 (SITE 69)
REMEDIAL INVESTIGATION, CTO-0212
MCB CAMP LEJEUNE, NORTH CAROLINA

Contaminant	Surface Water Criteria			Contaminant Frequency/Range		Comparison to Criteria		
	NCWQS[1]	Federal Health AWQCs[2]				Positive Detects Above NCWQS	Positive Detects Above AWQC	
		Water & Organisms	Organisms Only	No. of Positive Detects/ No. of Samples	Contaminant Range		Water & Organisms	Organisms Only
Barium	1,000	1,000	NE	3/3	15.2JB - 23B	0	0	NA
Cadmium	NE	10	NE	1/3	3JB	NA	0	NA
Cobalt	NE	NE	NE	1/3	8JB	NA	NA	NA
Copper	NE	1,300	NE	1/3	7JB	NA	0	NA
Lead	NE	50	NE	1/3	2JB	NA	0	NA
Manganese	50	50	100	3/3	9JB - 17.7J	0	0	0
Vanadium	NE	NE	NE	2/3	4.2JB - 10JB	NA	NA	NA
Zinc	NE	NE	NE	1/3	18B	NA	NA	NA

Notes: Concentrations expressed in microgram per liter (μg/L).

[1] NCWQS = North Carolina Water Quality Standards for Surface Water

[2] AWQC = Ambient Water Quality Standard

NE - Not Established

NA - Not Applicable

J - Estimated value

B - Reported value is greater than the Instrument Detection Limit (IDL), but less than five times the concentration in any blank. Therefore, the reported value is considered not detected.

JB - Value estimated is greater than the IDL.

TABLE 6-10

SEDIMENT DATA SUMMARY
ONSITE AND DRAINAGE AREA
OPERABLE UNIT NO. 14 (SITE 69)
REMEDIAL INVESTIGATION, CTO-0212
MCB CAMP LEJEUNE, NORTH CAROLINA

	Sediment Criteria		Range/Frequency		Comparison to Criteria	
					Positive Detects Above NOAA	
Contaminant	NOAA ER-L(1) Concentration	NOAA ER-M(2) Concentration	Range of Positive Detections	No. of Positive Detects/ No. of Samples	ER-L	ER-M
1,2-Dichloroethene (total)	NE	NE	5J - 9J	2/7	NA	NA
2-Butanone	NE	NE	36J	1/7	NA	NA
4-Methyl-2-pentanone	NE	NE	9J - 17	3/7	NA	NA
Toluene	NE	NE	18J	1/7	NA	NA
alpha-BHC	NE	NE	3.1J	1/7	NA	NA
beta-BHC	NE	NE	23.4J	1/7	NA	NA
delta-BHC	NE	NE	54.5J	1/7	NA	NA
4,4'-DDE	2	15	13.3J	1/7	1	0
4,4'-DDD	2	20	1.5J - 13.9J	3/7	2	0
4,4'-DDT	1	7	2.1J - 6.6J	2/7	2	0
Aroclor 1254(1)	22.7	180	79J	1/7	1	0
Acetophenone	NE	NE	60J - 960J	2/7	NA	NA
Barium	NE	NE	6.8 - 131	5/7	NA	NA
Beryllium	NE	NE	0.94 - 2	2/7	NA	NA
Chromium	81	370	2.9 - 21.5	3/7	0	0
Copper	39	270	21.7	1/7	0	0
Lead	46.7	218	3.1J - 45.5	7/7	0	0
Manganese	35	110	1.4 - 44.1	7/7	1	0
Mercury	0.15	0.71	0.5 - 0.56	2/7	2	0
Zinc	150	410	15.7 - 551	7/7	1	1

Notes: Organic concentrations expressed in microgram per Kilogram (µg/Kg).
Inorganic concentrations expressed in milligram per Kilogram (mg/Kg).
(1) ER-L - Effective Range-Low
(2) ER-M - Effective Range-Medium
(3) Total PCBs.
NE - Not Established
NA - Not Applicable
J - Estimated value

TABLE 6-11

SEDIMENT DATA SUMMARY
EVERETT CREEK
OPERABLE UNIT NO. 14 (SITE 69)
REMEDIAL INVESTIGATION, CTO-0212
MCB CAMP LEJEUNE, NORTH CAROLINA

Contaminant	Sediment Criteria		Range/Frequency		Comparison to Criteria Positive Detects Above NOAA	
	NOAA ER-L[1] Concentration	NOAA ER-M[2] Concentration	Range of Positive Detections	No. of Positive Detects/ No. of Samples	ER-L	ER-M
4,4'-DDE	2	15	6.6	1/5	1	0
Carbon disulfide	NE	NE	35	1/5	NA	NA
2-Butanone	NE	NE	5,300	1/5	NA	NA
Barium	NE	NE	13JB - 26.4B	3/5	NA	NA
Chromium	81	370	3.6J - 43.8	5/5	0	0
Copper	34	270	6.5J - 16.2JB	3/5	0	0
Lead	46.7	218	7.5J - 30.8	4/5	0	0
Manganese	NE	NE	4.1J - 85.9	5/5	NA	NA
Mercury	0.15	0.71	0.17B	1/5	1	0
Vanadium	NE	NE	7.2JB - 48.8	5/5	NA	NA
Zinc	150	410	31.8 - 62	3/5	0	0
Cobalt	NE	NE	1.3B - 7JB	4/5	NA	NA

Notes: Organic concentrations expressed in microgram per Kilogram (µg/Kg).
Inorganic concentrations expressed in milligram per Kilogram (mg/Kg).
[1] ER-L - Effective Range-Low.
[2] ER-M - Effective Range-Medium
NE - Not Established
NA - Not Applicable
J - Estimated value
B - Reported value is greater than the Instrument Detection Limit (IDL) but less than five times the concentration in any blank. Therefore, the reported value is considered not detected.
JB - Value estimated is greater than the IDL.

TABLE 6-12

SEDIMENT DATA SUMMARY
NEW RIVER
OPERABLE UNIT NO. 14 (SITE 69)
REMEDIAL INVESTIGATION, CTO-0212
MCB CAMP LEJEUNE, NORTH CAROLINA

	Sediment Criteria		Range/Frequency		Comparison to Criteria Positive Detects Above NOAA	
Contaminant	NOAA ER-L(1) Concentration	NOAA ER-M(2) Concentration	Range of Positive Detections	No. of Positive Detects/ No. of Samples	ER-L	ER-M
Arsenic	8.2	70	1.6B - 5.6	4/5	0	0
Beryllium	NE	NE	0.24JB - 0.37JB	4/5	NA	NA
Cadmium	1.2	9.6	0.53J - 1.2J	3/5	0	0
Chromium	81	370	6.2 - 17.7	5/5	0	0
Copper	34	270	1.6J - 2.5J	3/5	0	0
Lead	46.7	218	3.6 - 6	5/5	0	0
Manganese	NE	NE	13.6J - 28.9	5/5	NA	NA
Vanadium	NE	NE	10.3B - 35.3	5/5	NA	NA
Zinc	150	410	7 - 10.7	3/5	0	0

Notes: Organic concentrations expressed in microgram per Kilogram (µg/Kg).
Inorganic concentrations expressed in milligram per Kilogram (mg/Kg).
(1) ER-L - Effective Range-Low
(2) ER-M - Effective Range-Medium
J - Estimated value
B - Reported value is greater than the Instrument Detection Limit (IDL), but less than five times the concentration of any blank. Therefore, the reported value is not detected.
JB - Value estimated is greater than the IDL.

TABLE 6-13

SEDIMENT DATA SUMMARY
UNNAMED TRIBUTARY
OPERABLE UNIT NO. 14 (SITE 69)
REMEDIAL INVESTIGATION, CTO-0212
MCB CAMP LEJEUNE, NORTH CAROLINA

	Sediment Criteria		Range/Frequency		Comparison to Criteria Positive Detects Above NOAA	
Contaminant	NOAA ER-L(1) Concentration	NOAA ER-M(2) Concentration	Range of Positive Detections	No. of Positive Detects/ No. of Samples	ER-L	ER-M
PCB-1260(3)	22.7	180	360	1/5	1	1
Carbon disulfide	NE	NE	18J - 88	4/5	NA	NA
Toluene	NE	NE	2J	1/5	NA	NA
Diethyl phthalate	NE	NE	500J	1/5	NA	NA
benzo(a)pyrene	430	1600	290J - 2,500	2/5	1	1
4,4'-DDE	2	27	10J - 250	3/5	3	2
4,4'-DDD	2	20	14J - 150	3/5	3	2
Arsenic	8.2	70	4.7B - 7.1	4/5	0	0
Barium	NE	NE	14.2B - 23.1B	2/5	NA	NA
Beryllium	NE	NE	0.52JB - 0.61JB	2/5	NA	NA
Cadmium	1.2	9.6	1.80JB - 2.1JB	3/5	0	0
Chromium	81	370	3.3 - 22.4	3/5	0	0
Cobalt	NE	NE	1.4B - 2.1B	2/5	NA	NA
Copper	34	270	7.2B - 24J	4/5	0	0
Lead	46.7	218	1 - 34J	5/5	0	0
Manganese	NE	NE	2.9J - 69.3	5/5	NA	NA
Vanadium	NE	NE	25.8 - 41.1B	4/5	NA	NA
Zinc	150	410	22.4 - 24.6	2/5	0	0

Notes: Organic concentrations expressed in microgram per Kilogram (µg/Kg).
Inorganic concentrations expressed in milligram per Kilogram (mg/Kg).
(1) ER-L - Effective Range-Low
(2) ER-M - Effective Range-Medium
(3) Total PCBs.
J - Estimated value
B - Reported value is greater than the Instrument Detection Limit (IDL), but less than five times the concentration of any blank. Therefore, the reported value is not detected.
JB - Value estimated is greater than the IDL.

TABLE 6-14

SUMMARY OF RISK-BASED AND CRITERIA-BASED COPCs
OPERABLE UNIT NO. 14 (SITES 69)
REMEDIAL INVESTIGATION, CTO-0212
MCB CAMP LEJEUNE, NORTH CAROLINA

Contaminant	Surface Soil 69	Subsurface Soil 69	Groundwater 69	Surface Water 69	Sediment 69	Biota 69
Total 1,2-Dichloroethene			X●	●	●	
Trichloroethene			X●	●		
1,1,2,2-Tetrachloroethane			X●			
Toluene			●	●	●	X
Vinyl Chloride			●	●		
Ethylbenzene				●		
Xylene (Total)				●		
4,4'-DDE					●	X
4,4'-DDT					●	
4,4'-DDD					●	X
1,4-Dichlorobenzene			●			
1,1-Dichloroethene			●			
Benzene			●			
alpha-BHC			●		●	X
beta-BHC					●	
delta-BHC			●		●	
Arsenic			X●	●		
Barium			X●	●	●	
Beryllium			X●	●	●	X
Cadmium			●	●		X
Chromium		X	X●	●	●	
Copper			X●	●	●	
Lead			X●	●	●	
Nickel			X●	●		
Manganese		X	X●	●	●	
Mercury			X●	●	●	
Selenium			X●			X
Vanadium			X●	●	●	
Zinc			X●	●	●	X

X - Selected as risk-based COPC

● - Selected as criteria-based COPC

TABLE 6-15

MATRIX OF POTENTIAL HUMAN EXPOSURE
OPERABLE UNIT NO. 14 (SITE 69)
REMEDIAL INVESTIGATION, CTO-0212
MCB CAMP LEJEUNE, NORTH CAROLINA

Exposure Medium/ Exposure Route	Current Military Personnel	Future Construction Worker	Future Residential Population
Soil			
Incidental Ingestion	M	W	A, C
Dermal Contact	M	W	A, C
Groundwater			
Ingestion	NE	NE	A, C
Dermal Contact	NE	NE	A, C
Surface Water			
Ingestion	NE	NE	A, C
Dermal Contact	NE	NE	A, C
Sediment			
Incidental Ingestion	NE	NE	A, C
Dermal Contact	NE	NE	A, C
Air			
Inhalation of Vapor Phase Chemicals Indoor	NE	NE	A, C
Inhalation of Particulates Outdoor	M	NE	A, C

M = Military lifetime exposure
W = Construction duration exposure
NE = Not Exposed
A = Adult lifetime exposure
C = Exposure in children may be significantly greater than in adults

TABLE 6-16

EXPOSURE ASSESSMENT SUMMARY
INCIDENTAL INGESTION OF SOIL CONTAMINANTS
REMEDIAL INVESTIGATION, CTO-0212
MCB CAMP LEJEUNE, NORTH CAROLINA

Future Residential Child and Adult, Current Military Personnel, Future Construction Worker			
Input Parameter	Description	Value	Reference
C	Exposure Concentration	95% UCL (mg/kg)	USEPA, May 1992
IR	Ingestion Rate	Child 200 mg/day Adult 100 mg/day Military Personnel 100 mg/day Construction Worker 480 mg/day	USEPA, December 1989 USEPA, March 1991
CF	Conversion Factor	1E-6 kg/mg	USEPA, December 1989
Fi	Fraction Ingested from Contaminated Source	100%	Conservative Professional Judgement
EF	Exposure Frequency	Child 350 days/yr Adult 350 days/yr Military Personnel 350 days/yr Construction Worker 90 days/yr	USEPA, December 1989 USEPA, March 1991
ED	Exposure Duration	Child 6 years Adult 24 years Military Personnel 4 years Construction Worker 1 year	USEPA, March 1991 USEPA, December 1989
BW	Body Weight	Child 15 kg Adult 70 kg Military Personnel 70 kg Construction Worker 70 kg	USEPA, December 1989
AT_c	Averaging Time Carcinogen	All 25,550 days	USEPA, December 1989
AT_{nc}	Averaging Time Noncarcinogen	Child 2,190 days Adult 8,760 days Military Personnel 1,460 days Construction Worker 365 days	USEPA, December 1989

TABLE 6-17

EXPOSURE ASSESSMENT SUMMARY
DERMAL CONTACT WITH SOIL CONTAMINANTS
REMEDIAL INVESTIGATION, CTO-0212
MCB CAMP LEJEUNE, NORTH CAROLINA

Future Residential Child and Adult, Current Military Personnel, Future Construction Worker			
Input Parameter	Description	Value	Reference
C	Exposure Concentration	95% UCL (mg/kg)	USEPA, May 1992
CF	Conversion Factor	1E-6 kg/mg	USEPA, December 1989
SA	Exposed Surface Area of Skin Available for Contact	Child 2,300 cm^2 Adult 5,800 cm^2 Military Personnel 5,800 cm^2 Construction Worker 4,300 cm^2	USEPA, January 1992 Reasonable worst case: individual skin area limited to head, hands, forearms, lower legs
AF	Soil-to-Skin Adherence Factor	1.0 mg/cm^2	USEPA, Region IV, 1992
ABS	Absorption Factor (dimensionless)	Organics 1.0 Inorganics 0.1	USEPA, Region IV, 1992
EF	Exposure Frequency	Child 350 days/yr Adult 350 days/yr Military Personnel 350 days/yr Construction Worker 90 days/yr	USEPA, December 1989 USEPA, March 1991
ED	Exposure Duration	Child 6 years Adult 24 years Military Personnel 4 years Construction Worker 1 year	USEPA, March 1991 USEPA, December 1989
BW	Body Weight	Child 15 kg Adult 70 kg Military Personnel 70 kg Construction Worker 70 kg	USEPA, December 1989
AT_c	Averaging Time Carcinogen	All 25,550 days	USEPA, December 1989
AT_{nc}	Averaging Time Noncarcinogen	Child 2,190 days Adult 8,760 days Military Personnel 1,460 days Construction Worker 365 days	USEPA, December 1989

TABLE 6-18

EXPOSURE ASSESSMENT SUMMARY
INHALATION OF FUGITIVE PARTICULATES
REMEDIAL INVESTIGATION, CTO-0212
MCB CAMP LEJEUNE, NORTH CAROLINA

Future Residential Child and Adult, Current Military Personnel			
Input Parameter	Description	Value	Reference
C	Exposure Concentration	95% UCL (mg/kg)	USEPA, May 1992
EF	Exposure Frequency	Child 350 days/yr Adult 350 days/yr Military Personnel 350 days/yr	USEPA, December 1989
ED	Exposure Duration	Child 6 years Adult 24 years Military Personnel 4 years	USEPA, March 1991
IR	Inhalation Rate	Child 10 m^3 Adult 20 m^3 Military Personnel 20 m^3	USEPA, March 1991 USEPA, May 1989
BW	Body Weight	Child 15 kg Adult 70 kg Military Personnel 70 kg	USEPA, December 1989
AT_c	Averaging Time Carcinogen	All 25,550 days	USEPA, December 1989
AT_{nc}	Averaging Time Noncarcinogens	Child 2,190 days Adult 8,760 days Military Personnel 1,460 days	USEPA, December 1989
PEF	Site-Specific Particulate Emission Factor	4.63×10^9 m^3/kg	USEPA, December 1989 Cowherd, 1985

TABLE 6-19

EXPOSURE ASSESSMENT SUMMARY
INGESTION OF GROUNDWATER CONTAMINANTS
REMEDIAL INVESTIGATION, CTO-0212
MCB CAMP LEJEUNE, NORTH CAROLINA

Future Residential Child and Adult			
Input Parameter	Description	Value	Reference
C	Exposure Concentration	95% UCL (mg/L)	USEPA, May 1992
IR	Ingestion Rate	Child 1 L/day Adult 2 L/day	USEPA, March 1991 USEPA, December 1989
EF	Exposure Frequency	Child 350 days/yr Adult 350 days/yr	USEPA, December 1989
ED	Exposure Duration	Child 6 years Adult 30 years	USEPA, March 1991
BW	Body Weight	Child 15 kg Adult 70 kg	USEPA, December 1989
AT_c	Averaging Time Carcinogen	All 25,550 days	USEPA, December 1989
AT_{nc}	Averaging Time Noncarcinogen	Child 2,190 days Adult 10,950 days	USEPA, December 1989

TABLE 6-20

EXPOSURE ASSESSMENT SUMMARY
DERMAL CONTACT WITH GROUNDWATER CONTAMINANTS
REMEDIAL INVESTIGATION, CTO-0212
MCB CAMP LEJEUNE, NORTH CAROLINA

Future Residential Child and Adult			
Input Parameter	Description	Value	Reference
C	Exposure Concentration	95% UCL (mg/L)	USEPA, May 1992
SA	Exposed Surface Area of Skin Available for Contact	Child 10,000 cm^2 Adult 23,000 cm^2	USEPA, January 1992
PC	Permeability Constant	Chemical Specific	USEPA, January 1992
ET	Exposure Time	All 0.25 hr/day	USEPA, January 1992
EF	Exposure Frequency	Child 350 days/yr Adult 350 days/yr	USEPA, March 25, 1991
ED	Exposure Duration	Child 6 years Adult 30 years	USEPA, December 1989
CF	Conversion Factor	1 L/1000 cm^3	USEPA, December 1989
BW	Body Weight	Child 15 kg Adult 70 kg	USEPA, December 1989
AT_c	Averaging Time Carcinogen	All 25,550 days	USEPA, December 1989
AT_{nc}	Averaging Time Noncarcinogen	Child 2,190 days Adult 10,950 days	USEPA, December 1989

TABLE 6-21

EXPOSURE ASSESSMENT SUMMARY
INHALATION OF GROUNDWATER VOLATILE CONTAMINANTS
REMEDIAL INVESTIGATION, CTO-0212
MCB CAMP LEJEUNE, NORTH CAROLINA

Future Residential Child and Adult			
Input Parameter	Description	Value	Reference
C	Exposure Concentration	95% UCL (mg/m^3)	USEPA, May 1992
IR	Inhalation Rate	Child 0.6 m^3/hr Adult 0.6 m^3/hr	USEPA, December 1989
ET	Exposure Time	All 0.25 hr/day	USEPA, January 1992
EF	Exposure Frequency	All 350 day/yr	USEPA, December 1989
ED	Exposure Duration	Child 6 years Adult 30 years	USEPA, December 1989
BW	Body Weight	Child 15 kg Adult 70 kg	USEPA, December 1989
AT_c	Averaging Time Carcinogen	All 25,550 days	USEPA, December 1989
AT_{nc}	Averaging Time Noncarcinogens	Child 2,190 days Adult 10,950 days	USEPA, December 1989

TABLE 6-22

EXPOSURE ASSESSMENT SUMMARY
FISH INGESTION
REMEDIAL INVESTIGATION, CTO-0212
MCB CAMP LEJEUNE, NORTH CAROLINA

Current and Future Adult			
Input Parameter	Description	Value	Reference
C	Exposure Concentration	95% UCL (mg/kg)	USEPA, May 1992
IR	Ingestion Rate	0.54 kg/day	USEPA, March 25, 1991
Fi	Fraction Ingested from Contaminated Source	1.0	90th Percentile Consumption Rate
EF	Exposure Frequency	250 days/yr	Conservative Professional Judgement
ED	Exposure Duration	30 years	90th percentile at one residence (USEPA, December 1989)
BW	Body Weight	70 kg	USEPA, December 1989
AT_c	Averaging Time Carcinogen	25,550 days	USEPA, December 1989
AT_{nc}	Averaging Time Noncarcinogen	10,950 days	USEPA, December 1989

TABLE 6-23

TOXICITY FACTORS
REMEDIAL INVESTIGATION, CTO-0212
MCB CAMP LEJEUNE, NORTH CAROLINA

	RfD	RfC	CSF	CSFI	WOE	Reference
Volatiles:						
1,1-Dichloroethene	9.0E-03	--	6.0E-01	1.75E-01	C	IRIS, 1994
1,1,2,2-Tetrachloroethane	--	--	2.0E-01	2.03E-01	C	IRIS, 1994
Ethylbenzene	1.0E-01	1.0E+00	--	--	D	IRIS, 1994
T-1,2-Dichloroethene	2.0E-2	--	--	--	--	IRIS, 1994
Toluene	2.0E-01	4.0E-01	--	--	D	IRIS, 1994
Trichloroethene	6E-03	PDG	1.1E-02	6.0E-03	B2	IRIS, 1994; USEPA 1992
Vinyl Chloride	--	--	1.9E+00	2.9E-01	A	HEAST, 1994
Xylenes (total)	2.0E+00	PDG	--	--	D	IRIS, 1994
Pesticides/PCBs:						
4,4'-DDD	ND	ND	2.4E-01	--	B2	IRIS, 1994
4,4'-DDE	ND	ND	3.4E-01	--	B2	IRIS, 1994
4,4'-DDT	5.0E-04	ND	3.4E-01	3.4E-01	B2	IRIS, 1994
beta-BHC	ND	ND	1.8E+00	1.8E+00	C	IRIS, 1994
Inorganics:						
Arsenic	3.0E-04	ND	1.75+00	5.0E+01	A_I	IRIS, 1994
Barium	7.0E-02	--	--	--	--	IRIS, 1994
Beryllium	5.0E-03	ND	4.3E+00	8.4E+00	B2	IRIS, 1994
Cadmium	5.0E-04(2) 1.0E-03(3)	PDG	--	6.3E+00	B1	IRIS, 1994
Chromium VI	5.0E-03	PDG	--	4.2E+01	A_I	IRIS, 1994
Cyanide	2.0E-02	ND	--	--	--	IRIS, 1994
Manganese	5.0E-03(2) 1.4E-01(3)	5.0E-05	--	--	D	IRIS, 1994
Mercury	3.0E-04	3.0E-04	--	--	D	HEAST, 1994
Nickel	2.0E-02	PDG	--	--	--	IRIS, 1994
Selenium	5.0E-03	ND	--	--	D	IRIS, 1994
Vanadium	7.0E-03	--	--	--	--	HEAST, 1994
Zinc	3.0E-01	--	--	--	D	IRIS, 1994

Notes:

RfD	Oral Reference Dose (mg/kg - day)
RfC	Inhalation Reference Concentration (mg/cu m)
CSF	Oral Cancer Slope Factor $(mg/kg\text{-}day)^{-1}$
CSFI	Inhalation Cancer Slope Factor $(mg/kg\text{-}day)^{-1}$
WOE	Weight of Evidence
IRIS	Integrated Risk Information System
HEAST	Health Effects Assessment Summary Tables
USEPA	United States Environmental Protection Agency
ND	Not Determined
PDG	Pending
WOE	Weight of Evidence
PDG	Pending
UR	Under Review by USEPA
A	Human Carcinogen
B1	Probable Human Carcinogen - Limited Evidence
B2	Probable Human Carcinogen - Sufficient Evidence
C	Possible Human Carcinogen
D	Not Classifiable as to Human Carcinogenicity
I	Ingestion

(1) Pyrene RfD used as a surrogate

(2) RfD for evaluation in water

(3) RfD for evaluation in soil/sediment

TABLE 6-24

INCREMENTAL LIFETIME CANCER RISKS (ICRs) AND HAZARD INDICES (HIs)
OPERABLE UNIT NO. 14 (SITE 69)
SOIL
REMEDIAL INVESTIGATION, CTO-0212
MCB CAMP LEJEUNE, NORTH CAROLINA

Exposure Route	Receptor Group							
	Current Military Personnel		Future Residential Child		Future Residential Adult		Future Construction Worker	
	ICR	HI	ICR	HI	ICR	HI	ICR	HI
Incidental Ingestion	NA	NA	NA	NA	NA	NA	5E-08	0.2
Dermal Contact	NA	NA	NA	NA	NA	NA	1E-08	<0.01
Inhalation of Particulates	NA	NA	NA	NA	NA	NA	NA	NA
Total	NA	NA	NA	NA	NA	NA	6E-08	0.2

NA - Not Applicable

TABLE 6-25

INCREMENTAL LIFETIME CANCER RISKS (ICRs) AND HAZARD INDICES (HIs)
OPERABLE UNIT NO. 14 (SITE 69)
GROUNDWATER
REMEDIAL INVESTIGATION, CTO-0212
MCB CAMP LEJEUNE, NORTH CAROLINA

Exposure Route	Receptor Group			
	Future Residential Child		Future Residential Adult	
	ICR	HI	ICR	HI
Ingestion	3E-04	28	6E-04	12
Dermal Contact	2E-06	0.3	4E-06	0.2
Inhalation of Vapors	1E-04	<0.01	3E-07	<0.01
Total	4E-04	28.3	6E-04	12.2

TABLE 6-26

INCREMENTAL LIFETIME CANCER RISKS (ICRs) AND HAZARD INDICES (HIs)
OPERABLE UNIT NO. 14 (SITE 69)
BIOTA
REMEDIAL INVESTIGATION, CTO-0212
MCB CAMP LEJEUNE, NORTH CAROLINA

Exposure Route	Receptor Group	
	Current Residential Adult	
	ICR	HI
Ingestion	4E-05	0.7
Total	4E-05	0.7

TABLE 6-27

TOTAL SITE RISK
OPERABLE UNIT NO. 14 (SITE 69)
REMEDIAL INVESTIGATION, CTO-0212
MCB CAMP LEJEUNE, NORTH CAROLINA

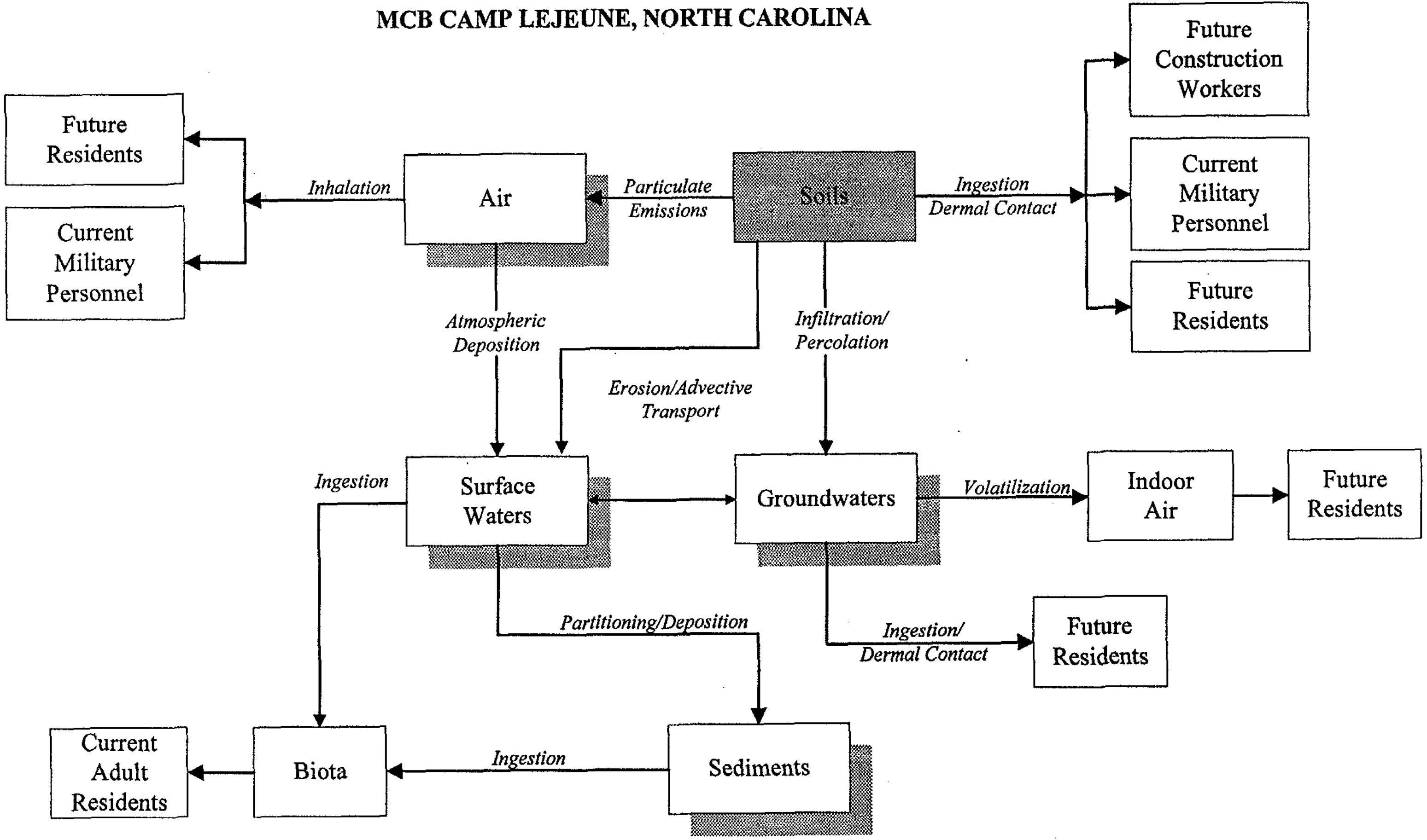
Receptors	Soil		Groundwater		Total	
	ICR	HI	ICR	HI	ICR	HI
Current Military Personnel	NA	NA	NA	NA	NA	NA
Future Child Resident	NA	NA	4E-04 (100)	28 (100)	4E-04	28
Future Adult Resident	NA	NA	6E-04 (100)	12 (100)	6E-04	12
Future Construction Worker	6E-08 (100)	0.02 (100)	NA	NA	6E-08	0.02

Notes: ICR = Incremental Lifetime Cancer Risk
HI = Hazard Index
( ) = Approximate percent contribution to the total ICR or HI values
Total = Soil + Groundwater
NA = Not Applicable

SECTION 6.0 FIGURE

FIGURE 6-1

CONCEPTUAL SITE MODEL
OPERABLE UNIT NO. 14
SITE 69
REMEDIAL INVESTIGATION, CTO-0212
MCB CAMP LEJEUNE, NORTH CAROLINA



7.0 ECOLOGICAL RISK ASSESSMENT

7.1 Introduction

This section presents the ecological risk assessment (ERA) conducted at Operable Unit (OU) No. 4, Site 69, that assesses the potential impacts to ecological receptors from contaminants detected at the site.

7.1.1 Objectives of the Ecological Risk Assessment

The Comprehensive Environmental Response, Compensation, and Liability Act of 1980 (CERCLA) as amended by the Superfund Amendments and Reauthorization Act (SARA) of 1986 directs EPA to protect human health and the environment with respect to releases or potential releases of contaminants from abandoned hazardous waste sites (USEPA, 1989a). In addition, there are various Federal and State laws and regulations concerning environmental protection that are considered applicable or relevant and appropriate requirements or to be considered (ARARs/TBC) criteria. For example, these ARARs/TBCs include comparisons of contaminant concentrations in surface water to State Water Quality Standards.

The objective of this ERA was to evaluate if past reported disposal practices at Site 69 potentially are adversely impacting the ecological viability of the terrestrial and aquatic habitats on, or adjacent to the sites. This assessment also evaluated the potential effects of contaminants at Site 69 on sensitive environments including wetlands, protected species, and fish nursery areas. The conclusions of the ERA will be used in conjunction with the human health risk assessment to evaluate the appropriate remedial action for this site for the overall protection of public health and the environment.

7.1.2 Scope of the Ecological Risk Assessment

This ERA evaluated and analyzed the results from the RI and historical data collected during other studies. The RI included sampling and chemical analysis of the surface water, sediments, biota, soil, and groundwater at the sites, as applicable. This ERA also compared the results of the surface water, sediment, fish, and benthic macroinvertebrate samples collected at background stations in the White Oak River Basin (Appendix R). Information used to evaluate sensitive environments was obtained from historical data and previous studies conducted at Marine Corps Base (MCB) Camp Lejeune, North Carolina. In addition, a qualitative habitat evaluation was conducted at the site to identify potential terrestrial receptors (Figure 7-1). The media of concern for this ERA were the surface water, sediment, biota (i.e., fish and benthic macroinvertebrates) and surface soil.

This ERA focused on adverse impacts to aquatic and terrestrial receptors. If potential risks are characterized for the ecological receptors, further ecological evaluation of the site and surrounding areas may be warranted.

The risk assessment methodologies used in this evaluation were consistent with those outlined in the Framework for Ecological Risk Assessment (USEPA, 1992a). In addition, information found in the following documents was used to supplement the USEPA guidance document:

- U.S. EPA Supplemental Risk Assessment Guidance for Superfund, Volume II, Environmental Evaluation Manual (USEPA, 1989a)

- Ecological Assessment of Hazardous Waste Sites: A Field and Laboratory Reference (USEPA, 1989b)
- Macroinvertebrate Field and Laboratory Methods for Evaluating the Biological Integrity of Surface Waters (USEPA, 1990)
- Fish Field and Laboratory Methods for Evaluating the Biological Integrity of Surface Waters (USEPA, 1993b)

7.1.3 Organization of The Ecological Risk Assessment

Based on the USEPA Framework for Ecological Risk Assessment, an ERA consists of three main components: (1) Problem Formulation, (2) Analysis, and (3) Risk Characterization (USEPA, 1992a). The Problem Formulation section includes a preliminary characterization of exposure and effects of the stressors to the ecological receptors. During the Analysis, the data is evaluated to determine the exposure and potential effects on the ecological receptors from the stressors. Finally, in the Risk Characterization, the likelihood of adverse effects occurring as a result of exposure to a stressor are evaluated. This section evaluates the potential impact on the ecological viability at the site from the contaminants detected in the media.

7.2 Problem Formulation

Problem formulation is the first step of an ERA and includes a preliminary characterization of exposure and effects, as well as scientific data needs, policy and regulatory issues, and site-specific factors to define the feasibility, scope, and objectives for the ERA (USEPA, 1992a).

The results of the various site investigations indicated the presence of contaminants in the surface water, sediment, surface soil, and biota. As discussed above, CERCLA directs USEPA to protect the environment with respect to releases of contaminants. Due to the potential for ecological receptors to be exposed to the contaminants detected at Site 69, it was decided that an ERA should be performed.

Three types of information are needed to evaluate potential links between the contaminants of potential concern (COPCs) and the ecological endpoints. First, chemical analyses of the appropriate media are necessary to establish the presence, concentrations, and variabilities of the COPCs. Second, ecological surveys are necessary to establish if adverse ecological effects have occurred. Finally, toxicological information is necessary to evaluate the potential effects of the COPCs on the ecological receptors. The combination of all three types of data allows the assessment of the relative contribution of other potential causes of the observed effects (as measured by the ecological endpoints) that may be unrelated to the toxic effects of the contaminants of concern (e.g., habitat alterations and natural variability). Therefore, confidence in cleanup and monitoring decisions is greatly enhanced when based on a combination of chemical, ecological, and toxicological data.

Chemical analyses were performed on samples collected from the surface water, sediment, surface soil, and biota to evaluate the presence, concentrations, and variabilities of the COPCs. Ecological surveys also were conducted as part of the Baker's field activities during the RI. Based on observations and available habitats, potential ecological receptors were identified. Finally, toxicological information for the COPCs detected in the media were obtained from available references and literature and used to evaluate the potential adverse ecological effects to the ecological receptors.

The components of the problem formulation include stressor characteristics, ecosystems potentially at risk, ecological effects, endpoint selection, and a conceptual model. The following sections discuss each of these components, and how they were evaluated in this ERA.

7.2.1 Stressor Characteristics

One of the initial steps in the problem formulation stage of an ERA is identifying the stressor characteristics. The term "stressor" is defined as any physical, chemical, or biological entity that can induce an adverse effect (USEPA, 1992a). For this ERA, the stressors that were evaluated include the contaminants detected in the surface water, sediment, biota, and surface soils. Contaminants in the subsurface soils and groundwater were not evaluated in this ERA.

The nature and extent of these contaminants were discussed in Section 4.0 of this report. Table 7-1 lists the contaminants that were detected in each media at Site 69. The location of samples was based on historical information available for the site and a site visit to evaluate potential ecosystems and ecological receptors.

7.2.1.1 Contaminants of Potential Concern (COPCs)

The COPCs for the ERA were selected following the same procedures and criteria (i.e., frequency of detection, toxicity, etc.) used for selecting the COPCs for the Human Health Risk Assessment (HHRA). Some of the COPCs included in the ERA were different than those included in the HHRA. This is because some of the COPCs, which may adversely impact the ecological integrity at the site, may not pose a significant risk to humans and vice-versa. Quantifying risk for all positively identified contaminants may distract from the dominant risk driving contaminants at the site. Therefore, the data set was reduced to a list of COPCs. COPCs are site-related contaminants used to quantitatively estimate ecological exposures and associated potential effects. The criteria used in selecting the COPCs from the constituents detected during the field sampling and analytical phase of the investigation were: historical information; prevalence; mobility; persistence; toxicity; comparison to investigation-associated field and laboratory blank information; comparison to background or naturally occurring levels; and comparison to federal and state saltwater criteria or standards and toxicological benchmarks. The frequency of detection and statistical summary tables are presented in Appendices O and P, respectively.

7.2.1.1.1 COPCs - Surface Water

Surface water samples were collected at Site 69. The ERA addressed the surface water samples from the unnamed tributary, Everett Creek and the New River at Site 69. At Site 69, samples were collected from the on-site areas and the drainage area. The surface water samples from these areas at Site 69 were collected from puddles. These samples will be used to evaluate the nature and extent of contamination. However, these surface water areas do not support ecologically significant receptor populations. Therefore, they were not included in the ecological risk evaluation. Sample locations are illustrated on Figure 7-4.

Unnamed Tributary

The following inorganics detected in the surface water samples were not addressed in the ERA because they are common naturally occurring chemicals, they were not expected to be ecologically significant at the detected concentrations, or they were infrequently detected: cadmium, calcium, cobalt, lead, magnesium, potassium, sodium, and zinc.

There were no VOCs, SVOCs, pesticides or PCBs detected in the surface water samples.

The following inorganics detected in the surface water samples at the unnamed tributary were included in the ERA: aluminum, barium, copper, iron, manganese, and vanadium.

Everett Creek

The following inorganics detected in the surface water samples were not addressed in the ERA because they are common naturally occurring chemicals and/or were not expected to be ecologically significant at the detected concentrations: calcium, magnesium, potassium, and sodium.

There were no VOCs, SVOCs, pesticides or PCBs detected in the surface water samples.

The following inorganics detected in the surface water samples in Everett Creek were included in the ERA: aluminum, barium, copper, iron, lead, manganese, and silver.

New River

The following inorganics detected in the surface water samples were not addressed in the ERA because they are common naturally occurring chemicals and were not expected to be ecologically significant at the detected concentrations: calcium, magnesium, potassium, and sodium.

There were no VOCs, SVOCs, pesticides or PCBs detected in the surface water samples.

The following inorganics detected in the surface water samples in the New River were included in the ERA: aluminum, barium, iron, manganese, silver, and thallium.

7.2.1.1.2 COPCs - Sediments

Sediment samples were collected from the major water bodies identified at Site 69 for the surface water COPCs. The sediments that were collected from the on-site and drainage areas at Site 69 were not expected to impact ecological receptors. Sample locations are illustrated on Figure 7-4.

Unnamed Tributary

The following detected VOCs, SVOCs, and PCBs in the sediment samples were not addressed in the ERA because they are common laboratory and/or decontamination contaminants, or were detected infrequently: acetone, carbon disulfide, toluene, diethyl phthalate and bis(2-ethylhexyl)phthalate.

The following inorganics detected in the sediment samples were not addressed in the ERA because they are common naturally occurring chemicals and they were not expected to be ecologically significant at the detected concentrations: calcium, magnesium, potassium, and sodium.

The following chemicals detected in the sediment samples were addressed in the ERA: benzo(a)pyrene, 4-4'-DDE, 4-4'-DDD, Aroclor 1260, aluminum, arsenic, barium, beryllium, cadmium, chromium, cobalt, copper, iron, lead, manganese, vanadium, and zinc.

Everett Creek

The following VOCs, SVOCs and pesticides detected in the sediment samples were not addressed in the ERA because they are common laboratory and/or decontamination contaminants, or were detected infrequently: acetone, carbon disulfide, 2-butanone, methylene chloride, and bis(2-ethylhexyl)phthalate.

The following inorganics detected in the sediment samples were not addressed in the ERA because they are common naturally occurring chemicals, they were not expected to be ecologically significant at the detected concentrations: calcium, magnesium, potassium, and sodium.

The following chemicals detected in the sediment samples were addressed in the ERA: 4,4'-DDE, aluminum, arsenic, barium, beryllium, cadmium, chromium, cobalt, copper, iron, lead, manganese, mercury, vanadium, and zinc.

New River

The following VOC and SVOC detected in the sediment samples were not addressed in the ERA because they are common laboratory and/or decontamination contaminants or were detected infrequently: acetone and bis(2-ethylhexyl)phthalate.

The following inorganics detected in the sediment samples were not addressed in the ERA because they are common naturally occurring chemicals and they were not expected to be ecologically significant at the detected concentrations: calcium, magnesium, potassium, and sodium.

The following chemicals detected in the sediment samples were addressed in the ERA: aluminum, arsenic, barium, beryllium, cadmium, chromium, cobalt, copper, iron, lead, manganese, vanadium, and zinc.

7.2.1.1.3 COPCs - Biota Samples

Biota samples for tissue analysis, which included fish, oysters, and blue crabs, were collected only at Site 69 from Everett Creek and the New River.

The following SVOCs, pesticides, and PCBs were not addressed in the ERA because they are common laboratory and/or decontamination contaminants; they were infrequently detected; or they were determined to be ecologically insignificant at detected concentrations based on previous literature studies: 2-methylphenol, di-n-octyl phthalate, endrin, Aroclor-1254, Aroclor-1260, methylene chloride, acetone, 2-butanone, 2-hexanone, and toluene.

The following inorganics detected were not addressed in the ERA because they are common naturally occurring chemicals, they were not expected to be ecologically significant, or they were infrequently detected: calcium, magnesium, potassium, silver, sodium, and thallium.

The following chemicals detected in biota samples were addressed in the ERA: 4-4'-DDE, 4-4'-DDD, benzene, aluminum, beryllium, cadmium, iron, selenium, and zinc.

7.2.1.1.4 COPCs - Surface Soils

Surface soil samples were collected at Site 69. Sample locations are illustrated on figures found in Section 4 of this report.

The following VOCs, SVOCs, pesticides, and PCB detected in the surface soil samples were not addressed in the ERA because they are common laboratory and/or decontamination contaminants; they were detected in and attributed to the laboratory or field blank; or were detected infrequently: acetone, methylene chloride, 1,2-dichloroethene (total), 2-butanone, 1,1,1-trichloroethane, trichloroethene, tetrachloroethene, xylenes (total), bis(2-ethylhexyl)phthalate, di-n-butyl phthalate, beta-BHC, 4-4'-DDE, endosulfan II, 4-4'-DDT, Aroclor-1260, acetophenone, and hydroxyacetophenone.

The following inorganics detected in the surface soil were not addressed in the ERA because they are common naturally occurring chemicals, they were not expected to be ecologically significant at the detected concentrations, they were infrequently detected or were within typical background concentrations found at the site: aluminum, barium, calcium, chromium, iron, lead, magnesium, manganese, potassium, selenium, vanadium, zinc, and total cyanide.

The following chemicals detected in the surface soil samples were addressed in the ERA: 4-methyl-2-pentanone and silver.

7.2.1.2 Physical/Chemical Characteristics of COPCs

Table 7-2 contains values for bioconcentration factors (BCFs, freshwater), water solubility, organic carbon partition coefficient, octanol water partition coefficient, and vapor pressure for the potential contaminants of concern identified in the sediments, surface water, surface soil, and biota samples for each site. Information from these tables were used to assess the fate and transport of the constituents and the potential risks to the environmental receptors at each site. The following paragraphs discuss the significance of each parameter included in the table.

Bioconcentration factors measure the tendency for a chemical to partition from the water column or sediment and concentrate in aquatic organisms. Bioconcentration is important for ecological receptors because chemicals with high BCFs could accumulate in lower-order species and subsequently accumulate to toxic levels in species higher up the food chain. The BCF is the concentration of the chemical in the organism at equilibrium divided by the concentration of the chemical in the water. Therefore, the BCF is unitless. Bioconcentration factors among the metals range from 1 for chromium to 350,000 for manganese. The bioconcentration factors among the organics range from 24 for benzene to 180,000 for 4-4'-DDE. The pesticides have the highest potential to concentrate in the tissue of organisms exposed to the contaminants. Published BCF data were not available for some of the COPCs at Site 69.

Water solubility is important in the ecological environment because it measures the tendency for a chemical to remain dissolved in the water column, partition to soil or sediment, or bioconcentrate in aquatic organisms. Chemicals with high water solubilities tend to be more bioavailable to aquatic organisms. However, they will not significantly bioconcentrate in the organisms. On the other hand, chemicals with a low water solubility will remain bound to the sediment and soils but may bioconcentrate in organisms to a significant degree. Water solubility for metals is negligible because they are practically insoluble in water. The water solubility of the organics ranged from less than 0.01 mg/L for some pesticides and semivolatiles to 1,800 mg/L for benzene.

The organic carbon partition coefficient (Koc) measures the tendency for a chemical to partition between soil or sediment particles containing organic carbon and water. This coefficient is important in the ecological environment because it determines how strongly an organic chemical will be bound to the organics in the sediments. The Koc is highest for benzo(a)pyrene at 5.5×10^6 mL/g and lowest for benzene at 83 mL/g. Koc values are negligible for metals.

The octanol/water partition coefficient (Kow) is the ratio of a chemical concentration in octanol divided by the concentration in water. The octanol/water partition coefficient has been shown to correlate well with bioconcentration factors in aquatic organisms and adsorption to soil or sediment. The log Kow is presented in Table 7-2. The log Kow is highest for benzo(a)pyrene at 6.0 and lowest for benzene at 2.1. Log Kow values are negligible for metals.

The vapor pressure measures the tendency for a chemical to partition into air. This parameter is important for the ecological environment because it can be used to determine the concentrations of the constituents in air. The vapor pressure is highest for thallium, 880 mm Hg. The vapor pressure for most of the other contaminants of concern are low or negligible.

7.2.2 Ecosystems Potentially at Risk

Based on the site-specific and regional ecology, several ecological receptors are potentially at risk from contaminants at the sites. Contaminants were identified in the surface water, sediment, soil, groundwater, and biota samples at the sites. Potential receptors of contaminants in surface water and sediment include fish, oysters, blue crabs, benthic macroinvertebrates, other aquatic flora and fauna and some terrestrial faunal species. Potential receptors of contaminants in soils include: deer, rabbits, foxes, raccoons, birds and other terrestrial flora and fauna.

7.2.3 Ecological Effects

The ecological effects data that were used to assess potential risks to aquatic and/or terrestrial receptors in this ERA include: aquatic reference values including North Carolina Water Quality Standards (NCWQS), USEPA Region IV Water Quality Screening Values (WQSV), USEPA Ambient Water Quality Criteria Documents (AWQC), the Aquatic Information Retrieval Database, and Sediment Screening Values, and terrestrial reference values. The following paragraphs discuss each of the above data sources.

The North Carolina Department of Environment, Health, and Natural Resources (NC DEHNR) has promulgated Water Quality Standards (WQS). These WQS meet the requirements of both federal and state law. These standards are regulatory values and are enforceable. They are used to evaluate the quality of waters in North Carolina.

The USEPA Region IV Waste Management Division (Region IV) has adopted Water Quality Screening Values (WQSV) for chemicals detected at hazardous waste sites (USEPA, 1992b). These values are intended as preliminary screening tools to review chemical data from hazardous waste sites. Exceedances of the screening level values indicate that there may be a need for further investigation of the site.

Section 304(a)(1) of the Clean Water Act of 1977 (P.L. 95-217) requires the Administrator of the USEPA to publish criteria for water quality accurately reflecting the latest scientific knowledge on the type and extent of all identifiable effects on health and welfare which may be expected from the presence of pollutants in any body of water, including groundwater. In accordance with the Clean Water Act, the USEPA Office of Water Regulations and Standards, Criteria and Standards Division have published Ambient Water Quality Criteria (AWQC) documents for several chemicals. These documents can be used to evaluate potential risks to aquatic organisms. In addition, potential risks to aquatic plants from contaminants also can be evaluated using these documents.

The Aquatic Information Retrieval Database (AQUIRE) database is an on-line system that contains information on acute, chronic, bioaccumulative, and sublethal effects data from tests performed on freshwater and saltwater organisms excluding bacteria, birds, and aquatic mammals. This database can be accessed to evaluate potential risks to aquatic organisms.

Currently, promulgated sediment quality criteria do not exist. Until these criteria are developed, USEPA Region IV is using Sediment Screening Values (SSV) compiled by National Oceanic and Atmospheric Administration for evaluating the potential for chemical constituents in sediments to cause adverse biological effects (USEPA, 1992b). The lower ten percentile (Effects Range-Low [ER-L]) and the median percentile (Effects Range-Median [ER-M]) of biological effects have been developed for several of the chemicals identified during the sediment investigations at OU No. 4. If sediment contaminant concentrations are above the ER-M, adverse effects on the biota are considered probable. If contaminant concentrations are between the ER-M and ER-L, adverse effects on the biota are considered possible. Finally, if contaminant concentrations are below the ER-L, adverse effects on the biota are considered unlikely (USEPA, 1992b).

There are no standards, criteria, or other screening values for assessing potential impacts to terrestrial ecological receptors from contaminants in soils. A literature search was conducted to identify levels of contaminants in the soil that could cause adverse effects to terrestrial flora and invertebrates. However, these data cannot be used to evaluate potential risks to other terrestrial fauna (e.g., birds, deer, rabbits), since the exposure doses for these species are different than exposure doses for invertebrates and plants, which are in constant direct contact with the contaminants in the soil. In addition, the sensitivity of the organisms to the COPCs are not similar.

Terrestrial reference values (TRVs) for evaluating estimated chronic daily intakes (CDIs) were calculated from available toxicity data. TRVs were developed from No-Observed-Adverse-Effect-Levels (NOAELs) or Lowest-Observed-Adverse-Effect-Levels (LOAELs) obtained from the Integrated Risk Information System (IRIS), toxicological profiles for specific chemicals and information from other reference books. These values were used to assess the potential effects of contaminants on terrestrial fauna.

7.2.4 Ecological Endpoints

The information compiled during the first stage of problem formulation (stressor characteristics, ecosystems potentially at risk, and ecological effects) was used to select the ecological endpoints for this ERA. The following section of this report contains a description of the ecological endpoints selected for this ERA, and the reason they were selected.

There are two primary types of ecological endpoints: assessment endpoints and measurement endpoints. Assessment endpoints are environmental characteristics, which, if they were found to be significantly affected, would indicate a need for remediation (e.g., decrease in sports/fisheries). Measurement endpoints are quantitative expressions of an observed or measured effect of the contamination of concern. Measurement endpoints may be identical to assessment endpoints (e.g., measurement of abundance of fish), or they may be used as surrogates for assessment endpoints (e.g., toxicity test endpoints). Both types of endpoints were used in the ecological risk evaluation and are discussed in the following sections.

7.2.4.1 Assessment Endpoints

Assessment endpoints are the ultimate focus of risk characterization and link the measurement endpoints to the risk management process (USEPA, 1992a). There are five criteria that an assessment endpoint should satisfy (Suter, 1993):

- Societal relevance
- Biological relevance
- Unambiguous operational definition
- Accessibility to prediction and measurement
- Susceptibility to the hazardous agent

Societal relevance is important because risk to ecological receptors of little intrinsic interest to the public (e.g., nematodes, zooplankton) are unlikely to influence decisions unless they can be shown to indicate risks to biota of direct human interest (e.g., fish, wildlife) (Suter, 1993). The biological significance of a property is determined by its importance to a higher level of the biological hierarchy (Suter, 1993). The endpoint should be well defined and operational with a subject (e.g., benthic macroinvertebrates) and a characteristic of the subject (e.g., decrease in numbers of benthic macroinvertebrate) (USEPA, 1989b). The endpoint should be measurable (e.g., numbers of individuals) or predictable from measurements (e.g., toxicity tests). Finally, the endpoint must be susceptible to the contaminant being assessed.

The assessment endpoints in this ERA were decreased viability of populations of aquatic and terrestrial floral and faunal species.

Aquatic organisms (e.g., fish, benthic macroinvertebrates) are socially relevant because humans enjoy the sport of fishing and they also are a food source for many people. The organisms are biologically relevant because they serve as food sources for other aquatic and terrestrial organisms. The endpoint is defined with a subject (aquatic organisms), and a characteristic of the subject (decreased viability to aquatic organisms). The risk may be predicted by contaminant concentrations in media exceeding published aquatic reference values. Finally, aquatic organisms are susceptible to the COPCs at Site 69.

Terrestrial organisms (e.g., rabbits, deer, fox, raccoon, quail) are socially relevant because humans enjoy the sport of hunting and they also are a food source for many people. The organisms are biologically relevant because they serve as food sources for other terrestrial organisms and some also consume smaller mammals and plants which potentially have been contaminated. The endpoint is defined with a subject (rabbits, deer, fox, raccoon, and quail), and a characteristic of the subject (decreased viability to rabbits, deer, fox, raccoon, and quail). The TRVs can be used to predict risks to terrestrial organisms. Finally, terrestrial organisms are susceptible to the COPCs at Site 69.

7.2.4.2 Measurement Endpoints

A measurement endpoint, or "ecological effects indicator" as it is sometimes referred, is used to evaluate the assessment endpoint. Therefore, measurement endpoints must correspond to, or be predictive of, assessment endpoints. In addition, they must be readily measurable, preferably quickly and inexpensively, using existing techniques. Measurement endpoints must take into consideration the magnitude of the contamination and the exposure pathway. The measurement endpoint should be an indicator of effects that are temporally distributed. Low natural variability in the endpoint is preferred to aid in attributing the variability in the endpoint to the contaminant. Measurement endpoints should be diagnostic of the pollutants of interest, as well as broadly applicable to allow comparison among sites and regions. Also, measurement endpoints should be standardized (e.g., standard procedures for toxicity tests). Finally, it is desirable to use endpoints that already are being measured (if they exist) to determine baseline conditions.

Endpoints are divided into four primary ecological groups: individual, population, community, and ecosystem endpoints. Individual endpoints (e.g., death, growth, tissue concentrations) are evaluated through toxicity tests, models, and other methods used to assess the effects on individual organisms. Population endpoints (e.g., occurrence, abundance, reproductive performance) are evaluated to determine presence and absence of species through field studies. Community endpoints (e.g., number of species, species diversity) are used to describe the complexity of the community. Finally, ecosystem endpoints (e.g., biomass, productivity, nutrient dynamics) are used to determine the effects between groups of organisms, and between organisms and the environment. Individual, population, and community endpoints were evaluated in this assessment.

The primary goal in deciding upon which ecological endpoints to evaluate was to determine the current effects that the contamination is having on the environment. The following sections discuss the measurement endpoints that were chosen for the ERA.

7.2.4.2.1 Aquatic Endpoints

Aquatic biota samples (e.g., fish, shellfish, and benthic macroinvertebrates) were collected as part of the field activities at Site 69. Appendix S contains the sampling station characterization data sheets for this activity. Fish and benthic macroinvertebrates are potential ecological receptors at risk at Site 69. The following paragraphs discuss how decreased viability to these species was evaluated in this ERA.

As discussed earlier in this report, aquatic species inhabit MCB Camp Lejeune including fish and benthic macroinvertebrates, and are exposed to the COPCs at Site 69. Potential effects from contaminants detected at Site 69 on these species were evaluated by comparing the exposure levels of COPCs in the surface water and sediments to aquatic reference values.

Community Similarity

Community similarity between benthic macroinvertebrate stations was measured using two qualitative indices of community similarity, the Jaccard coefficient (S_J) and the SΦrenson index (S_S). These indices were used to detect changes in the community structure. Stressed communities presumably will have different species than relatively non-stressed communities, given that all other factors are equal. The indices use two possible attributes of the ecosystem, that is whether a species was or was not present in the collected sample. Because these coefficients are based on the number of species collected and not the number of individuals, a few organisms from several taxa could significantly change the similarity value, whereas there may not be an overall significant difference between the communities.

The S_J is better than the S_S at discriminating between highly similar collections and has been used widely in stream pollution investigations . The S_J ranges from 0.0 (dissimilar) to 1.0 (similar) and is calculated using the following equation:

$$Sj = \frac{a}{a+b+c}$$

a = number of species common to both collections
b = number of species in the first collection but not the second
c = number of species in the second collection but not in the first

The S_S places more emphasis on common attributes, and is better than the $_JS$ at discriminating between highly dissimilar collections. The S_S ranges from 0.0 (dissimilar) to 1.0 (similar) and is calculated using the following equation:

$$Ss = \frac{2a}{2a+b+c}$$

Where a, b, and c are as described above.

Species Diversity

The benthic communities were examined using a mathematical expression of community structure called a diversity index (H'). Diversity data are useful because they condense a substantial amount of data into a single value. The Shannon-Wiener function is one of the more commonly used formulas for calculating species diversity. Species diversity was calculated in logarithmic base 10 for the benthic species collected during the ecological investigation using the following equation (Brower, 1977):

$$H' = \sum (p_i * \log(p_i)).$$

H' = mean species diversity
p_i = proportion of the total number of individuals occurring in species i.

Typically, in waterways that are unpolluted and contain suitable habitat for aquatic life, H' ranges from three to four, while in polluted rivers or rivers with unsuitable habitat H' generally is less than one (USEPA, 1989a). The operative assumption in the interpretation of H' values is that relatively undisturbed environments tend to support communities that consist of a large number of species with no single species present in overwhelming abundance. Many forms of stress tend to reduce diversity by producing an environment that is less desirable for some taxa and therefore giving a competitive advantage to other taxa.

Macroinvertebrate Biotic Index

Most of the benthic macroinvertebrates collected during the ecological investigation have been assigned a pollution tolerance rating. The tolerances were obtained from the NC DEHNR DEM, Environmental Sciences Branch (Lenat, 1993) and the USEPA Environmental Monitoring Systems Laboratory (USEPA, 1990). NC DEHNR maintains a complete list of benthic macroinvertebrate species collected, or known to occur, in North Carolina on a database called BINDEX. BINDEX contains the species Latin name, order, biotic index (BI), and feeding group. Biotic indices have not been established for estuarine species. The BI ranges from zero to ten; a zero is assigned to taxa found only in unaltered streams of high water quality, and a ten is assigned to taxa known to occur in streams with intermediate degrees of pollution or disturbance. In addition, the U.S. EPA lists many common benthic macroinvertebrate species along with their tolerance to organic wastes, heavy metals and acids (USEPA, 1990).

The Macroinvertebrate Biotic Index (MBI) was developed to provide a rapid stream quality assessment. The index is an average of BI weighted by organism abundance, and is calculated as follows:

$$MBI = \sum (n_i * BI)/N.$$

MBI = the macroinvertebrate biotic index
n_i = the number of individuals occurring in the i^{th} taxa
BI = the BI assigned to the i^{th} taxa
N = the total number of individuals in the sample

The sampled benthic macroinvertebrate population will be assigned a general stream/water quality condition based on the MBI value. The five classes and their corresponding MBI values are given below (Lenat, 1993):

Excellent Water Quality	Good Water Quality Problems	Fair Water Quality	Poor Water Quality	Serious Water Quality
<5.24	5.25-5.95	5.96-6.67	6.68-7.70	>7.71

The MBI for the benthic macroinvertebrate stations was calculated using the values listed in BINDEX. When a BI for a specific species was not listed, either the family BI (if available) was used or the species was not included in the MBI calculations.

7.2.4.2.2 *Terrestrial Endpoints*

As discussed earlier in this report, several terrestrial faunal species inhabit MCB Camp Lejeune including deer, birds, and small mammals, and potentially are exposed to the COPCs at Site 69. Potential effects from contaminants detected at Site 69 to these species were evaluated by comparing the CDIs to TRVs. In addition, comparisons of COPC concentrations in the soil to published plant and earthworm toxicity information was used to evaluate potential effects to some terrestrial species.

7.2.5 The Conceptional Model

This section of the report contains a list of hypotheses regarding how the stressors might affect ecological components of the natural environment:

- Aquatic receptors potentially may be adversely affected by exposure to contaminated water, sediment, and contaminated biota they ingest.
- Terrestrial receptors potentially may be adversely affected by exposure to contaminants in the surface water and surface soil.
- Terrestrial receptors potentially may be adversely affected by exposure to contaminated organisms and vegetation they ingest.

7.3 Analysis Phase

The next phase after the problem formulation is the analysis which consists of the technical evaluation of data on the potential effects and exposure of the stressor. This phase includes the ecological exposure characterization and the ecological effects characterization.

7.3.1 Characterization of Exposure

Characterization of exposure evaluates the interaction of the stressor with the ecological component. The following sections characterize the exposure in accordance with the stressors, ecosystem, exposure analysis, and exposure profile.

7.3.1.1 Stressor Characterization: Distribution or Pattern of Change

The remedial investigations involved collecting samples from five media; surface water, sediment, soil, groundwater, and biota. The analytical results of these investigations are presented in Section 4.0 of this report. In addition, the source identification also is presented in Section 4.0 of the report, while the extent of contamination is discussed in Section 4.3 of this report.

7.3.1.2 Ecosystem Characterization

This section describes the regional ecology of the coastal plain and the habitats present at Site 69. Information on sensitive environments and endangered species is also included.

Site Description

Site 69, the Rifle Range Chemical Dump, is located west of the New River estuary in the area of MCB Camp Lejeune known as the Rifle Range. The site is heavily wooded with several species of trees including pine, sweetgum, dogwood, and oak. Within the fenced in boundary, the forest type is mostly new growth with a predominance of pine species. However, old growth forests (i.e., oak, and sweetgum) dominate the land areas outside the boundaries of the site fence. The New River is located about one-quarter mile east of the site. Everett Creek is located about one-half mile south of the site. An unnamed tributary to the New River is situated about one-quarter mile north of the site. Both Everett Creek and the unnamed tributary drain into the New River.

Deer, rabbits, and birds were the only terrestrial faunal species observed at Site 69. Based on the regional ecology, and due to the wooded areas around Site 69, there is the potential for other terrestrial fauna to periodically visit the site.

Regional Ecology

Camp Lejeune covers approximately 108,800 acres, 84 percent of which is forested (USMC, 1987). Approximately 45.1 percent of this is pine forest, 22 percent is mixed pine/hardwood forest, and 16.8 percent is hardwood forest. Nine percent of the base, a total of 3,587 acres, is wetland and includes pure pond pine stands, mixed pond pine/hardwood, marshes, pocosins, and wooded swamps. The base also contains 80 miles of tidal streams, 21 miles of marine shoreline, and 12 freshwater ponds.

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

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

MCB Camp Lejeune is located in the Coastal Plain. The ecology of the region is influenced by climate, which is characterized by hot, humid summers and cool winters. Some subfreezing cold spells occur during the winters, and there are occasional accumulations of snow that rarely persist. The average precipitation is 55.96 inches and the mean temperature is 60.9°F. The area exhibits a long growing season, typically more than 230 days. Soils in the region range from very poorly drained muck to well-drained sandy loam.

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

- Mixed Hardwood Forest - Found generally on slopes of ravines. Beech is an indicator species with white oak, tulip, sweetgum, and holly.
- Southeastern Evergreen Forest - Dominated by pines, especially longleaf pine.
- Loblolly Pine/Hardwoods Community - Second growth forest that includes loblolly pine with a mix of hardwoods -- oak, hickory, sweetgum, sour gum, red maple, and holly.
- Southern Floodplain Forest - Occurs on the floodplains of rivers. Hardwoods dominate with a variety of species present. Composition of species varies with the amount of moisture present.

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

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

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

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

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

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

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

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

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

Water Body Description

The unnamed tributary from the New River is classified by the NC DEHNR as SC HQW. The SC classifies the water body as tidal saltwater, which allows for aquatic life propagation and survival, fishing, wildlife and secondary recreation. The HQW means high quality waters, which are waters rated as excellent based on biological and physical/chemical characteristics obtained by monitoring, special studies or special designations made by the Wildlife Resources Commission, the Marine Fisheries Commission and/or the Department of Agriculture. These special designations include trout fishing areas, primary and functional nursing areas, and critical habitat areas (NC DEHNR, 1993).

The NC DEHNR classified Everett Creek as SA, which indicated tidal saltwaters available for shellfishing for marketing purposes; primary recreation; aquatic life propagation and survival; fishing; wildlife and secondary recreation. Everett Creek is designated by the North Carolina

Fisheries Rules as Class C - coastal fishing waters (NCMFC, 1993). A portion of Everett Creek has been identified as a primary nursing area. The coordinates of this location are provided in Section 7.4.8 of this report.

The portion of the New River that includes Everett Creek and the unnamed tributary is classified by the NC DEHNR as SC. This restricted area includes all waters within 1,000 yards of the earthen dock at the MCB Rifle Range. SC indicates that this area is tidal saltwater available for aquatic life propagation and survival, fishing, wildlife, and secondary recreation. The New River is designated by the North Carolina Fisheries Rules as Class C -- coastal fishing waters (NCMFC, 1993). The unnamed tributary, which stems from the river, is also considered to be class C -- coastal fishing waters. The New River is located within surface water body sections. They are the Stone Bay Sector and the Stone Creek Sector. Both areas are designated Military Restricted.

Site-Specific Ecology

During April 1993, Baker conducted a qualitative habitat evaluation of the terrestrial environment at Site 69. Table 7-3 summarizes the habitats identified at each site and Appendix T includes data sheets that provide more detailed information.

Site 69 and the surrounding area are generally forested, although the type and composition of the forest reflects past history at the site. The forest within the fenced area at the site is less mature than the surrounding forest and contains a different mix of flora. A transition zone (ecotone) is present on both sides of the fence line, and small open areas occur within the forest inside the fence.

The forest within the fence and covering the disposal areas at the site can be classified as loblolly\hardwood. The trees are clearly younger and smaller than those outside the fence. Although trees are the dominant class of vegetation, no species is clearly dominant and pines and hardwood trees are well mixed. Tree species identified within the fences area include the following:

- Loblolly Pine- Pinus taeda
- Sweetgum - Liquidambar styraciflua
- Water Oak - Quercus nigra
- White Oak- Q. alba
- Red Maple - Acer rubrum
- Tulip - Liriodendron tulipifera
- Beech - Fagus grandifolia
- Black Gum - Nyssa sylvatica
- Bitternut Hickory - Carya cordiformis
- Mockernut Hickory - Carya tomentosa
- Spanish Oak - Q. falcata
- Post Oak - Q. stellata
- Sweetbay Magnolia - Magnolia virginiana

The understory of the forest includes saplings of the trees in the canopy as well as shrubs and smaller trees. Smaller trees include sassafras (Sassafras albidum), dogwood (Cornus florida), chestnut (Castanea dentata), and sourwood (Oxydendrum aboreum). Winged sumac (Rhus copallina), red buckeye (Aesculus pavia), and wax myrtle (Myrica cerifera) are also present. Woody vines also occur in the understory of this forest; species identified included sand grape (Vitis rupestris), greenbriar (Smilax rotundifolis), poison ivy (Rhus radicans), and bullbriar (Smilax bona-nox).

Ferns are common forbs on the floor of this forest. Seven different species were identified, some of which occurred in moister areas of the forest. For example, royal fern (Osmunda regalis), sensitive fern (Onoclea sensibilis), and cinnamon fern (Osmunda cinnamomea) were observed near seeps on the site. Beech fern (Phegopteris hexagonoptera), braken fern (Pteris aquilina). Virginia chainfern (Woodwardia virginica), and marsh fern (Aspidium thelypteris) are also present. In addition to the ferns, violets (Viola sp.), blue-eyed grass (Sisyrinchium sp.), and partridgeberry (Mitchella repens) are also growing at Site 69.

A small open area within the forest was evaluated during the habitat study. Vegetation in this open area is generally sparse . Small trees and saplings of loblolly pine (Pinus taeda) are mixed with saplings of sweetgum (Liquidambar styraciflua), water oak (Quercus nigra), and holly (Ilex opaca) and myrtle shrubs (Myrica cerifera). Three different species of blueberry -- coastal highbush blueberry (Vaccinium corymbosum), late low blueberry (V. augustifolium), and Elliott blueberry (V. elliottii) -- are also present. Vegetation at the ground surface is sparse and includes mosses and lichens with grasses and broom sedge (Andropogon virginicus). Round-leaved sundew (Drosera rotundifolia) grows in this area where the sandy soil is exposed.

The area on both sides of the fence has apparently been cleared regularly and is now a transition zone or ecotone. Plants in this area reflect this transition and are a mix of field herbs with shrubs, saplings, vines, and seedling forest trees. In some areas dog fennel (Eupatorium capillifolium) is dominant and little other vegetation is present.

Saplings present in this transition zone include loblolly (Pinus taeda), sweetgum (Liquidambar styraciflua), water oak (Quercus nigra), and winged sumac (Rhus copallina). Myrtle (Myrica cerifera) is also present. Two woody vines, sand grape (Vitis rupestris) and blackberry (Rubus sp.) are growing in portions of the transition zone. In addition to grasses the following field herbs were identified in this area:

- Broom Sedge - Andropogon virginicus
- Ticktrefoil - Desmodium sp.
- Bracken Fern - Pteris aquilina
- Tread-softly - Cnidoscolus stimulosus
- Lyre-leaved Sage - Salvia lyrata
- St Johnswort - Hypericum sp.
- Robin-plantain - Erigeron pulchellus
- Soft Rush - Juncus effusus
- Panic Grass - Panicum sp.

Christmas fern (Aspidium acrostichoides) and ebony spleenwort (Asplenium ebeneum) are also growing in shaded areas of the transition zone.

Beyond the transition zone mature hardwood forest is present. Trees in this forest are generally larger and older than those within the fenced area. Trees are dominant, although no single species is dominant. Species identified include the following:

- Water Oak- Quercus nigra
- White Oak- Q. alba
- Beech - Fagus grandifolia
- Tulip - Liriodendron tulipifera

- Sweetgum - Liquidambar styraciflua
- Red Oak - Q. falcata
- Mockernut Hickory - Carya tomentosa
- Bitternut Hickory - Carya cordiformis
- Red Maple - Acer rubrum
- Loblolly Pine - Pinus taeda

Trees in the understory are also well mixed and no single species is dominant. Understory species include holly (Ilex opaca), dogwood (Cornus florida), red buckeye (Aesculus pavia), umbrella magnolia (Magnolia tripetala), dwarf pawpaw (Asimina parviflora), and myrtle (Myrica cerifera). Greenbriar (Smilax rotundifolia) and poison ivy (Rhus radicans) are occasionally present, but only in open areas of the forest. Undergrowth is less dense in this forest than in the younger forest within the fence. In some areas it is almost nonexistent. Forbs on the forest floor are very limited. Only four species were noted: Christmas fern (Aspidium acrostichoides), partridgeberry (Mitchella repens), heartleaf (Hexastylis virginica), and spotted wintergreen (Chimaphila maculata).

Several small forested wetlands are present within the mature hardwood forest, although they do not appear on the NWI maps. Trees in these wetland areas exhibit buttressed trunks and wetland vegetation is present. Tree species identified include ash (Fraxinus sp.), sweetgum (Liquidambar styraciflua), tulip (Liriodendron tulipifera), and at the edges of the wetland areas beech (Fagus grandifolia). No shrubs or vines are present. Lizards tail (Saururus cernus) is the dominant forb in these forested wetlands. Water pennywort (Hydrocotyle americana), switch cane (Arundinaria tecta), and jack-in-the-pulpit (Arisaema triphyllum) are also present.

Birds observed at Site 69 included both resident species and neotropical migrants as follows:

- Carolina Wren - Thryothorus ludovicianus
- Red-eyed Vireo - Vireo oliveaceus
- Turkey Vulture - Cathartes aura
- Blue-grey Gnatcatcher - Polioptila caerula
- Yellow Warbler - Dendroica petechia
- Brown-headed Nuthatch - Sitta pusilla
- Fish Crow - Corvus ossifragus
- Mourning Dove - Zenaida macroura
- Wood Peewee - Contopus virens
- Summer Tanager - Piranga rubra
- Carolina Chickadee - Parus carolinensis
- Yellow-throated Warbler - Dendroica dominica
- Blue Jay - Cyanocitta cristata
- Bay-breasted Warbler - Dendroica castanea

Three species of reptiles were observed within the fenced area. They include the black racer (Coluber constrictor constrictor), which may have been nesting in a rotting tree; anole (Anolis carolinensis), and five-lined skink (Eumeces fasciatus).

Signs of white-tailed deer (Odocoileus virginianus) were noted throughout Site 69 and the surrounding area. Signs of moles (Talpidae), squirrels (Sciurus sp.), and raccoons (Procyon lotor) also were observed.

Sensitive Environments

This section describes the sensitive environments that were evaluated at Site 69. These sensitive environments include wetlands, threatened and endangered species, and other potentially sensitive environments.

Wetlands

The NC DEHNR's Division of Environmental Management (DEM) has developed guidance pertaining to activities that may impact wetlands (NC DEHNR, 1992a). In addition, certain activities affecting wetlands also are regulated by the U.S. Corps of Engineers.

The U.S. Fish and Wildlife Service (FWS) has prepared National Wetlands Inventory (NWI) maps for the Camp Lejeune, North Carolina area by stereoscopic analysis of high altitude aerial photographs (USDI, 1982). Site 69 is included on these maps. The wetlands were identified on the photographs based on vegetation, visible hydrology, and geography in accordance with Classification of Wetland and Deep-Water Habitats of the United States (Cowardin, et al, 1979). NWI maps are intended for an initial identification of wetland areas. They cannot be substituted for an actual wetland delineation that may be required by Federal, State and/or local regulatory agencies. Information from the wetlands maps was transferred to the site-specific biohabitat map (Figure 7-1).

Site-specific wetland delineations were not conducted at Site 69, although potential wetland areas were noted during the habitat evaluation. These wetlands are illustrated on the biohabitat map.

Site 69 is located in an area of dense hardwood forest. Several small palustrine forested wetlands were identified in low lying areas near the site. Estuarine wetlands are located along Everett Creek, along an unnamed tributary, and in areas of low topography along the New River. Palustrine wetlands also are present along freshwater tributaries of Everett Creek.

Threatened and Endangered Species

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

Surveys have been conducted to identify threatened and endangered species at Camp Lejeune and several programs are underway to manage and protect them. Table 7-4 lists protected species present at the base and their protected classification. Of these species, the red-cockaded woodpecker, American alligator, and sea turtles are covered by specific protection programs.

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

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

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

Four bird species, black skimmer, piping plover, Bachmans sparrow, and Peregrine falcon also have been identified during surveys at Camp Lejeune. The black skimmer and piping plover are sea and shore birds, respectively. Skimmers nest on low sandy islands and sand bars along the coast and piping plovers prefer beaches with broad open sandy flats above the high tide line. Skimmers feed above open water and piping plovers feed along the edge of incoming waves. Like the black skimmer and piping plover, Bachmans sparrows are very specific in their habitat requirements. They live in open stretches of pines with grasses and scattered shrubs for ground cover. Bachmans sparrows were observed at numerous locations throughout southern Camp Lejeune. A Peregrine falcon was observed approximately three miles east of OU No. 4 and may have been feeding in the area since the birds have a large foraging range.

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

No protected species were observed at Site 69 during the habitat evaluation nor would they be expected to occur. Protected species at Camp Lejeune require specific habitats that do not correspond to the habitats identified at the sites. Previous survey results and maps of locations were protected species have been identified were consulted to produce the biohabitat map. No protected species have been identified within half-mile radii of Site 69.

A natural heritage resources was conducted at Camp Lejeune (LeBlond, 1991) to identify threatened or endangered plants and areas of significant natural interest. From this list, the Rough-leaf loosestrife was the only Federally threatened or endangered plant species found on the Marine Corps Base. In addition, several State endangered or threatened and Federal and State candidate species were found on the MCB. The results of this survey are included in Appendix U.

Other Sensitive Environments

In addition to wetlands and protected species, other sensitive environments, including those listed in 40 CFR Part 300, were evaluated during Hazard Ranking System evaluations. These sensitive environments and their presence or absence at Site 69 are discussed below.

- Marine Sanctuary - Site 69 is not located within a Marine Sanctuary (NCMFC, 1993).

- National Park - Site 69 is not located within a National Park (NPS, 1991).

- Designated Federal Wilderness Area - Site 69 is not located within a Designated Federal Wilderness Area (WS, 1989).

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

- Sensitive Areas Identified under the National Estuary Program (NEP) or Near Coastal Waters Program (NCWP) - Site 69 is not located within a Sensitive Area identified under the NEP or NCWP (USEPA, 1993b).

- Critical Areas Identified under the Clean Lakes Program - Site 69 is not located within a Critical Area identified under the Clean Lakes Program (NPS, 1991).

- National Monument - Site 69 is not located near a National Monument (NPS, 1991).

- National Seashore Recreational Area - Site 69 is not located within a National Seashore Recreational Area (NPS, 1991).

- National Lakeshore Recreational Area - Site 69 is not located within a National Lakeshore Recreational Area (NPS, 1991).

- National Preserve - Site 69 is not located within a National Preserve (NPS, 1991).

- National or State Wildlife Refuge - Site 69 is not located within a National or State Wildlife Refuge (NCWRC, 1992).

- Unit of the Coastal Barrier Resource Program - Site 69 is not located within a unit of the Coastal Barrier Resource Program (USDI, 1993).

- Administratively Proposed Federal Wilderness Area - Site 69 is not located within an Administratively Proposed Federal Wilderness Area (WS, 1989, 1993).

- Spawning Areas Critical for the maintenance of fish/shellfish species within river, lake, or coastal tidal waters - Due to size restrictions, no critical spawning areas have been identified within Everett Creek, the unnamed tributary, or the New River (USMC, 1993). No specific spawning areas critical for the maintenance of fish/shellfish species in Everett Creek, the unnamed tributary, or the New River have been designated as such by state agencies (NC DEHNR, 1993).

- Migratory pathways and feeding areas critical for maintenance of anadromous fish species within river reaches or areas in lakes or coastal tidal waters in which fish spend extended periods of time - Surface waters associated with Site 69 are not migratory pathways or feeding areas critical for the maintenance of an anadromous fish species because there is not a significant population of anadromous fish in Everett Creek, the unnamed tributary, or the New River (USMC, 1993).

- National river reach designated as Recreational - The New River is not designated as a National Recreational River (NPS, 1990, 1993).

- Federal designated Scenic or Wild River - The New River is not a Federally designated Scenic or Wild River (NPS, 1990, 1993).

- State land designated for wildlife or game management - Site 69 is not located within a State game land (NCWRC, 1992).

- State designated Scenic or Wild River - The New River is not a State designated Scenic or Wild River (NCMFC, 1993).

- State designated Natural Area - Site 69 is not located within a State designated Natural Area or Area of Significant Value (LeBlond, 1991).

- State designated areas for protection or maintenance of aquatic life - A portion of Everett Creek at Site 69 is designated as a primary nursing area (NC DEHNR, 1993).

- Areas of Significant Value - Site 69 is not located within a State Area of Significant Value (LeBlond, 1991).

- State Registered Natural Resource Area - Site 69 is not located within a State Registered Natural Resource Area (LeBlond, 1991).

7.3.1.2.1 Biological Sampling

Biological samples collected at Site 69 consisted of fish, shellfish, and benthic macroinvertebrates. The biological samples were collected to obtain population statistics for fish and benthic macroinvertebrates and to obtain tissue samples of fish, oysters, and tissue samples of fish, oysters, and crabs. Prior to initiating the sampling event at each station, the following information describing the site was recorded in the field log book:

- Average width, depth and velocity of the water body

- Description of substrate

- Description of "abiotic" characteristics of the reach such as pools, riffles, runs, channel shape, degree of bank erosion, and shade/sun exposure

- Description of "biotic" characteristics of the reach including aquatic and riparian vegetation and wetlands

Water quality measurements were collected during the benthic macroinvertebrate sampling, at a minimum, and during collection of some of the fish samples. On-site water quality measurements at these stations consisted of temperature, pH, specific conductance, salinity and dissolved oxygen. These measurements were conducted prior to sample collection.

Reference Stations

Two creeks, Hadnot Creek and Holland Mill Creek, were sampled as reference stations for Site 69. Sampling included fish and benthic macroinvertebrate populations. One station from Hadnot Creek and two stations from Holland Mill Creek were used as references stations for Site 69. Fish and benthic macroinvertebrates were collected from these three stations.

Fish and Shellfish

This section discusses collection of the fish and shellfish samples in an unnamed tributary to the New River, Everett Creek, the New River, Hadnot Creek, and Holland Mill Creek.

A literature review was conducted to determine the fish species that may potentially be exposed to contaminants in the surface water/sediment exposure pathway. This review included compiling information from State and Federal natural resources agencies. In addition, Baker's experience in sampling similar areas formed a basis for a database of expected species for the area.

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

Sampling variability can prevent the same species of fish from being sampled at each station because either the preferred species was not captured, or adequate numbers of uniform-size individuals were not captured. Therefore, if the preferred species was not successfully collected to satisfy the above requirements, a substitute species was collected that, if possible, exhibiting a similar trophic position in the estuarine ecosystem.

The collected fish species were identified, measured, and counted. The small fish (less than 20 mm) were weighed in groups of 10 or 20 because of their low individual weight; the larger fish were weighed individually. The proportion of individuals as hybrids and the proportion of individuals with disease, tumors, fin damage, and skeletal anomalies was recorded at each station.

Everett Creek

This section discusses collection of the fish and oyster samples in Everett Creek including the station locations and sampling procedures.

Station Locations

Fish were collected from three stations on Everett Creek (69-EC-FS02, 69-EC-FS03, and 69-EC-FS04), while oysters were collected from one station on Everett Creek (69-EC-FS04). These stations are located near surface water/sediment sampling stations 69-EC1-SW/SD, 69-EC3-SW/SD, and 69-EC4-SW/SD, respectively (see Figure 7-3).

Station 69-EC-FS02 was moved to 69-EC-SW/SD01 because the lower salinity at 69-EC-SW/SD01 was more suitable for electrofishing. Station 69-EC-FS03 was located by 69-EC-SW/SD03, approximately three-quarters of a mile from Everett Creek's confluence with the New River. Finally, Station 69-EC-FS04 was located by 69-EC-SW/SD04 just upstream from Everett Creek's confluence with the New River. Oysters were not collected from 69-EC-FS02 or 69-EC-FS03 because they were not present at these stations. Blue crabs were collected from 69-EC-FS03.

Sampling Procedures

Fish were collected in Everett Creek using a combination of electrofishing, gill netting, and haul seining. Fish were collected by electrofishing at 69-EC-FS02, by gill netting at 69-EC-FS03, and gill netting and haul seining at 69-EC-FS04. Oysters were collected by hand collection at 69-EC-FS04.

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

The gill nets were six feet deep by 50 feet long with a stretch mesh size ranging from three to four inches, and an approximate twine break strength of 29 pounds. The nets were deployed approximately at the locations shown on Figure 7-3. Weights were attached to the nets to secure them on the bottom of the stream and yellow buoys marked with "Baker Environmental" were attached to the tops of the nets. The nets were deployed in the morning or evening, and they were checked for fish within twelve hours after deployment.

At each station where haul seines were utilized, a minimum of two haul seines were conducted. The haul seine was deployed with one person securing the seine on the shore and another person walking out in a loop. The bottom of the net was kept in contact with the sediment to prevent fish from swimming under the net. Other field personnel aided in removing snags from the net and preventing fish from jumping over the net. When the person deploying the net arrived back at shore, the net was pulled in, making sure the bottom of the net remained in the sediment. After the bag in the middle of the seine reached the shore, the bag was lifted and the fish were carefully transferred into plastic tubs filled with water.

<u>Unnamed Tributary</u>

This section discusses collection of the fish samples in the unnamed tributary including the station locations and sampling procedures.

Station Locations

Fish were collected from one station on the unnamed tributary (69-UT-FS01). This station is located near surface water/sediment sampling station 69-UT1-SW/SD, near the headwaters of the unnamed tributary (see Figure 7-3). Fish were not able to be collected at the other two proposed locations because the shallow water precluded site access during the times the sampling events were planned.

Sampling Procedures

Fish were collected in the unnamed tributary using electrofishing. The fish sampling via electroshocking was conducted using a Smith-Root, Inc., backpack electrofisher powered by a 300-watt portable generator. A DC current was applied utilizing a "rattail" as the cathode and a hand-held electrode as the anode. Blocking seines were placed downstream and upstream of the shocking areas to aid in the collection of the fish. The length of shocking time per subsection was recorded as seconds of applied current. Stunned fish were collected with one-inch mesh or smaller dip nets handled by members of the field sampling team.

New River

This section discusses the collection of fish and oysters in the New River including the station locations and sampling procedures.

Station Locations

Fish were collected from three stations on the New River (69-NR-FS01, 69-NR-FS02, and 69-NR-FS03), while oysters were collected from two stations on the New River (69-NR-FS02 and 69-NR-FS03). These stations are located near surface water/sediment sampling stations 69-NR1-SW/SD, 69-NR2-SW/SD, and 69-NR3-SW/SD, respectively (see Figure 7-3).

Station 69-NR-FS03 was located on the New River by its confluence with Everett Creek. Station 69-NR-FS02, was located on the New River between Everett Creek and the unnamed tributary. Finally, Station 69-NR-FS01 on the New River just upstream from the unnamed tributary. Oysters were not collected from 69-NR-FS01 because they were not present at this station.

Sampling Procedures

Fish were collected in the New River using a combination of gill netting and haul seining. Fish were collected by gill netting at 69-NR-FS03 and haul seining at 69-NR-FS01, 69-NR-FS02, and 69-NR-FS03. Oysters were collected by hand collection at 69-NR-FS02 and 69-NR-FS03. The same procedures used for the collection of fish via gill nets and haul seines in Everett Creek were used at these stations.

Holland Mill Creek

This section discusses collection of the fish samples in Holland Mill Creek including the station locations and sampling procedures.

Station Locations

Fish were collected from two stations in Holland Mill Creek (HM02 and HM03). HM02 was located at the confluence of Holland Mill Creek and Cartwheel Branch. HM03 was located in the White Oak River approximately fifty feet downstream from Holland Mill Creek (see Figure 7-2.2). The salinity at HM02 ranged from 1 to 19 ppt and fish were collected at this location. The salinity increased to 22 ppt at HM03, and fish were collected from this station.

Sampling Procedures

Fish were collected from these stations for population statistics and not tissue analysis. Fish were collected using gill nets and hoop nets. The same procedures used for the collection of fish via gill nets in Everett Creek were used at these stations. The hoop nets were 3 to 4 feet in diameter and 14 to 16 feet in length. Twenty-five-foot wings were attached to the nets to help direct fish into the net. The nets were deployed in the middle of the channel with the wings stretched across the creek in a 45° angle. The end of the net and the wings were secured using 6.5-foot wooden posts. The nets were checked at least once daily, as the fish usually survive when captured in these nets.

Hadnot Creek

This section discusses collection of the fish samples in Hadnot Creek including the station locations and sampling procedures.

Station Locations

Fish were collected from one station in Hadnot Creek (HC03). HC03 was located in the White Oak River, approximately 100 feet upstream from its confluence with Hadnot Creek.

Sampling Procedures

Fish were collected from this station for population statistics using a haul seine. The same procedures used for the collection of fish via haul seine in Everett Creek were used at this station. Fish were not collected at this station for tissue analysis.

Benthic Macroinvertebrates

This section discusses collection of benthic macroinvertebrate samples in Everett Creek, the unnamed tributary, the New River, Hadnot Creek, and Holland Mill Creek.

Everett Creek

This section discusses collection of the benthic macroinvertebrate samples in Everett Creek including the station locations and sampling procedures.

Station Locations

Benthic macroinvertebrates were collected from three stations in Everett Creek; one where each of the fish stations were located.

Sampling Procedures

Benthic macroinvertebrates were collected from a boat using a standard ponar grab. The dimensions of the ponar are 23 x 23 cm (9 x 9 in.) for a sampling area of 529 cm^2 or 0.0523 m^2 (81 in^2).

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

After all the benthic sampling at Site 69 was completed, the sample jars were transported to the Baker Ecological Laboratory for sample processing. Sample processing included washing each sample through a 0.5 mm sieve, transferring the washed sample back into the jar, and adding 70 percent isopropyl alcohol, as a preservative, to the washed sample in the jar. A small amount of rose bengal was added to each jar to stain the benthic macroinvertebrates a pink-red color to aid in the sorting process. The rose bengal stains the tissue cells of the organisms and helped to distinguish them from plant and other materials in the sediments.

The benthic macroinvertebrates were stained for at least 24 hours prior to sorting under a dissecting microscope. The benthic macroinvertebrates were removed from the sediments using a pair of forceps, and placed into glass vials containing 70 percent isopropyl alcohol and a 100 percent cotton paper label marked in pencil with the sample number. The vials were sealed with cotton and placed into a jar containing 70 percent isopropyl alcohol. The date, sorting time, approximate number of benthic macroinvertebrates collected, and the name of the person who sorted the sample were recorded on a sample processing log sheet.

The same sorting procedures outlined above were repeated as a QA/QC measure, with any additional species identified being placed into their respective vials. A senior environmental scientist was employed to perform this QA/QC measure. Fifty percent of a sample was resorted. If more than five percent of the individuals were missed during the initial sorting, than the rest of the sample was resorted. If less than five percent of the individuals were missed during the initial sorting, than the rest of the sample was not resorted.

The date, sorting time, number and type of additional organisms found and percent of sample that underwent QA/QC were recorded on the sample processing log sheet. The vials containing the benthic macroinvertebrates were sent to RMC Environmental Services for taxonomic identification.

Unnamed Tributary

Benthic macroinvertebrates were collected from three stations in the unnamed tributary; one where each of the surface water/sediment stations were located. The same procedures used for collecting benthic macroinvertebrates in Everett Creek were used at this water body.

New River

Benthic macroinvertebrates were collected from three stations in the New River; one where each of the fish stations were located. Benthic macroinvertebrates were collected using the same procedures used for collecting benthic macroinvertebrates in Everett Creek.

Hadnot Creek

Benthic macroinvertebrates were collected in Hadnot Creek using the ponar grab deployed from the boat. The same sample collection and sample processing procedures used in Everett Creek were conducted at the Hadnot Creek station (See Figure 7-2.1).

Holland Mill Creek

Benthic macroinvertebrates were collected at stations HM02 and HM03 (see Figure 7-2.2). Benthic macroinvertebrates were collected using the same procedures used for collecting benthic macroinvertebrates in Everett Creek.

7.3.1.2.2 Biological Sampling Results

The following sections present the results of sampling the abiotic habitat and biotic communities from the ecological investigation.

Abiotic Habitat

Information describing the abiotic habitat at Site 69 was recorded in the field log books at each station and was later transferred to data sheets (see Appendix S). The data sheets also include representative photographs of the stations.

Fish Stations

Fish were sampled at three stations in Everett Creek, one station in the unnamed tributary, and three stations in the New River (see Figure 7-3). Fish also were sampled at one station in Hadnot Creek and two stations in Holland Mill Creek (see Figures 7-2.1 and 7-2.2).

Unnamed Tributary

Station 69-UT1 was surrounded by deciduous trees and foliage, the stream was partly shaded. The channel at this station was approximately 0.15 m wide.

Everett Creek

Station 69-EC2 was surrounded by forest. The stream depth, width and velocity were not evaluated.

Station 69-EC3 was surrounded by grasses, hedges, wetland trees, spanish moss, pines and hardwood. The water at this station was approximately 0.9 m deep. The water was turbid.

Station 69-EC4 was surrounded by grasses, hedges, wetland trees, spanish moss, pines and hardwood. The water at this station was approximately 0.76 m deep.

New River

Station 69-NR1 was surrounded by grasses, hedges, wetland trees, spanish moss, pines and hardwood. The water at this station was approximately 0.61 m deep.

Station 69-NR2 was surrounded by forests. The water at this station was approximately 0.61 m deep.

Station 69-NR3 was surrounded by forests. The water at this station was approximately 0.61 m deep.

Hadnot Creek

Station HC03 was surrounded by forests and some urban development. The water at this station was 1 to 3 feet deep, although the White Oak River is much deeper.

Holland Mill Creek

Station HM02 was surrounded by forests. The water at this station was approximately 3 - 4 feet deep.

Station HM03 was surrounded by forests. The water at this station was approximately 1 to 3 feet deep, although the White Oak River is much deeper.

Benthic Macroinvertebrate Stations

Benthic macroinvertebrates were collected from three stations in the unnamed tributary, three stations in Everett Creek, and three stations in the New River (see Figure 7-3). Benthic macroinvertebrates also were collected from one station in Hadnot Creek and two stations in Holland Mill Creek (see Figures 7-2.1 and 7-2.2). The following sections discuss the sediment type at each station. The abiotic habitat and biotic communities are discussed in the previous sections of this report.

Unnamed Tributary

At Station 69-UT1, between thirty-two to seventy-two ounces of sediments were collected for the replicates. The sediments did not have a discernible odor. They were mostly sand with some organic material.

At Station 69-UT2, approximately sixteen ounces of sediments were collected in each replicate. The sediment had a slight anaerobic odor and was approximately ninety percent silt with ten percent detritus.

At Station 69-UT3, approximately twenty-four to thirty-two ounces of sediments were collected in the replicates. The sediments had a slight anaerobic odor and were approximately ninety percent silt with ten percent sticks. A salt wedge was recorded at this station.

Everett Creek

Between sixteen to twenty-four ounces of sediments were collected for the replicates at Station 69-EC2. There was no odor to the sediments which were very sandy.

Approximately eight ounces of sediments were collected for the replicates at Station 69-EC3. There was no odor in the sediments. The sediment consisted of approximately ninety-nine percent silt with one percent detritus.

Between twenty-four and thirty-two ounces of sediments were collected for the replicates at Station 69-EC4. There was no odor in the sediments. The sediment was primarily sandy with oyster shells, organic debris, stones, and twigs.

New River

Approximately eight ounces of sediment were collected for replicates at Station 69-NR1. There was no odor in the sediments, which were approximately ninety-nine percent silt and one percent sand with shell fragments.

Approximately eight ounces of sediment were collected for replicates at Station 69-NR2. There was no odor in the sediments that were approximately ninety-five percent sand with shell fragments and five percent silt.

Approximately eight ounces of sediments were collected for replicates at Station 69-NR3. There was no odor in the sediments that were very silty with some leaves, small shells and wood debris.

Hadnot Creek

Station HC03 was located in the White Oak River approximately one hundred feet upstream from Hadnot Creek. Approximately sixteen ounces of sediment were collected for replicates at station HC03. There was no odor in the sediments which were primarily fine sand/silt with some organic debris.

Holland Mill Creek

Between thirty-two and forty ounces of sediment were collected for replicates at station HM02. The sediments had a slight anaerobic odor. The sediments were approximately 50 percent silt with traces of sand and 50 percent organic debris, some organisms were also noted in the sediment.

Between eight and sixteen ounces of sediment were collected for replicates at station HM03. The sediment had a slight anaerobic odor. The sediments were approximately 90 percent fine silt with shell fragments and 10 percent organic debris, some live clams and mussels were also observed at this station.

7.3.1.3 Exposure Analysis/Profile

The next step in the characterization of exposure is to combine the spatial and temporal distributions of both the ecological component and the stressor to evaluate exposure. This section of the ERA addresses and quantifies each exposure pathway via surface water, sediment, air, soil, and groundwater.

To determine if ecological exposure via these pathways may occur in the absence of remedial actions, an analysis was conducted including the identification and characterization of the exposure pathways. The following four elements were examined to determine if a complete exposure pathway was present:

- A source and mechanism of chemical release
- An environmental transport medium
- A feasible receptor exposure route
- A receptor exposure point

7.3.1.3.1 Potential Exposure Scenarios

This section discusses the potential exposure scenarios at Site 69 including surface water, sediments, soil, groundwater and air. The location of samples was based on historical information available for the site and a site visit to evaluate potential ecosystems and ecological receptors (see Figure 7-1, Biohabitat Map).

Surface Water Exposure Pathway

Potential release sources to be considered in evaluating the surface water pathway are contaminated surface soils and groundwater. The release mechanisms to be considered are groundwater seepage and surface runoff. The potential routes to be considered for ecological exposure to the contaminated surface waters are ingestion and dermal contact. Potential exposure points for ecological receptors include species living in, or coming in contact with, the surface water on site or off site and downgradient relative to tidal influence.

COPCs were detected in the surface water demonstrating a release from a source to the surface water transport medium. Potential receptors that may be exposed to contaminants in surface waters in/or around surface water include: fish, benthic macroinvertebrates, deer, birds, and other aquatic and terrestrial life.

Aquatic organisms (i.e., fish, benthic macroinvertebrates) are exposed to contaminants in the surface water by ingesting water while feeding and by direct contact. In addition, aquatic organisms may ingest other aquatic flora and fauna that have bioconcentrated chemicals from the surface water. Overall, aquatic organisms have a high exposure to contaminants in the surface water. Potential decreased viability of aquatic receptors from contaminants in the surface water were evaluated in this ERA by direct comparisons of contaminant concentrations in the surface water to published water quality standards and criteria.

Terrestrial faunal receptors potentially are exposed to contaminants in the surface water through ingestion and dermal contact. The magnitude of the exposure depends on their feeding habits and the amount of time they reside in the contaminated waters. In addition, terrestrial species may ingest organisms (e.g., fish, insects, plants) that have bioconcentrated contaminates from the surface water. Potential decreased viability of terrestrial receptors from contaminants in the surface water was evaluated in this ERA by comparing CDI to TRVs. Total exposure of the terrestrial receptors to the COPCs in the surface waters was determined by estimating the CDI dose and comparing this dose to TRVs representing acceptable daily doses in mg/kg/day.

Sediment Exposure Pathway

The potential release sources to be considered in evaluating the sediment pathway are contaminated surface soils and groundwater. The release mechanisms to be considered are groundwater seepage and surface runoff. The potential routes to be considered for ecological exposure to the contaminated sediments are ingestion and dermal contact. Potential exposure points for ecological receptors include species living in, or coming in contact with, the sediments.

COPCs were detected in the sediment demonstrating a release from a source to the sediment transport medium. Potential receptors that may be exposed to contaminants in sediments include benthic macroinvertebrates, bottom feeding fish, aquatic vegetation and other aquatic life.

Aquatic organisms (i.e. fish, benthic macroinvertebrates) are exposed to contaminants in the sediments by ingesting sediments while feeding and by direct contact. In addition, aquatic organisms may ingest other aquatic flora and fauna that have bioconcentrated chemicals from the sediments. Overall, aquatic organisms have a high exposure to contaminants in the sediment. Potential decreased viability of aquatic receptors from contaminants in the sediment were evaluated in this ERA by direct comparisons of contaminant concentrations in the sediments to SSVs.

Terrestrial faunal receptors potentially are exposed to contaminants in the sediments through ingestion and dermal contact. The magnitude of the exposure depends on their feeding habits and the amount of time they reside in the contaminated sediments. In addition, terrestrial species may ingest organisms (e.g., fish, insects, small mammals, plants) that have bioconcentrated contaminates from the sediments. Potential decreased viability of terrestrial receptors from contaminants in the sediments was qualitatively evaluated in this ERA.

Soil Exposure Pathway

Potential release sources to be considered in evaluating the soil pathway are surface or buried wastes and contaminated soil. The release mechanisms to be considered are fugitive dust, leaching, tracking, and surface runoff. The transport medium is the soil. The potential routes to be considered for ecological exposure to the contaminated soils are ingestion and dermal contact. Potential exposure points for ecological receptors include species living in, or coming in contact with, the soils.

COPCs were detected in the surface soil demonstrating a release from a source to the surface soil transport medium. Potential receptors that may be exposed to contaminants in surface soil at/or around surface soil in the areas of detected COPCs including: deer, fox, raccoon, rabbit, bird, plants, and other terrestrial life.

Terrestrial receptors potentially are exposed to contaminants in the soils through ingestion, dermal contact, and/or direct uptake (for flora). The magnitude of the exposure depends on their feeding habits and the amount of time they reside in the contaminated soils. In addition, terrestrial species may ingest organisms (e.g., insects, small mammals, plants) that have bioconcentrated contaminates from the soils. Potential decreased viability of terrestrial receptors from contaminants in the surface soils was evaluated in this ERA by comparison of CDIs to TRVs, and direct comparisons of soil concentrations to literature toxicity value for plants and invertebrates.

Groundwater Exposure Pathway

The potential release source to be considered in evaluating the groundwater pathway is contaminated soils. The release mechanism to be considered is leaching. The routes to be considered for ecological exposure to the contaminated groundwater are ingestion and dermal contact. Groundwater discharge to area surface waters may represent a pathway for contaminant migration. Since organisms are not directly exposed to groundwater at Site 69, the groundwater to surface water exposure is accounted for in the surface water section of the ERA.

Air Exposure Pathway

There are two potential release mechanisms to be considered in evaluating the atmospheric pathway: release of contaminated particulates and volatilization from surface soil, groundwater and surface water. The potential exposure points for receptors are areas on or adjacent to the site.

No data has been collected to document exposure to receptors via the air pathway. However, based on the low concentrations of VOCs detected in the soils, sediments, and surface water, and the negligible vapor pressure of pesticides and metals, the air concentration of the COPCs is not expected to cause a decrease in viability of the terrestrial receptors. Therefore, this pathway was not evaluated as part of the ERA.

7.3.2 Ecological Effects Characterization

The potential ecological effects to aquatic receptors were evaluated by direct comparisons of contaminant concentrations in surface water and sediment to ARARs and other available criteria or TBCs. Potential ecological effects to terrestrial receptors were evaluated by comparison to literature values and by comparing the CDIs to TRVs. The following sections further discuss the Aquatic Reference Values (ARV) comparisons and the CDI to TRV comparisons to evaluate the potential ecological effects to aquatic and terrestrial receptors from the COPCs.

Contaminant concentrations detected in the surface water at Site 69 were compared to the NC DEHNR WQS, USEPA WQSV, USEPA AWQC and other toxicity values obtained from the USEPA AWQC documents and AQUIRE to determine if there were any exceedances of the published values. In addition, the log normal upper 95 percent confidence limit or the maximum value detected were compared to the WQS, the acute and chronic WQSVs, and the acute and chronic AWQC using the quotient ratio method. If the variability in measured concentration values is great and the log normal upper 95 percent confidence limit was greater than the maximum detected value, the maximum detected value was used in the quotient ratio. This yields a value termed the Quotient Index (QI). A QI greater than unity indicates a potential for adverse effects to aquatic life. The log normal upper 95 percent confidence limit were used to represent a conservative estimate of exposure at the site. The ratio of the upper 95 percent confidence limit (or maximum detected value) and the ARVs were calculated for each COPC.

Contaminant concentrations detected in the sediments at Site 69 were compared to the SSVs to determine if there were any exceedances in the established values. In addition, the upper 95 percent confidence limit or the maximum value detected was compared to the Region IV lower 10 percentile (ER-L) and median percentile (ER-M) using the quotient ratio method. Because the screening values are set to be protective of the aquatic environment, any exceedances of these values indicate a potentially toxic environment for the aquatic organisms inhabitating the water body.

7.3.2.1 Surface Water Quality

Tables 7-5 through 7-7 contain the saltwater North Carolina WQS, the Region IV USEPA WQSV, and the USEPA AWQC for the COPCs detected at the unnamed tributary, Everett Creek and the New River at Site 69, respectively.

The following COPCs detected in the surface water samples do not have WQS, WQSV, or AWQC values: aluminum, barium, iron, manganese, and vanadium. The potential impact to aquatic species from these chemicals in the surface water was evaluated using the results of acute and chronic tests obtained from the AQUIRE database (AQUIRE, 1993). The maximum detected concentration of these chemicals in the surface water were below the adverse effects levels obtained from the database. Therefore, no decrease in viability of ecological receptors from these chemicals is expected.

7.3.2.1.1 Field Chemistry Results

Table 7-8 is a summary of the field chemistry results for the unnamed tributary, Everett Creek and the New River. Samples from these surface water bodies were collected from the water surface and bottom.

Unnamed Tributary

In the unnamed tributary, salinity ranged from 0 to 8.5 parts per thousand (ppt). Conductivity ranged from 75 to 15,200 micromhos/cm. Dissolved oxygen levels ranged from 4.5 to 10.3 mg/L. The pH in the unnamed tributary ranged from 4 to 8.5 S.U. in the water surface samples. The temperature of the unnamed tributary water ranged from 23 to 30.5°C.

Everett Creek

At Everett Creek, salinity ranged from 0 to 13.5 ppt. Conductivity ranged from 79 to 26,000 micromhos/cm. Dissolved oxygen levels ranged from 0.4 to 5.85 mg/L. The pH in Everett Creek ranged from 3.8 to 6.0 S.U. in the water surface samples. The temperature of Everett Creek water ranged from 22.2 to 27.5°C.

New River

In the New River, salinity ranged from 8 to 14 ppt. Conductivity ranged from 2,300 to 23,000 micromhos/cm. Dissolved oxygen levels ranged from 5.5 to 9.1 mg/L. The pH in the New River ranged from 6.9 to 7.7 S.U. in the water surface samples. The temperature of New River water ranged from 26.9 to 30.8°C.

7.3.2.2 Sediment Quality

Tables 7-9 through 7-11 contain the sediment SSVs for hazardous waste sites for the COPCs detected in the unnamed tributary, Everett Creek and the New River at Site 69. Sediment samples were collected from zero to six inches, and six to twelve inches at most of the sediment stations. Some sediment stations were sampled at a depth of zero to six inches only, due to sampler refusal or other difficulties in collecting the 6 to 12-inch sample.

The following COPCs detected in the sediments do not have SSVs for them: aluminum, barium, beryllium, cobalt, iron, manganese, and vanadium. There is limited, if any, data assessing the effects on aquatic organism exposed to these chemicals in sediment samples. Therefore, the effects of these chemicals on aquatic organisms were not determined.

7.3.2.3 Biological Tissue Samples

Table 7-12 is a summary of the biota tissue samples evaluated for chemical analysis. The number of organisms, species type, total weight, and sample type (i.e., whole body or fillet) are presented. No samples from the unnamed tributary were sent for analysis due to their small size. Samples from two stations at Everett Creek were sent for tissue analysis. The fish species to be evaluated included summer flounder, blue crab, Atlantic croaker, striped mullet, and oyster. Of the three stations sampled in the New River, the species sent for chemical analysis included Atlantic croaker, Atlantic menhaden, spot, striped mullet and oyster.

The analytical parameters included VOCs, SVOCs, total metals, pesticides and PCBs. Appendix R presents the statistical summary results for the organic and metals analyses for the Everett Creek and New River tissue samples. These tables include the minimum and maximum detected concentration, the location of the maximum detection and the frequency of detection. Appendices Q and R contains the analytical results in total. The following sections provide brief discussions of the chemical results for the Everett Creek and New River ecological samples.

No background fish, crab, or oyster tissue chemical analyses were completed for this site. Consequently, comparison of the chemical levels from the tissue samples collected from Everett Creek and the New River to site background was not addressed. However, comparisons were made to available chemical concentration ranges found in fish tissue based on published studies and other literature results. This was used to provide some insight as to how site levels compare to the chemical levels found in fish tissue samples collected from surface water bodies around the world. Section 7.5.1.2 provides this information and discussion.

7.3.2.3.1 Everett Creek

Several metals were detected in the Everett Creek tissue samples. These metals included beryllium, cadmium, calcium, magnesium, potassium, selenium, silver, sodium and zinc. The inorganics considered to be essential nutrients and of low toxicity in humans were found in most of the samples. These metals included calcium, magnesium, potassium, sodium and zinc. The range of detected levels for these chemicals in the fish, oyster, and crab tissue samples from Everett Creek are as follows:

	Minimum (mg/kg)	Maximum (mg/kg)
Beryllium	0.001	0.01
Cadmium	0.11	0.11
Calcium	1,600	35,600
Magnesium	299	2,180
Potassium	617	3,870
Selenium	0.14	0.45
Silver	0.02	0.28
Sodium	755	3,730
Zinc	8.3	239

Beryllium, cadmium, and silver were found in the summer flounder, oyster, blue crab and striped mullet samples. Selenium was found in all tissue samples. The maximum detection of the following metals were found in the blue crab sample: calcium, magnesium, silver and sodium. The maximum detection of potassium was detected in the summer flounder tissue sample.

Two pesticides detected throughout most of the tissue samples were 4-4'-DDE and 4-4'-DDD. The maximum levels for these pesticides, 0.28 and 0.15 mg/kg, respectively, were detected in the summer flounder tissue. Endrin and Aroclor-1254 and Aroclor-1260 were detected only once in the summer flounder and Atlantic croaker tissue samples, respectively. The range of detected concentrations for these constituents were as follows:

	Minimum (mg/kg)	Maximum (mg/kg)
4-4'-DDE	0.079	0.280
4-4'-DDD	0.022	0.150
Endrin	0.039	0.039
Aroclor-1254	0.034	0.340
Aroclor-1260	0.068	0.068

Several VOCs were detected in the tissue samples. Common laboratory contaminants were the primary detections, which included methylene chloride, acetone, 2-butanone and 2-hexanone. In addition, benzene and toluene were detected. The maximum level of most of the detected parameters, excluding 2-butanone and 2-hexanone, were found in the blue crab and summer flounder tissue samples. The concentration ranges for these chemicals were the following:

	Minimum (mg/kg)	Maximum (mg/kg)
Methylene chloride	0.007	0.069
Acetone	0.064	1.30
2-butanone	0.015	0.019
2-hexanone	0.038	0.038
Benzene	0.002	0.079
Toluene	0.001	0.039

Only one SVOC, di-n-octylphthalate, was detected in the Everett Creek samples at a concentration of 0.120 mg/kg. It was only found in one Atlantic croaker tissue sample.

7.3.2.3.2 New River

The following metals were detected in the tissue samples collected from the New River: aluminum, beryllium, cadmium, calcium, iron, magnesium, potassium, selenium, silver, sodium, thallium and zinc. Similar to the Everett Creek tissue samples, calcium, magnesium, potassium and sodium were found in all the New River tissue samples. Maximum tissue levels were found in the Atlantic menhaden (aluminum, iron); oyster (beryllium, cadmium, zinc); and Atlantic croaker (selenium, thallium). The range of detected concentrations is as follows:

	Minimum (mg/kg)	Maximum (mg/kg)
Aluminum	1.4	362
Beryllium	0.005	0.01
Cadmium	0.12	0.22
Calcium	603	16,300
Iron	8.9	263
Magnesium	268	540
Potassium	742	3,680
Selenium	0.12	0.51
Silver	0.01	0.14
Sodium	663	2,540
Thallium	0.03	0.03
Zinc	7.8	312

Similar to Everett Creek, the same two pesticides were detected throughout most of the tissue samples, 4-4'-DDE and 4-4'-DDD. The concentration ranges for these two pesticides were 0.0025 to 0.017 mg/kg and 0.0003 to 0.0064 mg/kg.

Common laboratory contaminants were also the primary detections in the New River samples, which included methylene chloride, acetone, 2-butanone and 2-hexanone. In addition, benzene and toluene were detected. The maximum level of 2-butanone and 2-hexanone were found in the Atlantic menhaden tissue samples.

The detected levels ranged between the listed values:

	Minimum (mg/kg)	Maximum (mg/kg)
Methylene chloride	0.003	0.020
Acetone	0.015	0.460
2-butanone	0.007	0.049
2-hexanone	0.010	0.073
Benzene	0.002	0.036
Toluene	0.002	0.014

Only one SVOC, 2-methylphenol, was found in this sample group. The only detected concentration was 0.22 mg/kg.

7.3.2.4 Surface Soil Quality

There are no standards, criteria, or other screening values for assessing potential impacts to terrestrial ecological receptors from contaminants in soils. In addition, the amount of literature data evaluating adverse ecological effects on terrestrial species exposed to contaminants in surface soils is limited. However, toxicological effects on plants and/or invertebrates inhabiting soils contaminated by the following chemicals were obtained from various studies in the literature: barium, chromium, lead, manganese, silver, vanadium, and zinc. This data was used to evaluate decreased viability of terrestrial flora and invertebrates from COPCs in the soil.

No toxicological effects of plants and/or invertebrates inhabiting soils contaminated by the following chemicals were obtained from various studies in the literature: aluminum, cobalt, iron, nickel, selenium, and thallium. Therefore, these contaminants were not evaluated in the ERA.

No information was found which evaluate the toxicological affects on plants and/or invertebrates inhabiting soils contaminated with TCL organics, therefore, the evaluation was limited to TAL inorganics.

7.3.2.5 Terrestrial Chronic Daily Intake

As discussed above, there are no standards, criteria, or other screening values for assessing potential impacts to terrestrial receptors from contaminants in soils. However, there are some models that exist to estimate the exposure to terrestrial receptors. The following describes the procedures used to evaluate the potential soil exposure to terrestrial fauna at Site 69 by both direct and indirect exposure to COPCs via water (surface water), soil, and foodchain transfer.

Contaminants of concern at Site 69 are identified in Section 7.2.1.1 for each media. Based on the regional ecology and potential habitat at the site, the indicator species used in this analysis are the white-tailed deer, cottontail rabbit, red fox, raccoon, and the bobwhite quail. The exposure points for these receptors are the surface soils, surface water, and vegetation. The routes for terrestrial exposure to the COPCs in the soil and water are incidental soil ingestion, drinking water, vegetation (leafy plants, seeds and berries) ingestion, fish ingestion, and ingestion of small mammal ingestion.

Total exposure of the terrestrial receptors to the COPCs in the soil and surface waters was determined by estimating the Chronic Daily Intake (CDI) dose and comparing this dose to TRVs representing acceptable daily doses in mg/kg/day. For this analysis, TRVs were developed from NOAELs or LOAELs obtained from the Integrated Risk Information System (IRIS, 1993), or other toxicological data in the literature (Table 7-13).

7.4 Risk Characterization

The risk characterization is the final phase of a risk assessment. It is at this phase that the likelihood of adverse effects occurring as a result of exposure to a stressor are evaluated. This section evaluates the potential adverse effects on the ecological viability at Site 69 from contaminants identified at the site.

A Quotient Index (QI) approach was used to characterize the risk to aquatic receptors from exposure to surface water and sediments. This approach characterizes the potential effects by comparing exposure levels of COPCs in the surface water and sediments to the ARVs presented in

Section 7.2.3, Ecological Effects. The QI is calculated as follows:

$$QI = \frac{EL}{ARV}$$

Where: QI = Quotient Index
EL = Exposure Level, mg/L or mg/kg
ARV = Aquatic Reference Value, mg/L or mg/kg

7.4.1 Surface Water Quality

Table 7-14 contains a comparison of the COPCs identified in the surface water at Site 69 to the ARVs to determine if they exceeded the published values. A QI ratio of the detected value at each sampling station, and WQS, WQSVs, and AWQC were calculated for each COPC. A QI ratio greater than unity indicates a potential for decreased viability of aquatic life. Table 7-14 presents only the ratios that are greater than unity for the COPCs at each site. Figure 7-4 presents the QI exceedances per sampling station.

The following sections discuss the surface water quality results at Site 69. These sections contain comparisons of the contaminants detected in the surface water and sediments at the sites to their ARVs and comparisons to base-wide background (inorganics only) concentrations (see Section 4.4 for base background concentration tables).

Unnamed Tributary

Three surface water samples collected in the unnamed tributary were analyzed for TCL organics, TCL pesticides, TCL PCBs, and TAL inorganics. Copper had a QI ratio greater than unity when compared to the NCWQS, the acute and chronic WQSV, and the acute AWQC in one sample. Copper was detected at a concentration below the base-wide background average concentration. The locations of these exceedances are presented in Table 7-14 and Figure 7-4. No other TAL inorganics exceeded any of the surface water ARVs in the unnamed tributary.

No organics, pesticides, or PCBs were detected in the unnamed tributary in any of the surface water samples. Therefore, there were no other exceedances.

Everett Creek

Three surface samples collected in Everett Creek were analyzed for TCL organics, TCL pesticides, TCL PCBs, and TAL inorganics. None of the organics, pesticides or PCBs had QIs greater than unity when compared to the surface water ARVs. However, silver had QIs greater than unity when compared to the NCWQS, the acute and chronic WQSVs and the acute and chronic AWQC in two samples. Silver was not detected in the base-wide background samples. The locations of these exceedances are presented in Table 7-14 and Figure 7-4. No other inorganics detected in Everett Creek exceeded any of the surface water ARVs.

New River

Three surface water samples collected in the New River were analyzed for TCL organics, TCL pesticides, TCL PCBs, and TAL inorganics. Silver had QIs greater than unity when compared to the NCWQS, the acute and chronic WQSV, and the acute and chronic AWQC in two samples. Silver was not detected in the base-wide background samples. The locations of these exceedances are presented in Table 7-14 and Figure 7-4. No other TAL inorganics exceeded any of the surface water ARVs in the New River.

No TCL organics, TCL pesticides or TCL PCBs detected in the New River had QIs greater than unity when compared to the surface water ARVs.

7.4.2 Sediment Quality

Table 7-15 contains a comparison of the COPCs identified in the sediment to the ARVs to determine if exceedances of published values occurred. For reasons stated above, the sediment samples collected in the drainage areas at Site 69 were not evaluated. The QI ratio of the detected values at each sampling station and the ER-L and ER-M were calculated for each COPC. A ratio greater than unity indicates a possibility for adverse effects to aquatic life. Table 7-15 presents only the ratios that are greater than unity for the COPCs. Figure 7-4 presents the ratios that are greater than unity per sampling location.

The following sections discuss the sediment quality results at the sites. These sections contain a comparison of the contaminants detected in the sediments to their ARVs and base-wide background concentrations (see Section 4.4 for base background inorganic concentration tables).

Unnamed Tributary

Five sediment samples collected from three stations in the unnamed tributary were analyzed for TCL organics, TCL pesticides, TCL PCBs, and TAL inorganics.

No inorganics detected in the unnamed tributary exceeded the ER-L or ER-M values for the sediment samples.

Among the pesticides, 4-4'-DDE and 4-4'-DDD exceeded the ER-L in three samples and the ER-M in two samples. No other pesticides detected in the unnamed tributary sediments exceeded the ER-L or ER-M values in any of these samples. Also, Aroclor-1260 and benzo(a)pyrene each exceeded the ER-L in one sample.

The following COPCs in the unnamed tributary sediments had QIs greater than unity when compared to the ER-L: benzo(a)pyrene, 4-4'-DDE, 4-4'-DDD, and Aroclor-1260. The following COPCs had ratios greater than unity when compared to the ER-M: 4-4'-DDE and 4-4'-DDD.

Everett Creek

Five sediment samples collected from three stations were analyzed for TCL semivolatile organics, TCL pesticides, TCL PCBs, and TAL inorganics. Cadmium and mercury exceeded the ER-L in one sample each. Cadmium was detected at concentrations above the base-wide background average concentration in five samples. Mercury was not detected in the base-wide background samples. No other inorganics detected in the sediments exceeded the ER-L or ER-M values. Among the pesticides, 4-4'-DDE exceeded the ER-L in one sample. No other organics, pesticides or PCBs exceeded the ER-L or ER-M values in any of the sediment samples.

The following COPCs in the sediments had QIs greater than unity when compared with the ER-Ls: cadmium, mercury, and 4-4'-DDE. No COPCs had QIs greater than unity when compared with the ER-Ms.

New River

Five sediment samples collected from three stations in the New River were analyzed for TCL organics, TCL pesticides, TCL PCBs, and TAL inorganics.

No TCL organics, TCL pesticides, TCL PCBs or TAL inorganics were detected in the New River sediments exceeded the ER-L or ER-M values.

7.4.3 Fish

The following sections discuss the fish statistics for the unnamed tributary, Everett Creek and the New River. Appendix V presents a summary of the fish population statistics for the unnamed tributary, Everett Creek, the New River, and the reference stations. Included in this appendix are the aquatic species identified, the total number found at each sampling station, and the average, minimum and maximum length and weight for each species identified. Table 7-16 is a summary of the fish species collected at Site 69 and the reference stations. Table 7-17 is a summary of the total number of aquatic species and the number of individuals for the fish identified at the sampling stations along the unnamed tributary, Everett Creek, the New River and the reference stations while Table 7-18 describes the fish characterization. Section 7.5.1.2 discusses the results presented in the tables and appendix.

7.4.3.1 Unnamed Tributary

Only one station, 69-UT-1, was used for collection of fish in the unnamed tributary. At this station, only two species were identified: a minnow and American eel. These species were only found in the unnamed tributary and at low densities (i.e., 10 minnows and one American eel). The length of the minnows ranged from 3.2 to 5.4 cm. The weight was 0.5 grams. The American eel was 16 cm. long and 5 grams in weight. The two species identified at this sample station consisted of 11 individuals with ten individuals not identified.

7.4.3.2 Everett Creek

Species were collected from three stations, 69-EC-2, 69-EC-3 and 69-EC-4, at Everett Creek. A total of nine fish species consisting of 119 individuals and 2 aquatic species other than fish consisting of three individuals were collected in Everett Creek.

Of the nine fish species and two other aquatic species collected at the three Everett Creek sample stations, the predominant fish species were Atlantic croaker, Eastern mosquito, and pinfish. Blue crabs were also collected in Everett Creek. Approximately 40 Atlantic croakers were collected at station 69-EC-4. The length of these fish ranged from 10 to 14.5 cm. The weight ranged from 15 to 17 grams. At station 69-EC-2, approximately 33 Eastern mosquito were found. The fish length varied between 1.6 and 4.9 cm. The weight of the fish was 0.45 grams. Twenty-four pinfish were collected at station 69-EC-4. The length of the fish ranged from 8.1 to 14.6 cm. The weight varied between 1.1 and 20 grams.

Of the aquatic species other than fish collected at the Everett Creek sampling stations, only two blue crab were identified at station 69-EC-3. The length of the crabs ranged from 14.5 to 15 cm. The crab weight ranged from 215 to 225 grams. Fish and oyster species were collected at station 69-EC-4.

7.4.3.3 New River

A total of 15 fish species and 3 other aquatic species were collected at the three sampling stations located on the New River. Of the nine species collected at 69-NR-1, 252 individuals were collected. Eleven species were found at 69-NR-2. There were approximately 176 individuals collected at this station. Eight species consisting of 325 individuals were collected at 69-NR-3.

The most species were collected at station 69-NR-2, as compared to the other two stations. The predominant fish species in the New River were spot, Atlantic croaker and pinfish. Blue crab and oyster were also collected.

At station 69-NR-1, approximately 106 spot were collected. The length of the fish ranged from 6.1 to 9.6 cm. The fish weight varied from 6.3 to 7.3 grams. Approximately 43 spot were identified at station 69-NR-2. The length varied between 6.2 and 9.4 cm. The fish weight ranged from 6.3 to 7.0 grams. At station 69-NR-3, 70 spot were collected. The length varied between 6.5 and 10.2 cm. The average fish weight was 5.7 grams.

Atlantic croaker were collected at the three New River stations. At stations 69-NR-1 and 69-NR-2, 40 Atlantic croakers were identified. Sixty-six Atlantic croakers were found at station 69-NR-3. The fish length ranged from 9.5 to 14.2 cm at station 69-NR-1. The weight of the fish varied between 13 and 16.5 grams. At station 69-NR-2, the length ranged from 7.4 to 11.8 cm, and the weight only slightly varied between 10.5 and 10.8 grams. The length of Atlantic croakers collected at station 69-NR-3 ranged from 9 to 13.5 cm. The weight varied between 7.5 and 35 grams.

The quantities of pinfish collected at the New River sampling stations were as follows: 24 at 69-NR-1; 43 at 69-NR-2; and 60 at 69-NR-3. The length of pinfish collected at 69-NR-1 ranged from 6.5 to 9.5 cm. The total fish weight was 235 grams. At 69-NR-2, the fish length ranged from 7 to 13 cm. The weight only slightly varied between 8.3 and 8.8 grams. The length of fish collected at station 69-NR-3 varied between 6.5 and 10.3 cm. The weight of these fish were between 6.5 and 9.0 grams.

One blue crab was identified at station 69-NR-1. The length was 12 cm. Seventy oysters were collected at station 69-NR-2 and 50 oysters were collected at station 69-NR-3. The oysters were not weighed or measured.

7.4.3.4 Fish Similarity

The following sections summarize the results of similarity between the fish species collected at the unnamed tributary, Everett Creek and the New River. Background comparisons to Hadnot Creek and Holland Mill Creek were included.

Unnamed Tributary

Ten unidentified minnows and one American eel were collected in the unnamed tributary. Neither of these species were found in Everett Creek, the New River, Hadnot Creek or Holland Mill Creek.

Everett Creek

One hundred nineteen individuals from nine species of fish were collected in Everett Creek. The species found were, Atlantic menhaden, herring, stripped mullet, pin fish, palemento, Atlantic croaker, pig fish, summer flounder, and eastern mosquito. The pin fish and Atlantic croaker were the most abundant species collected in Everett Creek. All of the species were found in the New River with the exception of the eastern mosquito. The stripped mullet, Atlantic croaker, summer flounder, pin fish, and Atlantic menhaden were also collected in Hadnot Creek and Holland Mill Creek.

New River

Seven hundred fifty three individuals from fifteen fish species were collected in the New River. The species found were the Atlantic menhaden, herring, spot, perch, stripped mullet, pin fish, mahara, palemento, Atlantic croaker, pig fish, northern puffer, jack, white perch, sheeps head, and summer flounder. The spot, Atlantic croaker, and pin fish were the most abundant species collected in the New River. The Atlantic menhaden, herring, stripped mullet, pin fish, palemento, Atlantic croaker, pig fish, and summer flounder were also found in Everett Creek. The spot, stripped mullet, Atlantic croaker, summer flounder, pin fish, Atlantic menhaden, and white perch were also found in Hadnot Creek, with the spot, Atlantic croaker, and pin fish being the most abundant species collected in Hadnot Creek. The spot, stripped mullet, summer flounder, pin fish, and Atlantic menhaden were also collected in Holland Mill Creek, with the stripped mullet and Atlantic menhaden being the most abundant species collected in Holland Mill Creek.

7.4.4 Benthic Macroinvertebrates

Table 7-19 contains the summary statistics for the benthic organisms collected from the unnamed tributary, Everett Creek, the New River, and the reference stations. Appendix W contains the raw data. The parameters include the number of benthic species collected at each station, the number of benthic organisms identified at each station, the species density, which is the number of organisms per square meter study area, and the macroinvertebrate biotic index. Overall species richness is indicated by the number of benthic species collected at each station. The macroinvertebrate biotic index (MBI), ranging from 0 to 10, summarizes overall population tolerance to a single value, which is used specifically for detecting organic pollution. These MBIs are presented in Table 7-20.

Table 7-21 is a systematic listing of all benthic organisms collected from the sampling stations along the unnamed tributary, Everett Creek and the New River. Individual organisms were classified based on the specific genus or species classification. The results of the benthic macroinvertebrate sample collection from the unnamed tributary, Everett Creek and the New River are presented in the following sections.

7.4.4.1 Unnamed Tributary

In the unnamed tributary, 11 species consisting of 41 individuals were identified at the 3 sampling stations. The identified phyla were Anthropoda, Annelida, Mollusca, and Rhynchocoela. Eleven taxa of benthic macroinvertebrates from these four phyla were found in the unnamed tributary. Approximately 29 percent of these species (12 individuals out of a total of 41 detected organisms) was the capitellid Heteromastus filiformis. Seventeen percent of the detected organisms was the tubificid Limnodrilus udekemianus. Most of the benthic macroinvertebrate species found in the unnamed tributary were from the Annelida phylum.

Most of the benthic species (7 species) were found at station 69-UT3. At stations 69-UT1 and 69-UT3, 15 and 25 individual organisms were found, respectively. Only one species consisting of one organism was found at station 69-UT2. Species density was highest at station 69-UT3 (159 organisms/m^2). The greater species diversity occurred at stations 69-UT1 (0.51); and 69-UT3 (0.69). An MBI was calculated for station 69-UT1. The MBI was 8. MBIs were not calculated for the other two stations.

7.4.4.2 Everett Creek

A total of 15 species consisting of 301 individuals were collected from the two sampling stations at Everett Creek. No benthic macroinvertebrates were present in the sample collected at Station 69-EC2. Similar to the unnamed tributary, the identified phyla were Anthropoda, Annelida, Mollusca, and Rhynchocoela. Twelve taxa of benthic macroinvertebrates from these four phyla were found in Everett Creek. Approximately 29 percent of these species (88 individuals out of a total of 301 detected organisms) was the capitellid Heteromastus filiformis. Twenty-six percent of the detected organisms was the spionid Streblospio benedicti. The next abundant group of benthic macroinvertebrate species was the bivalve Anatina anatina, found at a frequency of 18 percent.

Species abundance was greatest at station 69-EC4. The number of species detected at this station was 12, consisting of 236 organisms. Three species consisting of 65 organisms were found at station 69-EC3. Similarly, species density and diversity was greatest at station 69-EC4. The MBI calculated for sampling station 69-EC4 was 6.3.

7.4.4.3 New River

Three sampling stations consisting of three replicates each were utilized for collection of benthic organisms from the New River. A total of 29 aquatic species consisting of 1,074 individuals were identified. Similar to the unnamed tributary and Everett Creek, the identified phyla consisted of Anthropoda, Annelida, Mollusca, and Rhynchocoela. Twelve taxa of benthic macroinvertebrates from these four phyla were found in the New River. Approximately 69 percent of these species (741 individuals out of a total of 1,074 detected organisms) was the capitellid Heteromastus filiformis. Nine percent of the detected organisms was the goniadid Glycinde solitaria. The next abundant groups of benthic macroinvertebrate species were the spionid Streblospio benedicti, found at a frequency of eight percent, and the bivalve Anatina anatina, found at a frequency of 6 percent.

Similar quantities of species and individuals were collected among these three sampling stations. The quantities ranged from 9 to 11 species and 201 to 452 individuals per station. Species density ranged from 1,281 to 2,881 individuals per m^2. Species diversity varied between 0.40 and 0.718. An MBI was calculated for station 69-NR2. The MBI was 9.4.

7.4.4.4 Community Similarity

The following sections present the results of species similarity among the benthic macroinvertebrates collected at the unnamed tributary, Everett Creek and the New River. Background from Hadnot and Holland Mill Creek was included in the discussion.

7.4.4.4.1 Unnamed Tributary

Table 7-22 presents the results of the Jaccard coefficient (Sj) of community similarity and the SΦrenson index (Ss) of community similarity between benthic macroinvertebrate collection stations along the unnamed tributary and the background stations.

The Sj values for the unnamed tributary sampling stations ranged from 0 to 0.14. The Ss values ranged from 0 to 0.25. The Sj values for the unnamed tributary and the background sampling stations ranged from 0 to 0.17. The Ss values ranged from 0 to 0.29. These low index values indicate that little community similarity exists between the benthic macroinvertebrate species found at the unnamed tributary and background sampling stations.

7.4.4.4.2 Everett Creek

Table 7-23 presents the results of the Jaccard coefficient (Sj) of community similarity and the SΦrenson index (Ss) of community similarity between benthic macroinvertebrate collection stations along Everett Creek and background.

The Sj value for the Everett Creek sampling stations was 0.25. The Ss value was 0.40. The Sj values for Everett Creek and the background sampling stations ranged from 0 to 0.25. The Ss values ranged from 0 to 0.40. Similar to the unnamed tributary, community similarity between the sampling stations of Everett Creek and background was low.

7.4.4.4.3 New River

Table 7-24 presents the results of the Jaccard coefficient (Sj) of community similarity and the SΦrenson index (Ss) of community similarity between benthic macroinvertebrate collection stations along the New River and background.

The Sj values between the New River collection stations ranged from 0.67 to 0.82. The Ss values between these stations ranged from 0.8 to 0.9. The Sj values between the New River and background stations ranged from 0.08 to 0.23. The Ss values between these stations ranged from 0.13 to 0.38.

Based on these results, it appears that a higher degree of community similarity exists between the sampling stations of the New River on comparison to both the other surface water bodies and background.

7.4.5 Surface Soils

The following sections discuss the results of the risk characterization of surface soils at Site 69. These sections contain a comparison of the contaminants detected in the surface soils to the concentrations of the contaminants in soil that caused adverse effects to plants, terrestrial invertebrates, and terrestrial vertebrates. This data was obtained from various sources in the literature.

Barium concentrations ranged from 3.0 to 6.8 mg/kg, which are below the 2,000 mg/kg that induced plant toxicity (Adriano, 1986). Chromium concentrations of 1.6 to 3.6 mg/kg were found in the surface soils, which are less than the 10 mg/kg in surface soils that caused mortality in the earthworm species Pheretima pesthuma, (Hopkin, 1989).

Lead concentrations ranged from 1.1J to 12.5 mg/kg which are less than the 670 mg/kg which is considered hazardous to earthworms (Beyer, 1993). Manganese concentrations ranged from 1.3 to 15.5 mg/kg, which are lower than the mean U.S. soil concentration of 560 mg/kg (Adriano, 1986). Silver concentrations ranged from 0.095 to 10.2J mg/kg, which are below the 11 mg/kg which was lethal to bush beans in solution (Adriano, 1986). Vanadium concentrations ranged from 3.9 to 5.3 mg/kg, which are less than the U.S. soil concentrations of 58 mg/kg (Adriano, 1986). Zinc concentrations ranged from 1.5 to 6.6 mg/kg, which are less than the 450 to 1,400 mg/kg that caused plant toxicity (Adriano, 1986).

7.4.6 Terrestrial Chronic Daily Intake Model

The following sections discuss the CDIs and QIs calculated for the terrestrial receptors.

7.4.6.1 CDI Calculations

Total exposure of the terrestrial receptors at Site 69 to the COPCs in the soil and surface waters was determined by estimating the CDI dose and comparing this dose to TRVs representing acceptable daily doses in mg/kg/day. CDIs were estimated for the white-tailed deer, cottontail rabbit, bobwhite quail, and red fox at Site 69. The estimated CDI dose of the receptors (bobwhite quail, cottontail rabbit, and white-tailed deer) to soils, surface water, and vegetation was determined using the following equation:

$$E = \frac{(Cw)(Iw) + [(Cs)(Bv\ or\ Br)(Iv) + (Cs)(Is)][H]}{BW}$$

where:

E = Total Exposure, mg/kg/d
Cw = Constituent concentration in the surface water, mg/L
Iw = Rate of drinking water ingestion, L/d
Cs = Constituent concentration in soil, mg/kg
Bv = Soil to plant transfer coefficient (leaves, stems, straw, etc.), unitless
Br = Soil to plant transfer coefficient (fruits, seeds, tubers, etc.), unitless
Iv = Rate of vegetation ingestion, kg/d
Is = Incidental soil ingestion, kg/d
H = Contaminated area/Home area range area ratio, unitless
BW = Body weight, kg

The estimated CDI dose of the raccoon was determined using the following equation.

$$E = \frac{(Cw)(Iw)+[(Cs)(Br)(Iv)+(Cs)(Is)+(Cf)(If)][H]}{BW}$$

where:

E = Total Exposure, mg/kg/d
Cw = Constituent concentration in the surface water, mg/L
Iw = Rate of drinking water ingestion, L/d
Cs = Constituent concentration in soil, mg/kg
Br = Soil to plant transfer coefficient (fruit, seeds, tubers, etc.), unitless
Iv = Rate of vegetation ingestion, kg/d
Is = Incidental soil ingestion, kg/d
If = Rate of fish ingestion, kg/d
Cf = Constituent concentration in the fish, mg/kg (whole body concentrations)
H = Contaminated area/Home area range area ratio, unitless
BW = Body weight, kg

The estimated CDI dose of the red fox was determined using the following equation:

$$E = \frac{(Cw)(Iw)+[(Cs)(Br)(Iv)+(Cs)(Is)+(Cm)(Im)][H]}{BW}$$

where:

E = Total Exposure, mg/kg/d
Cw = Constituent concentration in the surface water, mg/L
Iw = Rate of drinking water ingestion, L/d
Br = Soil to plant transfer coefficient (fruit, seeds, tubers, etc.), unitless
Iv = Rate of vegetation ingestion, kg/d
Cs = Constituent concentration in soil, mg/kg
Is = Incidental soil ingestion, kg/d
Im = Rate of small mammal ingestion, kg/d
Cm = Constituent concentrations in small mammals, mg/kg
where: Cm = (Cs)(Bv) + (Cs)(Is)
Bv = Soil to plant transfer coefficient (leaves, stems, straw, etc.), unitless
H = Contaminated area/Home area range area ratio, unitless
BW = Body weight, kg

Bioconcentration of the COPCs to plants was calculated using the soil to plant transfer coefficient (Bv or Br) for organics (Travis and Arms, 1988) and metals (Baes, et al., 1984). If a chemical was not detected in the surface water, it was assumed to be a nondetect in the fish. The concentrations of the COPCs in the soil (Cs) used in the model were the upper 95 percent confidence limit or the maximum concentration detected of each COPC at each site. The upper 95 percent confidence limit or the maximum concentration detected for each constituent was also used as the concentration of each COPC in the surface water. The exposure parameters used in the CDI calculations are presented in Table 7-25 and are summarized for each receptor below.

For the white-tailed deer, the feeding rate is 1.6 kg/d (Dee, 1991). The incidental soil ingestion rate is 0.019 kg/d (Scarano, 1993). The rate of drinking water ingestion is 1.1 L/d (Dee, 1991). The rate of vegetation ingestion is 1.6 kg/d. The body weight is 45.4 kg (Dee, 1991), and the home range is 454 acres (Dee, 1991). The deer's diet was assumed to be 100 percent vegetation (leaves, stems, straw).

For the eastern cottontail rabbit, the feeding rate is 0.1 kg/d (Newell, 1987). The incidental soil ingestion rate is 0.002 kg/d (Newell, 1987). The rate of drinking water ingestion is 0.119 L/d (USEPA, 1993a). The rate of vegetation ingestion is 0.1 kg/d. The body weight is 1.229 kg (USEPA, 1993a), and the home range is 9.29 acres (USEPA, 1993a). The rabbit's diet was assumed to be 100 percent vegetation (leaves, stems, straw).

For the bobwhite quail, the feeding rate is 0.014 kg/d (USEPA, 1993a). The quail's diet was assumed to be 100 percent vegetation (leaves, stems, straw). The incidental soil ingestion rate is 0.001 kg/d (Newell, 1987). The rate of drinking water ingestion is 0.019 L/d (USEPA, 1993a). The rate of vegetation ingestion is 0.014 kg/d. The body weight is 0.177 kg (USEPA, 1993a), and the home range is 8.89 acres (USEPA, 1993a).

For the red fox, the feeding rate is 0.446 kg/d (USEPA, 1993a). The fox's diet was assumed to be 20 percent vegetation (seed, berries) and 80 percent small mammals. The incidental soil ingestion rate is 0.012 kg/d (USEPA, 1993a). The rate of drinking water ingestion is 0.399 L/d (USEPA, 1993a). The rate of vegetation ingestion is 0.089 kg/d, the rate of small mammal ingestion is 0.356 kg/d. The body weight is 4.69 kg (USEPA, 1993a), and the home range is 1,771 acres (USEPA, 1993a).

For the raccoon, the feeding rate is 0.319 kg/d (USEPA, 1993a). The raccoon's diet was assumed to be 40 percent vegetation (nuts, seeds, berries) and 60 percent fish. The incidental soil ingestion rate is 0.030 kg/d (USEPA, 1993a). The rate of drinking water ingestion is 0.331 L/d (USEPA, 1993a). The rate of vegetation ingestion is 0.128 Kg/d and the rate of fish ingestion is 0.192 kg/d. The body weight is 3.99 kg (USEPA, 1993a), and the home range is 385 acres (USEPA, 1993a).

7.4.6.2 QI Calculations

As was used to characterize the risk to aquatic receptors, the QI approach was used to characterize the risk to terrestrial receptors. In this use of the QI, the risk are characterized by comparing the CDIs for each COPCs to the TRVs and is calculated as follows:

$$QI = \frac{E}{TRV}$$

Where: QI = Quotient Index
E = Total Exposure, mg/kg/day
TRV = Terrestrial Reference Value, mg/kg/day

Tables 7-26 contains the QIs for the COPCs at Site 69. A QI of greater than "unity" is considered to be indicative of potential risk. Such values do not necessarily indicate that an effect will occur but only that a lower threshold has been exceeded. The evaluation of the significance of the QI has been judged as follows: (Menzie et al., 1993)

- QI exceeds "1" but less than "10": some small potential for environmental effects;

- QI exceeds "10": significant potential that greater exposures could result in effects based on experimental evidence;

- QI exceeds "100": effects may be expected since this represents an exposure level at which effects have been observed in other species.

The risks characterized above provide insight into general effects upon animals in the local population. However, depending on the endpoint selected, they may not indicate if population-level effects will occur.

There are some differences of opinion found in the literature as to the effectiveness of using models to predict concentrations of contaminants found in terrestrial species. According to one source, the food chain models currently used incorporate simplistic assumption that may not represent conditions at the site, bioavailability of contaminants, or site-specific behavior of the receptors. Simple food chain models can provide an effective means of initial characterization of risk, however, residue analyses, toxicity tests, and the use of biomarkers provide a better approach for assessing exposure (Menzie et al., 1993).

The following sections discuss the results of the terrestrial CDI compared to the TRVs, the COPCs in the soils compared to published soil toxicity data, and an evaluation of the potential impacts to threatened and endangered species, wetlands, and other sensitive environments. TRVs could not be located for 4-methyl-2-pentanone, aluminum, and iron. Therefore, these COPCs could not be included in this comparison.

The CDI model was used to assess decreased viability in terrestrial species from exposure to contaminants in surface water and surface soils.

At Site 69, the QIs of the CDI to the TRVs were less than unity for all COPCs except manganese for the rabbit which was calculated to be 1.02. Therefore, the total QI for the quail was greater than unity (1.73), this was primarily due to the QI for manganese (1.02) and the QI for silver (0.68). Also, the total QI for the rabbit was greater than unity (1.55). This was primarily due to the additive effect of the QIs from manganese (0.90) and silver (0.63). The QIs for these animals were greater than unity, but less than 10 for all the contaminants indicating only a small potential that the animals are being adversely affected.

7.4.7 Threatened and/or Endangered Species

Several threatened and/or endangered species inhabit MCB Camp Lejeune. However, these threatened and/or endangered species are not known to regularly frequent or breed at Site 69 (USMC, 1993). In addition, no protected species were observed at Site 69 during the habitat evaluation nor would they be expected to occur. Protected species at Camp Lejeune require specific habitats that do not correspond to the habitats identified at the sites. Previous survey results and maps of locations where protected species have been identified were consulted to produce the biohabitat map. No protected species have been identified within half-mile radii of Site 69. Therefore, potential adverse impacts to these protected species from contaminants at Site 69 appear to be low.

7.4.8 Flora/Wetlands

Site-specific wetland delineations were not conducted at Site 69, although potential wetland areas were noted during the habitat evaluation. Generally, wetlands were not identified at the site, although wetlands were present within a half mile radius of the site. These wetlands are illustrated on the biohabitat map (Figure 7-1) potential impacts to wetlands are addressed in the surface water and sediment sections.

7.4.9 Other Sensitive Environments

Everett Creek is designated as tidal saltwaters with designated usage for aquatic life propagation and survival, fishing, wildlife, and secondary recreation by the North Carolina Department of Environment, Health, and Natural Resources (NC DEHNR, 1993). The New River in this area is designated as tidal saltwaters with designated usage for shellfishing for market purposes, primary recreation, aquatic life propagation and survival, fishing, and wildlife by the North Carolina Department of Environmental, Health, and Natural Resources (NC DEHNR, 1993). Everett Creek south of a line beginning at a point on the east shore 34°34'13"N - 77°24'44"W, running 273° (m) to a point on the west shore 34°34'12"N - 77°24'49"W is designated as a primary nursery area. The potential impacts to the fish in these waters have already been discussed in this report. No areas within the boundaries of Site 69 are designated as unique or special waters of exceptional state or national recreational or ecological significance which require special protection to maintain existing uses. The New River within the Stone Bay Sector and Stone Creek Sector is designated as a Military Restricted Area.

The potential impact to terrestrial organisms that are present at Site 69 is discussed in earlier sections of this report. The terrestrial organisms that may be breeding in contaminated areas at Site 69 may be more susceptible to chemical stresses due to the higher sensitivity of the reproductive life stages of organisms to these types of stresses.

7.5 Ecological Significance

This section essentially summarizes the overall risks to the ecology at the site. It addresses impacts to the ecological viability at the Operable Unit from the COPCs detected in the media, and to determine which COPCs are impacting the site to the greatest degree. This information, to be used in conjunction with the human health RA, supports the selection of remedial action(s) for the Operable Unit that are protective of public health and the environment.

7.5.1 Aquatic Endpoints

The measurement endpoint used to assess the aquatic environment is decreased viability of aquatic organisms.

7.5.1.1 Surface Water and Sediments

Overall, metals and pesticides appear to be the most significant site related COPCs that have the potential for decreasing the viability of aquatic organisms at Site 69. Pesticides are not only potentially toxic to aquatic life through a direct exposure pathway, but as indicated by their high BCF value, they have a high potential to bioconcentrate pesticides in organisms. Therefore, other fauna that feed upon these organisms will be exposed to pesticides via this indirect exposure pathway. Following is a summary of other findings within Site 69.

Based on the potential habitat, and other physical characteristics, the most significant populations of aquatic organisms at the site, including fish, benthic macroinvertebrates, and some terrestrial vertebrates, potentially are in or surrounding Everett Creek and the New River. Aluminum, copper, iron, lead, mercury, silver, and zinc were the only inorganic COPCs detected in the surface water at concentrations that exceeded any of the ARVs. Copper exceeded the ARV at Site 69. Cadmium, mercury, benzo(a)pyrene, 4,4'-DDE, 4,4'-DDD, and PCB-1260 were the only COPCs detected in sediment at Site 69 that exceeded any of the ARVs.

7.5.1.2 Fish

The following sections discuss the chemical concentrations detected in the fish tissue and the population results for the samples collected from the unnamed tributary, Everett Creek and the New River. Background information from Hadnot Creek and Holland Mill Creek were included in this discussion.

7.5.1.2.1 Unnamed Tributary

The following sections discuss the fish species population results from the unnamed tributary. No tissue samples were analyzed for chemical content.

Fish Population

Only one station, 69-UT1, was used for collection at the unnamed tributary. At this station, only one species was identified, the American eel. The habitat of the American eel is in brackish or freshwater. Salinity readings in this area indicate some salinity at depth. This suggests that this area may be an appropriate habitat for this identified species.

Analytical results indicated elevated levels of inorganics in the surface water and semivolatiles, PCBs, pesticides and inorganics in the sediment. In terms of field chemistry, the pH measured at stations 1 and 2 suggest acidic conditions in the water. In addition, the American eel is classified as an intermediate tolerant species.

7.5.1.2.2 Everett Creek

The following sections discuss the chemical concentrations detected in the fish tissue and the population statistics for the samples collected from Everett Creek.

Fish Tissue

Volatile Organic Compounds in Fish Tissue

Several VOCs were found in the fish tissue collected from Everett Creek. Common laboratory contaminants were the primary detections, which included methylene chloride, acetone, 2-butanone and 2-hexanone. In addition, benzene and toluene were detected.

Studies concerning the levels of benzene found in fish tissue could not be located. Benzene is not expected to bioconcentrate in aquatic organisms. This chemical rapidly volatilizes upon release to water. There is not enough information available to determine if the levels of benzene found in the fish tissue samples are significant. However, it is important to note that benzene was not detected in the surface water or sediment of Everett Creek does not appear to be site-related.

Studies on toluene in fish tissue have been conducted. In Japan, the average concentration of toluene in fish collected from a petroleum-contaminated harbor was 5 mg/kg. The maximum level of toluene in the site fish tissue was 0.039 mg/kg. The level of toluene identified in the Japanese study is significantly greater than the level measured at the site. Toluene does not readily bioaccumulate in fish. When released to water, toluene volatilizes and/or biodegrades. In addition, the level identified in the Japanese study was collected from a fairly polluted surface water body, which may represent a worse case scenario. At Everett Creek, toluene was not detected in the surface water or sediment. Consequently, it is reasonable to assume that the toluene found in the fish tissue does not appear to be site-related.

Semivolatile Organic Compounds in Fish Tissue

Only one SVOC, di-n-octylphthalate, was detected in the Everett Creek samples at a concentration of 0.120 mg/kg. It was found only once in the Atlantic croaker tissue sample. No studies discussing typical levels of phthalate compounds found in fish tissue were located. In addition, this phthalate compound was not detected in the surface water or sediment of Everett Creek. It is not expected that the presence of this chemical in the fish tissue is site-related.

Pesticides in Fish Tissue

Two pesticides detected throughout most of the Everett Creek tissue samples were 4-4'-DDE and 4-4'-DDD. These chemicals biodegrade at a very slow rate and have a high potential for bioaccumulation in aquatic organisms. The maximum levels for these pesticides, 0.28 and 0.15 mg/kg, respectively, were detected in the summer flounder tissue.

The average concentration level established in the National Study of Chemical Residues in Fish (NSCRF) for industrial/urban sites for any p,p'-DDE compound in fish tissue ranged between 0.00723 and 14.028 mg/kg with a mean concentration of 0.60234 mg/kg (USEPA, 1992c). In 1989, other ecological studies were conducted in Indonesia. These studies identified levels of p,p'-DDE in saltwater fish tissue to be between 0.040 and 6.8 mg/kg. Levels in the tissue of fish from the North Sea ranged between nondetect and 0.041 mg/kg. Another study conducted in Rhode Island detected levels of p,p'-DDD to be between 0.018 and 0.046 mg/kg. North Sea studies showed levels between nondetect and 0.028 mg/kg. Studies conducted in the Pacific Ocean revealed levels of 4-4'-DDT ranging from nondetect to 0.0736 mg/kg. Levels in the central Mediterranean Sea fell between 0.0039 and 0.0855 mg/kg.

The pesticide levels detected in the summer flounder tissue samples from Everett Creek are comparable to the published findings. The maximum levels fell within the range identified by the NSCRF. Pesticides were expected to be detected in the fish tissue samples because pesticide use has been documented as widespread throughout MCB Camp Lejeune, North Carolina. However, at Everett Creek, no pesticides were detected in the surface water, and 4-4'-DDE was detected at a maximum of 0.0066 mg/kg in the sediment. It is not expected that these low levels of pesticides in the fish tissue have significant potential to impact Everett Creek as a result of site activities.

PCBs in Fish Tissue

Aroclor-1254 and Aroclor-1260 were detected only once in the summer flounder and Atlantic croaker tissue samples from Everett Creek, respectively. The detected concentrations were 0.034 and 0.068 mg/kg, for Aroclor-1254 and Aroclor-1260, respectively. The national average of PCBs found in fish tissue is 1.897 mg/kg (USEPA, 1992c). The NSCRF reported that 91 percent of all the stations included in the survey had detected levels of PCBs. The PCB levels found in these tissue samples were much lower than the NSCRF national average. In addition, PCBs were not found in the surface water or sediment. Consequently, it is reasonable to assume that the low levels of PCBs found in the media of Everett Creek are not site-related.

Inorganics in Fish Tissue

As mentioned previously, several metals were detected in the Everett Creek tissue samples. These metals included beryllium, cadmium, calcium, magnesium, potassium, selenium, silver, sodium and zinc. The inorganics considered to be essential nutrients and of low toxicity in humans were found in most of the samples. These metals included calcium, magnesium, potassium, sodium and zinc. Information available for silver and zinc is discussed below. Studies on the other detected inorganics in fish tissue were not located.

The concentration of silver found in the fish tissue sampled from Everett Creek ranged from 0.02 to 0.28 mg/kg. A National Marine Fishery (NMF) survey conducted in March, 1978, reported the average silver concentration to be 0.1 mg/kg in the muscle of fish and 0.2 mg/kg in the whole body (Hall, 1978). The maximum level of silver found in the site fish tissue samples is slightly above these reported values. However, silver was detected at a maximum concentration of 0.0041 mg/L in the surface water and was not detected in the sediment. The levels of silver associated with the media of Everett Creek are relatively low. As a result, it is reasonable to expect that these levels of silver are not a result of site activities.

Zinc concentrations in the tissue samples ranged from 8.3 to 239 mg/kg. Other saltwater ecological studies detected the following zinc levels in fish tissue: 5.9 to 16.6 mg/kg in the Arabian Gulf (Ginn, 1989); 4.1 to 58.8 mg/kg in the Mediterranean Sea in Israel; 0.02 to 5.6 mg/kg in the United Kingdom (Ginn, 1988); and 88 to 145 mg/kg in the Gulf of Mexico (Ginn, 1987). The National Marine Fishery trace element survey revealed that the average concentration of zinc in fish muscle ranged from 2 to 200 mg/kg (Hall, 1978). It can be determined from the published levels that the concentrations of zinc found in the fish in Everett Creek fell within or slightly above the reported ranges. Zinc was not detected in the surface water and was found in the sediment at a maximum concentration of 62 mg/kg. Similar to silver, it is unlikely to expect that these levels of zinc are a result of site activities.

Fish Population

The predominant fish species detected were Atlantic croaker, Eastern mosquito, and pinfish. Atlantic croaker can be found in estuaries, brackish water or marine water. The habitat of the Eastern mosquito includes ponds, lakes, ditches, backwaters and sluggish streams. The pinfish is found primarily in shallow marine water. As mentioned previously, salinity levels in Everett Creek increased with water depth. This suggests that Everett Creek is a mixture of freshwater and brackish water, which appears to be the habitat for the fish species identified at these stations.

Eight of the nine species found in Everett Creek were found in the New River, while five of the nine species were collected at the background stations. Field chemistry results indicated slightly acidic waters at stations 2 and 3. Low dissolved oxygen level was measured at station 3. These levels may have impacted the species populations identified at stations 2 and 3.

Analytical results indicated the presence of inorganics in the surface water and VOCs, pesticides and inorganics in the sediment. Fish tissue results showed levels of VOCs, one SVOC, pesticides and inorganics. On comparison to available criteria, it was reasonable to assume that these levels would not significantly impact the water body. Information concerning the tolerance level of the Atlantic croaker and pinfish species was not found. The tolerance level of the Eastern mosquito, found at only station 2, is intermediate, suggesting a moderate level of organics in the surface water.

7.5.1.2.3 New River

The following sections discuss the chemical concentrations detected in the fish tissue samples collected from the New River. Population statistics are also discussed.

Fish Tissue

Volatile Organic Compounds in Fish Tissue

Common laboratory contaminants were also the primary detections in the New River samples, which included methylene chloride, acetone, 2-butanone and 2-hexanone. In addition, benzene and toluene were detected.

As stated previously, studies focusing on the levels of benzene found in fish tissue could not be located. Benzene is not expected to bioconcentrate in aquatic organisms. This chemical rapidly volatilizes upon release to water. In addition, was not found in the surface water or sediment of the New River. As a result, it is reasonable to assume that presence of benzene in the fish tissue is not a result of site activities.

As mentioned before, studies on toluene have been conducted. In Japan, the average concentration of toluene in fish collected from a petroleum-contaminated harbor was 5 mg/kg. The maximum level of toluene in the site fish tissue was 0.014 mg/kg. The level of toluene identified in the Japanese study is significantly greater than the level measured at the New River, similar to Everett Creek. Toluene does not readily bioaccumulate in fish. When released to water, toluene volatilizes and/or biodegrades. In addition, the level identified in the Japanese study was collected from a fairly polluted surface water body, which may represent a worse case scenario. At the New River, toluene was not found in the surface water or sediment. Consequently, toluene in the fish tissue collected from the New River is not expected to be due to site activities.

Semivolatile Organic Compounds in Fish Tissue

Only one SVOC, 2-methylphenol, was found in this sample group. The only detected concentration was 0.22 mg/kg. Studies regarding cresol levels in fish tissue were not located. Also, this compound was not detected in the surface water or sediment. It is reasonable to assume that the origin of this compound is not based on site activities.

Pesticides in Fish Tissue

Similar to Everett Creek, the same two pesticides were detected throughout most of the tissue samples, 4-4'-DDE and 4-4'-DDD. The concentration ranges for these two pesticides were 0.0025 to 0.017 mg/kg and 0.0003 to 0.0064 mg/kg. In addition, no pesticides were found in the surface water or sediment of the New River. Consequently, it is reasonable to expect that pesticides found in the fish are not attributed to site activities.

PCBs in Fish Tissue

As mentioned previously, the national average of PCBs found in fish tissue as reported by the NSCRF is 1.897 mg/kg (USEPA, 1992c). The PCB levels found in these tissue samples were much lower than the NSCRF national average. No PCBs were detected in the surface water or sediment of the New River. Consequently, it is reasonable to expect that the presence of PCBs in the fish tissue collected from the New River are not a result of site activities.

Inorganics in Fish Tissue

The following metals were detected in the tissue samples collected from the New River: aluminum, beryllium, cadmium, calcium, iron, magnesium, potassium, selenium, silver, sodium, thallium and zinc. Similar to the Everett Creek tissue samples, calcium, magnesium, potassium and sodium were found in all the New River tissue samples. Information available for silver and zinc is discussed below. Studies on the other detected inorganics in fish tissue were not located.

The concentration of silver found in the fish tissue sampled from the New River ranged from 0.01 to 0.14 mg/kg. As mentioned previously, the NMF reported the average silver concentration to be 0.1 mg/kg in the muscle of fish and 0.2 mg/kg in the whole body (Hall, 1978). The maximum level of silver found in the site fish tissue samples is slightly above one of the reported values. Silver was found at a maximum of 0.0045 mg/L in surface water and was not detected in sediment. Consequently, these low levels of silver at the New River are not expected to be site-related.

Zinc concentrations in the tissue samples ranged from 7.8 to 312 mg/kg. As stated previously, there a several published other saltwater ecological studies detected the following zinc levels in fish tissue: 5.9 to 16.6 mg/kg in the Arabian Gulf (Ginn, 1989); 4.1 to 58.8 mg/kg in the Mediterranean Sea in Israel; 0.02 to 5.6 mg/kg in the United Kingdom (Ginn, 1988); and 88 to 145 mg/kg in the Gulf of Mexico (Ginn, 1987). The NMF determined that the average concentration of zinc in fish muscle ranged from 2 to 200 mg/kg (Hall, 1978). It can be determined from the published levels that the concentrations of zinc found in the fish at the New River fell within or above the reported ranges. Zinc was not detected in the surface water. It was detected in the sediment at a maximum of 10.7 mg/kg. Because the zinc levels appear to be slightly elevated, potential impact to the New River may be attributable to site activities.

Fish Population

The primary fish species in the New River were spot, Atlantic croaker and pinfish. Spot reside predominantly in brackish or marine water. They may also enter fresh water. As mentioned previously, Atlantic croaker can be found in estuaries, brackish water or marine water. The pinfish is found primarily in shallow marine water. Consistent levels of salinity were detected in the New River. This suggests that the New River is primarily brackish in nature. It would appear that this surface water is an appropriate habitat for these fish species.

It is important to note that a larger amount of species and individual organisms were collected at the New River sampling stations as compared to the unnamed tributary, Everett Creek, and the background stations. In terms of field chemistry, the results were consistently moderate. Inorganics were primarily detected in the surface water, and a volatile and several inorganics were found in the sediment. Similar to Everett Creek, volatiles, one semivolatile, pesticides and inorganics were found in the fish tissue samples. The tolerance levels of the identified fish species in the New River were not identified in available literature. These results suggest that the level of contamination in the New River is relatively low and similar to background. The results also suggest that there are fish species abundance in both surface water bodies. It appears that site activities do not have a significant impact on this water body based on these results.

7.5.1.3 Benthic Macroinvertebrates

The following sections discuss the benthic macroinvertebrate population results from the unnamed tributary, Everett Creek and the New River.

In general, the species richness of benthic invertebrates in estuaries is at a minimum within a salinity range of 5 to 8 ppt. This range is called the critical salinity. These areas are characterized by a reduced number of species because the water is too fresh for marine organisms and too salty for freshwater species. Based on salinity readings taken at stations located at the unnamed tributary, Everett Creek and the New River, the results either exceeded or fell below this range. Consequently, it is expected that salinity will impact benthic species population results at any of the surface water bodies.

There was little species similarity between the stations at each water body, between each water body and on comparison to background. Most values fell below 0.5. However, the similarity measured at the New River stations was the highest on comparison to the other surface water bodies. In addition, the capitellids were the species identified the most frequently at all surface water sampling stations.

7.5.1.3.1 Unnamed Tributary

Based on the benthic macroinvertebrate population results, it appears that the smallest number of species were identified at the unnamed tributary. The number of stations sampled and the number of samples collected was also limited. The species diversity was moderate, ranging from 0.5 to 0.7. The biotic index, which measures benthic species tolerance to organic pollution, was elevated. In fact, one of the species identified the most frequently is highly tolerant to organic pollution. Analytical results showed levels of inorganics in the surface water and volatiles, semivolatiles, PCBs, pesticides and inorganics in the sediment, which may further compromise the integrity of this water body. Field chemistry results indicated potentially acidic pH levels at stations 1 and 2.

7.5.1.3.2 Everett Creek

At Everett Creek, a number of benthic species were collected, primarily at station 4. Species diversity was relatively high at station 4. Although analytical results indicated the presence of inorganics in the surface water and volatiles, pesticides and inorganics in the sediment, species tolerance to organic pollution was low. This suggests that conditions at station 4 were sufficient to support a number of benthic species. The other station sampled for benthic organisms was station 3. This station was one of the two locations that had significantly low dissolved oxygen levels (less than 1 mg/L). Also, the pH measured at the stations 2 and 3 along this surface water body were consistently below 7, suggesting potential acidic conditions. This may explain the reduced number of both benthic and fish species identified at the stations preceding station 4. Based on these results, it is reasonable to assumed that this water body was not significantly impacted by site activities.

7.5.1.3.3 New River

The New River, which is the largest surface water body of the three, had the most species identified, including both fish and benthic organisms. Species diversity was also high, primarily at station 1. Community similarity among the sampling stations was higher on comparison to background. In fact, the highest values for community similarity were found between the New River sampling stations. Primarily inorganics were detected in the surface water, and a volatile and several inorganics were found in the sediment. Species tolerance to organic pollution was low. In terms of field chemistry, results were fairly consistent. Only elevated water temperatures were measured at station 3. Overall, these results indicate that the New River is a relatively healthy water body, able to sufficiently support aquatic habitats. Site activities do not appear to have a significant impact on this water body.

7.5.2 Terrestrial Endpoints

During the habitat evaluation, no areas of vegetation stress or gross impacts from site contaminants were noted. Habitats surrounding all three sites appeared to be diverse and the community and ecosystem structure appeared to be intact.

The measurement endpoints used to assess the terrestrial environment is decreased viability of terrestrial organisms. Overall, metals appear to be the most significant site-related COPCs that have the potential for decreasing the viability of terrestrial organisms at Site 69.

Other terrestrial organisms (e.g., rabbits, birds, deer) may be exposed to contaminants in the surface soils and surface water by ingestion. Based on the comparison of the CDI to the TRVs, there is a small potential that terrestrial receptors are being adversely affected.

7.5.3 Threatened and Endangered Species

Potential adverse impacts to these threatened or endangered species from contaminants at Site 69 appear to be low. There are no areas where protected, threatened, or endangered species have been observed on Site 69.

7.5.4 Wetlands

Site-specific wetland delineations were not conducted at Site 69, although potential wetland areas were noted during the habitat evaluation. Generally, wetlands were not identified on each of the sites, although wetlands were present within a half mile radius of each site. These wetlands are illustrated on the biohabitat map (Figure 7-1) potential impacts to wetlands are addressed in the surface water and sediment sections.

7.5.5 Other Sensitive Environments

There are no known spawning and nursery areas for resident fish species within the unnamed tributary and the New River. Therefore, there is no potential for decreased viability of fish spawning or nursing in the unnamed tributary, or the New River. However, a portion of Everett Creek was identified as a primary nursing area. Consequently, the potential for decreased viability of fish nursing in the area exists.

7.6 Uncertainty Analysis

The procedures used in this evaluation to assess risks to ecological receptors, as in all such assessments, are subject to uncertainties. The following discusses the uncertainty in the ERA.

The chemical sampling program at Site 69 consisted of surface water, sediments, soil, tissue, and groundwater. The concentrations of chemicals in the surface water will vary with the tides; the concentrations are expected to be lower at higher tides (more dilution) and higher at low tides (less dilution).

The proximity of estuaries to landmasses renders them highly susceptible to pollution from human activities; this pollution threatens fish communities in many regions. Anthropogenic stresses on fish populations can be intense. Whereas much attention has been focused on the acute exposure of these populations to pollutants, sublethal and chronic exposures also debilitate resident and seasonal species. The mobility and migratory habits of fishes, however, make observations on anthropogenic effects more difficult to assess, and most of the evidence on pollution-induced changes in fish populations has been derived from laboratory experiments. Effects of man-made stresses on fishes in estuaries are often obscured by naturally occurring and poorly understood, long-term variations.

The ecological investigation consisted of one sampling effort. The results of this sampling will only provide a "snapshot in time" of the ecological environment. Because the biotic community can have a high amount of natural variability, the "snapshot in time" may not be an accurate representation of actual site conditions. There also is error and uncertainty in the sampling methods used to collect the fish and benthic macroinvertebrates. Because few, if any, fish were collected at the stations, the population statistics were not reliable. In addition, in several of the tissue samples, only one fish was analyzed because only one was collected of that species. Therefore, the concentrations of contaminants may not be a good representation of the average tissue concentration.

The collection of benthic macroinvertebrates has less uncertainty than the collection of fish. However, the effectiveness of the ponar depends upon the sediment type. The ponar is less effective in hard, rocky sediments, or sediments with a lot of organic debris that may prevent the ponar from completely closing, than in soft, mucky sediments. Because the sediment types varied among the stations, the effectiveness of the ponar also would have varied.

There is uncertainty in trying to attribute differences in species density, diversity, and similarities between stations to specific hazards, because these differences may be the result of natural causes. As discussed previously, fish and crabs are mobile. Therefore, the tissue contaminant concentrations cannot be correlated with the contaminants detected at Site 69 because the fish or crabs may have been exposed to the contaminants at a different location. Also, as observed in this investigation, natural conditions (salt wedge, low dissolved oxygen) can result in low numbers of individuals.

There also is uncertainty in the use of toxicological data in ecological risk assessments. The surface water and sediment values established by North Carolina and Region IV are set to be protective of a majority of the potential receptors. There will be some species, however, that will not be protected by the values because of their increased sensitivity to the chemicals. Also, the toxicity of chemicals mixtures is not well understood. All the toxicity information used in the ERA for evaluating risk to the ecological receptors is for individual chemicals. Chemical mixtures can affect the organisms very differently than the individual chemicals.

Estuaries are physically unstable areas characterized by large spatial and temporal variations in temperature, salinity, oxygen concentration, turbidity, and other factors. Temporally, such variations take place in the short term and long term. Yet, despite these variations, the basic structure of estuarine fish communities is reasonably stable, and the fishes often have more or less predictable patterns of abundance and distribution. However, estuarine fish populations change dramatically in response to environmental perturbations; these population changes can be permanent even though the predominantly estuarine species have broad temperature tolerances and strong osmoregulatory abilities. The species composition of estuarine communities change constantly, attesting to the variable environmental conditions and the limitations of the tolerances of the fish populations to alterations in the habitat.

There is uncertainty in the ecological endpoint comparison. The values used in the ecological endpoint comparison (either the WQS of the SSV) are set to be protective of a majority of the potential receptors. There will be some species, however, that will not be protected by the values because of their increased sensitivity to the chemicals. Also, the toxicity of chemical mixtures is not well understood. All the toxicity information used in the ecological risk assessment for evaluating risk to the ecological receptors is for individual chemicals. Chemical mixtures can affect the organisms very differently than the individual chemicals. In addition, there were several contaminants that did not have WQS or SSVs. Therefore, potential effects to ecological receptors from these chemicals cannot be determined.

The SSVs were developed using data obtained from freshwater, estuarine and marine environments. Therefore, their applicability for use to evaluate potential effects to aquatic organisms from contaminants in estuarine habitats must be evaluated on a chemical specific basis because of differences in both the toxicity of individual contaminants to freshwater and saltwater organisms, and the bioavailability of contaminants in the two aquatic systems. In addition, the toxicity of several of the metals (cadmium, chromium, copper, lead, nickel, and zinc) to aquatic organisms increases or decreases based on water hardness. Because water hardness was not available, a default value of 50 mg/L of $CaCO_3$ was used.

Several contaminants in the surface water and sediment exceeded applicable ARVs values. Some of the surface water and sediment samples were collected from areas that were not considered ecologically significant (drainage ditch in Site 69). Therefore, although the ARVs may have been exceeded in these samples, the potential for them to impact aquatic life may not be significant.

Finally, there is also uncertainty in the chronic daily intake models used to evaluate decreased viability to terrestrial receptors. Many of the input parameters are based on default values (i.e., ingestion rate) that may or may not adequately represent the actual values of the parameters. In addition, there is uncertainty in the amount that the indicator species will represent other species potentially exposed to COPCs at the site. Finally, terrestrial species will also be exposed to contaminants by ingesting fauna that have accumulated contaminants. This additional exposure route was not evaluated in this ERA because the high uncertainty associated with this exposure route.

7.7 Conclusions

Overall, metals and pesticides appear to be the most significant site related COPCs that have the potential to affect the integrity of the aquatic ecosystems at Site 69. For the terrestrial ecosystems, metals appear to be the most significant site related COPCs that have the potential to affect terrestrial receptors at Site 69.

Potential adverse impacts to threatened or endangered species are low due to the absence of critical habitats or noted observations at the site. The biohabitat map did not indicate a significant impact to ecological resources on or near the site.

Copper and silver exceeded the surface water ARVs and cadmium, mercury, benzo(a)pyrene, 4,4'-DDE, 4,4'-DDT, and Aroclor-1260 exceeded sediment ARVs. The silver quotient ratio was slightly high. However, although silver was above the base-wide and median concentrations, it is not related to the site. In addition, silver was detected in the New River in upstream samples at concentrations similar to those found in Everett Creek. The sediment exceedances indicated concentrations above the base-wide and median concentrations for cadmium, mercury, 4,4'-DDE, 4,4'-DDT, and Aroclor-1260.

The potential risks to aquatic receptors due to the above exceedances in the surface waters around the site was evaluated by conducting biosurveys and fish tissue analysis. Fish populations were sampled and were representative of estuarine and tidal freshwater systems. The predominant fish species were Atlantic croaker, Easter mosquito, and pinfish. There were no anomalies observed on the fish. The fish community appeared healthy and not impacted due to site contaminants.

Fish tissues were sampled and the following were detected: organics (benzene, toluene, and 2-methylphenol), pesticides (4,4'-DDE and 4,4'-DDD), PCBs (1254 and 1260), and metals (aluminum, beryllium, cadmium, iron, selenium, silver, and zinc). The levels detected in the fish tissue were low when compared to published background values, and did not indicate that these COPCs were site related.

Benthic invertebrates were sampled and were representative of estuarine and tidal freshwater species. The predominant species included capitellids followed by tubificids, spionids, goniadids, and bivalves. Diversity and density were characteristic of salinity ranges of zero to 15 ppt in regional surface waters.

Manganese was the only COPC that exceeded soil toxicity reference levels and based on the comparison of chronic daily intakes and terrestrial reference values for the quail. This indicated a small potential for adverse affects to terrestrial organisms. However, the comparisons for all other COPCs does not indicate that there could be adverse affects to terrestrial organisms.

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SECTION 7.0 TABLES

TABLE 7-1

LIST OF CONTAMINANTS DETECTED IN THE SURFACE WATER, SEDIMENT, SURFACE SOIL AND BIOTA SAMPLES
SITE 69
REMEDIAL INVESTIGATION, CTO-0212
MCB CAMP LEJEUNE, NORTH CAROLINA

Analyte	Surface Water				Sediment				Surface Soil	Biota Samples
	Unnamed Tributary	Everett Creek	New River	On-Site and Drainage Area	Unnamed Tributary	Everett Creek	New River	On-Site and Drainage Area	Chemical Storage Area	
Volatiles										
Acetone				X	X	X	X	X	X	X
Benzene										X
2-Butanone						X		X	X	X
Carbon Disulfide					X	X				
Chloroform				X						
Ethylbenzene				X						
1,2-Dichloroethene (total)				X				X	X	
2-Hexanone										X
Methylene Chloride						X		X	X	X
4-Methyl-2-pentanone								X	X	
Toluene				X	X			X		X
Tetrachloroethene									X	
Trichloroethene				X					X	
1,1,1-Trichloroethane									X	
Vinyl Chloride				X						
Xylenes (total)				X					X	

TABLE 7-1 (Continued)

LIST OF CONTAMINANTS DETECTED IN THE SURFACE WATER, SEDIMENT, SURFACE SOIL AND BIOTA SAMPLES
SITE 69
REMEDIAL INVESTIGATION, CTO-0212
MCB CAMP LEJEUNE, NORTH CAROLINA

	Surface Water				Sediment				Surface Soil	
Analyte	Unnamed Tributary	Everett Creek	New River	On-Site and Drainage Area	Unnamed Tributary	Everett Creek	New River	On-Site and Drainage Area	Chemical Storage Area	Biota Samples
Semivolatiles										
Diethyl phthalate					X					
Di-n-butyl phthalate				X				X	X	
1,4-Dichlorobenzene				X						
Bis(2-ethylhexyl)phthalate					X	X	X		X	
Benzo(a)pyrene					X					
Di-n-octyl phthalate										X
2-Methylphenol										X
Pesticides										
4,4'-DDE					X	X		X	X	X
4,4'-DDD					X			X		X
4,4'-DDT								X	X	
Endrin										X
Endosulfan II									X	
alpha-BHC								X		
beta-BHC								X	X	
delta-BHC								X		
PCBs										
PCB-1254								X		X
PCB-1260					X				X	X

TABLE 7-1 (Continued)

LIST OF CONTAMINANTS DETECTED IN THE SURFACE WATER, SEDIMENT, SURFACE SOIL AND BIOTA SAMPLES
SITE 69
REMEDIAL INVESTIGATION, CTO-0212
MCB CAMP LEJEUNE, NORTH CAROLINA

	Surface Water				Sediment				Surface Soil	
Analyte	Unnamed Tributary	Everett Creek	New River	On-Site and Drainage Area	Unnamed Tributary	Everett Creek	New River	On-Site and Drainage Area	Chemical Storage Area	Biota Samples
Chemical Surety										
Acetophone								X	X	
Hydroxyacetophone									X	
Inorganics										
Aluminum	X	X	X		X	X	X	X	X	X
Arsenic				X	X	X	X			
Barium	X	X	X	X	X	X	X	X	X	
Beryllium				X	X	X	X	X		X
Cadmium	X				X	X	X			X
Calcium	X	X	X	X	X	X	X	X	X	X
Chromium				X	X	X	X	X	X	
Cobalt	X				X	X	X			
Copper	X	X		X	X	X	X	X		
Iron	X	X	X	X	X	X	X	X	X	X
Lead	X	X		X	X	X	X	X	X	
Magnesium	X	X	X	X	X	X	X	X	X	X
Manganese	X	X	X	X	X	X	X	X	X	
Mercury				X		X		X		
Nickel				X						
Potassium	X	X	X	X	X	X	X	X	X	X

TABLE 7-1 (Continued)

LIST OF CONTAMINANTS DETECTED IN THE SURFACE WATER, SEDIMENT, SURFACE SOIL AND BIOTA SAMPLES
SITE 69
REMEDIAL INVESTIGATION, CTO-0212
MCB CAMP LEJEUNE, NORTH CAROLINA

Analyte	Surface Water				Sediment				Surface Soil	Biota Samples
	Unnamed Tributary	Everett Creek	New River	On-Site and Drainage Area	Unnamed Tributary	Everett Creek	New River	On-Site and Drainage Area	Chemical Storage Area	
Selenium									X	X
Silver		X	X					X	X	X
Sodium	X	X	X	X	X	X	X	X		X
Thallium			X							X
Vanadium	X			X	X	X	X		X	
Zinc	X			X	X	X	X	X	X	X
Total Cyanide									X	

TABLE 7-2

PHYSICAL/CHEMICAL CHARACTERISTICS OF THE COPCs
SITE 69
REMEDIAL INVESTIGATION CTO-0212
MCB CAMP LEJEUNE, NORTH CAROLINA

Analyte	BCF	Water Solubility (mg/L)	Organic Carbon Partition Coefficient (mL/g)	Vapor Pressure (mm Hg)	Log Octanol/ Water Coefficient
Inorganics					
Aluminum	ND(1,3)	ND(1,3)	ND(1)	ND(1,3)	ND(1,3,4)
Arsenic	4(3)	ND(1,3)	ND(1)	ND(1,2,3)	ND(1,3,4)
Barium	ND(1,3)	ND(1,3)	ND(1)	ND(1,2,3)	ND(1,3,4)
Beryllium	19(3)	ND(1,3)	ND(1)	ND(1,2,3)	ND(1,3,4)
Cadmium	3,800(3)	ND(1,3)	ND(1)	ND(1,2,3)	ND(1,3,4)
Chromium	1(3)	ND(1,3)	ND(1)	ND(1,2,3)	ND(1,3,4)
Cobalt	ND(3)	ND(1,3)	ND(1)	1,300(3)	ND(1,3,4)
Copper	23,000(3)	ND(1,3)	ND(1)	ND(1,2,3)	ND(1,3,4)
Iron	ND(3)	ND(1,3)	ND(1)	ND(1,3)	ND(1,3,4)
Lead	45(3)	ND(1,3)	ND(1)	ND(1,2,3)	ND(1,3,4)
Manganese	350,000(3)	ND(1,3)	ND(1)	ND(1,3)	ND(1,3,4)
Mercury	52,175(6)	ND(1,3)	ND(1)	0.002(3)	ND(1,3,4)
Selenium	5,700(3)	ND(1,2)	ND(1)	ND(1,2,3)	ND(1,3,4)
Silver	28(3)	ND(1,3)	ND(1)	ND(1,2,3)	ND(1,3,4)
Thallium	130(3)	ND(1,3)	ND(1)	880(3)	ND(1,3,4)
Vanadium	ND(3)	ND(1,3)	ND(1)	ND(3)	ND(1,3,4)
Zinc	4.4(6)	ND(1,3)	ND(1)	ND(1,2,3)	ND(1,3,4)
VOCs					
Benzene	24(5)	1,800(3)	83(1)	95(3)	2.1(3)
SVOCs					
Benzo(a)pyrene	83,000(3)	ND(1,2,3)	5,500,000(1)	ND(1,2,3)	6.0(3)
4-methyl-2-pentanone	ND	ND	ND	ND	ND
Pesticides/PCBs					
4,4'-DDE	180,000(3)	0.12(3)	4,400,000(1)	ND(1,2,3)	5.7(3)
4,4'-DDD	ND(3)	0.09(3)	770,000(1)	ND(1,2,3)	.60(3)
PCBs, total	61,000(3)	ND(1,3)	530,000(1)	ND(1,3)	5.6(3)

(1) USEPA, 1986.
(2) Negligible (less than 0.1).
(3) SCDM, 1992.
(4) USEPA, 1985.
(5) Howard, 1990.
(6) USEPA, 1993c.

ND = No data
BCF = Bioconcentration Factor
VOCs = Volatile Organic Compounds
SVOCs = Semivolatile Organic Compounds

TABLE 7-3

SUMMARY OF HABITAT TYPES
SITE 69
REMEDIAL INVESTIGATION, CTO-0212
MCB CAMP LEJEUNE, NORTH CAROLINA

Area Designation	Habitat Type	Dominant Vegetation	Secondary Vegetation	Fauna Present
69A	Open Ecotone Within Forest	Loblolly pine (young trees)	Sweetgum, holly, water oak, wax myrtle, blueberry (coastal highbush, late low, Elliott's), mosses/lichens, broom sedge and other grasses, round-leaved sundew	Mourning dove, turkey vulture, resident and migratory songbirds including neotropical migrants, white-tailed deer
69B	Pine/Hardwood Forest	Trees dominant but not species clearly dominant. Species include loblolly pine, sweetgum, oaks (water, white, spanish, post), tulip, red maple, beech, blackgum, bitternut and mockernut hickory, sweetbay	Sassafras, winged sumac, dogwood, wax myrtle, chestnut, sourwood, red buckeye, greenbriars, sand grape, poison ivy, partridgeberry, ferns (beech, cinnamon, braken, royal, sensitive, marsh, Virginia chainfern), violet	Mourning dove, turkey vulture, resident and migratory songbirds including neotropical migrants, white-tailed deer, mole, black racer, anole, five-lined skink
69C	Ecotone Between Field and Forest	Saplings/shrubs dominant. No species clearly dominant. Species include loblolly pine, sweetgum, winged sumac, water oak, wax myrtle, dog fennel is dominant forb	Sand grape, blackberry, broom sedge and other grasses, tick trefoil, braken fern, tread-softly, lyre-leaved sage, St. Johnswort, robin-plantain, soft rush, Christmas fern, ebony spleenwort	Mourning dove, turkey vulture, resident and migratory songbirds including neotropical migrants, white-tailed deer, raccoon
69D	Mature Hardwood Forest	Trees dominant but no species clearly dominant. Species include tulip, beech, sweetgum, oaks (white, red, water), hickory (mockernut, bitternut), red maple, occasional loblolly	Holly, dogwood, red buckeye, wax myrtle, umbrella magnolia, dwarf pawpaw, poison ivy, greenbriar, Christmas fern, wild ginger, partridgeberry, spotted wintergreen	Mourning dove, turkey vulture, resident and migratory songbirds including neotropical migrants, white-tailed deer, squirrel
69E	Forested Wetlands (Swamp)	Trees dominant, no species clearly dominant. Species present include sweetgum, ash, tulip, beech (on drier edges of swamp). Trees exhibit buttressed trunks	No shrubs or vines present. Forbs include lizard's tail, water pennywort, Jack-in-the-pulpit, cane. Lizard's tail is dominant forb	Mourning dove, turkey vulture, resident and migratory songbirds including neotropical migrants

TABLE 7-4

SITE 69
PROTECTED SPECIES WITHIN MCB CAMP LEJEUNE
REMEDIAL INVESTIGATION CTO-0212
MCB CAMP LEJEUNE, NORTH CAROLINA

Species	Protected Classification
American alligator (Alligator mississippienis) (2)	T(f), T(s)
Bachmans sparrow (Aimophilia aestivalis)(1)	SC
Black skimmer (Rhynochops niger)(1)	SC
Green (Atlantic) turtle (Chelonia m. mydas) (2)	T(f), T(s)
Loggerhead turtle (Caretta caretta) (2)	T(f), T(s)
Peregrine falcon (*)(1)	(*)
Piping plover (Charadrius melodus)(1)	T(f), T(s)
Red-cockaded woodpecker (Picoides borealis)(3)	E(f), E(s)
Rough-leaf loosestrife (Lysimachia asperulifolia)(4)	E(f), E(s)

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

* The observer did not differentiate between the American eastern peregrine falcon [E(f), E(s)] or the Arctic peregrine falcon [T(f), T(s)].

Source:
(1) Fussell, 1991
(2) USMC, 1991
(3) Walters, 1991
(4) LeBlond, 1991

TABLE 7-5

SITE 69 - UNNAMED TRIBUTARY
FREQUENCY AND RANGE OF DETECTION COMPARED TO SALTWATER NORTH CAROLINA WQSs, USEPA WQSVs, AND USEPA AWQC
REMEDIAL INVESTIGATION, CTO-0212
MCB CAMP LEJEUNE, NORTH CAROLINA

Analyte	Surface Water ARARs					Contaminant Frequency/Range		Comparison to ARARs				
	North Carolina (NCWQS)	Region IV Screening Values (USEPA WQSVs)		USEPA Water Quality Criteria (USEPA AWQC)		No. of Positive Detects/No. of Samples	Range of Positive Detections	No. of Positive Detects Above NCWQS	No. of Positive Detects Above Screening Values		No. of Positive Detects Above USEPA AWQC	
		Acute	Chronic	Acute	Chronic				Acute	Chronic	Acute	Chronic
Inorganics (μg/L)												
Aluminum	NE	NE	NE	NE	NE	3/3	881 - 3490	NA	NA	NA	NA	NA
Barium	NE	NE	NE	NE	NE	3/3	15.2 - 23	NA	NA	NA	NA	NA
Copper(1)	3	2.9	2.9	2.9	NE	1/3	7	1/1	1/1	1/1	1/1	NA
Iron	NE	NE	NE	NE	NE	3/3	740 - 1840	NA	NA	NA	NA	NA
Manganese	NE	NE	NE	NE	NE	3/3	9 - 17.7	NA	NA	NA	NA	NA
Vanadium	NE	NE	NE	NE	NE	2/3	4.2 - 10	NA	NA	NA	NA	NA

NE = Not Established
NA = Not Applicable
(1) Criteria are hardness dependent

TABLE 7-6

SITE 69 - EVERETT CREEK
FREQUENCY AND RANGE OF DETECTION COMPARED TO SALTWATER NORTH CAROLINA WQSs, USEPA WQSVs, AND USEPA AWQC
REMEDIAL INVESTIGATION, CTO-0212
MCB CAMP LEJEUNE, NORTH CAROLINA

Analyte	Surface Water ARARs					Contaminant Frequency/Range		Comparison to ARARs				
	North Carolina (NCWQS)	Region IV Screening Values (USEPA WQSVs)		USEPA Water Quality Criteria (USEPA AWQC)		No. of Positive Detects/No. of Samples	Range of Positive Detections	No. of Positive Detects Above NCWQS	No. of Positive Detects Above Screening Values		No. of Positive Detects Above USEPA AWQC	
		Acute	Chronic	Acute	Chronic				Acute	Chronic	Acute	Chronic
Inorganics (μg/L)												
Aluminum	NE	NE	NE	NA	NA	2/3	445 - 501	NA	NA	NA	NA	NA
Barium	NE	NE	NE	NA	NA	3/3	10.4 - 22.2	NA	NA	NA	NA	NA
Copper$^{(1)}$	3	2.9	2.9	2.9	NA	1/3	2.6	0/1	0/1	0/1	0/1	NA
Iron	NE	NE	NE	NA	NA	3/3	490 - 667	NA	NA	NA	NA	NA
Lead	25	140	5.6	220	8.5	2/3	1.4 - 2.3	0/2	0/2	0/2	0/2	0/2
Manganese	NE	NE	NE	NA	NA	3/3	14.3 - 32.5	NA	NA	NA	NA	NA
Silver	0.1	2.3	0.23	2.3	0.92$^{(2)}$	2/3	3.2 - 4.1	2/2	2/2	2/2	2/2	2/2

NE = Not Established
NA = Not Applicable
(1) Criteria are hardness dependent
(2) Proposed criteria

TABLE 7-7

SITE 69 - NEW RIVER
FREQUENCY AND RANGE OF DETECTION COMPARED TO SALTWATER NORTH CAROLINA WQSs, USEPA WQSVs, AND USEPA AWQC
REMEDIAL INVESTIGATION, CTO-0212
MCB CAMP LEJEUNE, NORTH CAROLINA

Analyte	Surface Water ARARs					Contaminant Frequency/Range		Comparison to ARARs				
	North Carolina (NCWQS)	Region IV Screening Values (USEPA WQSVs)		USEPA Water Quality Criteria (USEPA AWQC)		No. of Positive Detects/No. of Samples	Range of Positive Detections	No. of Positive Detects Above NCWQS	No. of Positive Detects Above Screening Values		No. of Positive Detects Above USEPA AWQC	
		Acute	Chronic	Acute	Chronic				Acute	Chronic	Acute	Chronic
Inorganics (μg/L)												
Aluminum	NE	NE	NE	NE	NE	3/3	554 - 1840	NA	NA	NA	NA	NA
Barium	NE	NE	NE	NE	NE	3/3	11.7 - 15.2	NA	NA	NA	NA	NA
Iron	NE	NE	NE	NE	NE	3/3	682 - 1330	NA	NA	NA	NA	NA
Manganese	NE	NE	NE	NE	NE	3/3	19.2 - 21.7	NA	NA	NA	NA	NA
Silver	0.1	2.3	0.23	2.3	0.92$^{(1)}$	2/3	3.5 - 4.5	2/2	2/2	2/2	2/2	2/2
Thallium	NE	213	21.3	NE	NE	1/3	11.3	NA	0/1	0/1	NA	NA

NE = Not Established
NA = Not Applicable
(1) Proposed criteria

TABLE 7-8

FIELD CHEMISTRY FROM BIOLOGICAL SAMPLES - SITE 69
REMEDIAL INVESTIGATION, CTO-0212
MCB CAMP LEJEUNE, NORTH CAROLINA

Sample Identification	Sample Location	Salinity (ppt)	Conductivity (micromhos/cm)	DO (mg/L)	pH (S.U.)	Temperature (deg. C)
69-EC2-BN	surface	0	79	5.85	3.8	23
	bottom	0	98	5.80	NA	22.2
69-EC3-BN	surface	1.5	2,700	5.60	5.6	26.8
	bottom	15.5	26,000	0.50	NA	26.8
69-EC4-BN	surface	3.5	4,000	5.75	6	27.5
	bottom	13.5	22,500	5.15	NA	26.2
69-NR1-BN	surface	8	14,200	5.50	6.9	27
	bottom	10	18,000	6.80	NA	27.5
69-NR2-BN	surface	10	17,500	6.60	7.7	26.9
	bottom	12	20,000	5.50	NA	26.9
69-NR3-BN	surface	14	23,000	9.10	7.7	30.8
	bottom	13	2,300	8.70	NA	30.1
69-UT1-BN	surface	0	75	6.50	4	23
69-UT2-BN	surface	0	172	4.50	5.5	24.2
	bottom	0	240	4.50	NA	24
69-UT3-BN	surface	8.5	15,200	10.00	8.3	30.5
	bottom	8.5	15,200	10.30	NA	30.5
69-EC1-SW/SD	bottom	10	15,000	0.4	NA	25.5
69-EC3-SW/SD	NA	NA	NA	NA	NA	NA
69-EC4-SW/SD	NA	NA	NA	NA	NA	NA
69-NR1-SW/SD	NA	NA	NA	NA	NA	NA
69-NR2-SW/SD	NA	NA	NA	NA	NA	NA
69-NR3-SW/SD	NA	NA	NA	NA	NA	NA
69-UT1-SW/SD	NA	NA	NA	NA	NA	NA
69-UT2-SW/SD	NA	NA	NA	NA	NA	NA
69-UT3-SW/SD	NA	NA	NA	NA	NA	NA

ppt = parts per thousand
S.U. = Standard Units
NA = Not Analyzed
Sample Location = Water surface or water bottom
DO = Dissolved Oxygen level
BN = Benthic Macroinvertebrate sample

FS = Fish sample
NR = New River
EC = Everett Creek
UT = Unnamed tributary
SW/SD = Surface water/sediment sample

TABLE 7-9

SITE 69 - UNNAMED TRIBUTARY
FREQUENCY AND RANGE OF DETECTION COMPARED TO SEDIMENT SCREENING VALUES
REMEDIAL INVESTIGATION CTO-0212
MCB CAMP LEJEUNE, NORTH CAROLINA

Analyte	Sediment Screening Values (SSVs)		Contaminant Frequency/Range		Contaminant to Screening Values	
	ER-L	ER-M	No. of Positive Detects/No. of Samples	Range of Positive Detections	No. of Positive Detects Above ER-L	No. of Positive Detects Above ER-M
Inorganics (mg/kg) Aluminum	NE	NE	5/5	1,240-23,400	NA	NA
Arsenic	33	85	4/5	4.7B-7.1	0/4	0/4
Barium	NE	NE	2/5	14.2B-23.1B	NA	NA
Beryllium	NE	NE	2/5	0.52JB-0.61JB	NA	NA
Cadmium	5	9	3/5	1.8JB-2.1JB	0/3	0/3
Chromium	80	145	3/5	3.3-22.4	0/3	0/3
Cobalt	NE	NE	2/5	1.4B-2.1B	NA	NA
Copper	70	390	4/5	7.2B-24.1	0/4	0/4
Iron	NE	NE	5/5	3,530-17,900	NA	NA
Lead	35	110	5/5	1-34.1	0/5	0/5
Manganese	NE	NE	5/5	2.9-69.3	NA	NA
Vanadium	NE	NE	4/5	25.8-41.1B	NA	NA
Zinc	120	270	2/5	22.4-24.6	0/2	0/2
Organics (μg/kg) Benzo(a)pyrene	400	2,500	2/5	290J-2500	1/2	0/2

TABLE 7-9 (Continued)

SITE 69 - UNNAMED TRIBUTARY
FREQUENCY AND RANGE OF DETECTION COMPARED TO SEDIMENT SCREENING VALUES
REMEDIAL INVESTIGATION, CTO-0212
MCB CAMP LEJEUNE, NORTH CAROLINA

	Sediment Screening Values (SSVs)		Contaminant Frequency/Range		Contaminant to Screening Values	
Analyte	ER-L	ER-M	No. of Positive Detects/No. of Samples	Range of Positive Detections	No. of Positive Detects Above ER-L	No. of Positive Detects Above ER-M
Pesticides/PCBs (μg/kg) 4,4-DDE	2	15	3/5	10J-250	3/3	2/3
4,4-DDD	2	20	3/5	14J-150	3/3	2/3
PCB-1260	50	400	1/5	360	1/1	0/1

NE = Not Established
NA = Not Applicable

TABLE 7-10

SITE 69 - EVERETT CREEK
FREQUENCY AND RANGE OF DETECTION COMPARED TO SEDIMENT SCREENING VALUES
REMEDIAL INVESTIGATION, CTO-0212
MCB CAMP LEJEUNE, NORTH CAROLINA

Analyte	Sediment Screening Values (SSVs)		Contaminant Frequency/Range		Contaminant to Screening Values	
	ER-L	ER-M	No. of Positive Detects/No. of Samples	Range of Positive Detections	No. of Positive Detects Above ER-L	No. of Positive Detects Above ER-M
Inorganics (mg/kg)						
Aluminum	NE	NE	5/5	888J-32,700	NA	NA
Arsenic	33	85	3/5	4.4B-5.3B	0/3	0/3
Barium	NE	NE	3/5	13JB-26.4B	NA	NA
Beryllium	NE	NE	5/5	0.13JB-0.96B	NA	NA
Cadmium	5	9	5/5	0.52JB-5.2JB	1/5	0/5
Chromium	80	145	5/5	3.6J-43.8	0/5	0/5
Cobalt	NE	NE	4/5	1.3B-7JB	NA	NA
Copper	70	390	3/5	6.5BJ-16.2JB	0/3	0/3
Iron	NE	NE	5/5	4,150-28,900	NA	NA
Lead	35	110	4/5	7.5J-30.8	0/4	0/4
Manganese	NE	NE	5/5	4.1J-85.9	NA	NA
Mercury	0.15	1.3	1/5	0.17B	1/1	0/1
Vanadium	NE	NE	5/5	7.2JB-48.8	NA	NA
Zinc	120	270	3/5	31.8-62	0/3	0/3
Pesticides/PCBs (μg/kg)						
4,4-DDE	2	15	1/5	6.6J	1/1	0/1

NE = Not Established
NA = Not Applicable

TABLE 7-11

SITE 69 - NEW RIVER
FREQUENCY AND RANGE OF DETECTION COMPARED TO SEDIMENT SCREENING VALUES
REMEDIAL INVESTIGATION CTO-0212
MCB CAMP LEJEUNE, NORTH CAROLINA

Analyte	Sediment Screening Values (SSVs)		Contaminant Frequency/Range		Contaminant to Screening Values	
	ER-L	ER-M	No. of Positive Detects/No. of Samples	Range of Positive Detections	No. of Positive Detects Above ER-L	No. of Positive Detects Above ER-M
Inorganics (mg/kg)						
Aluminum	NE	NE	5/5	3,450-16,200	NA	NA
Arsenic	33	85	4/5	1.6B-5.6	0/4	0/4
Barium	NE	NE	3/5	4.6B-12.5B	NA	NA
Beryllium	NE	NE	4/5	0.24JB-0.37JB	NA	NA
Cadmium	5	9	3/5	0.53BJ-1.2J	0/3	0/3
Chromium	80	145	5/5	6.2-17.7	0/5	0/5
Cobalt	NE	NE	5/5	0.58B-1.2B	NA	NA
Copper	70	390	3/5	1.6BJ-2.5BJ	0/3	0/3
Iron	NE	NE	5/5	4,320-14,500	NA	NA
Lead	35	110	5/5	3.6-6	0/5	0/5
Manganese	NE	NE	5/5	13.6J-28.9	NA	NA
Vanadium	NE	NE	5/5	10.3B-35.3	NA	NA
Zinc	120	270	3/5	7-10.7	0/3	0/3

NE = Not Established
NA = Not Applicable

TABLE 7-12

SUMMARY OF BIOTA SAMPLES SENT TO CEIMIC FOR TISSUE ANALYSIS
REMEDIAL INVESTIGATION, CTO-212
MCB CAMP LEJEUNE, NORTH CAROLINA

Station Location	Sample Identification	Number of Organisms	Species	Total Weight (grams)	Whole Body or Fillet
Site 69 - New River (NR)					
Station 1					
NR1	69-NR1-CR1	9	CR	260	WB
NR1	69-NR1-CR2	20	CR	330	WB
NR1	69-NR1-AM1	20	AM	320	WB
NR1	69-NR1-AM2	20	AM	315	WB
NR1	69-NR1-SP	70	SP	425	WB
Station 2					
NR2	69-NR2-AM	5	AM	350	F
NR2	69-NR2-CR1	20	CR	210	WB
NR2	69-NR2-CR2	20	CR	215	WB
NR2	69-NR2-SM1	1	SM	1,080	F
NR2	69-NR2-SM2	1	SM	820	F
NR2	69-NR2-SM3	1	SM	860	F
NR2	69-NR2-SM4	1	SM	1,250	F
NR2	69-NR2-SM5	1	SM	800	F
NR2	69-NR2-OY	70	OY	NR	WB
Station 3					
NR3	69-NR3-CR1	10	CR	140	WB
NR3	69-NR3-CR2	10	CR	155	WB
NR3	69-NR3-CR3	10	CR	140	WB
NR3	69-NR3-CR4	6	CR	60	WB
NR3	69-NR3-SM1	10	SM	210	WB
NR3	69-NR3-SM2	10	SM	200	WB
NR3	69-NR3-SM1D	10	SM	195	WB
NR3	69-NR3-SM2D	10	SM	170	WB
NR3	69-NR3-SM3D	10	SM	190	WB
NR3	69-NR3-SM4	1	SM	550	F
NR3	69-NR3-OY	50	OY	NR	WB

TABLE 7-12 (Continued)

SUMMARY OF BIOTA SAMPLES SENT TO CEIMIC FOR TISSUE ANALYSIS
REMEDIAL INVESTIGATION, CTO-0212
MCB CAMP LEJEUNE, NORTH CAROLINA

Station Location	Sample Identification	Number of Organisms	Species	Total Weight (grams)	Whole Body or Fillet
Site 69 - Everett Creek (EC)					
Station 3					
EC3	69-EC3-FL1	1	FL	200	F
EC3	69-EC3-FL2	1	FL	300	F
EC3	69-EC3-BC1	1	BC	225	WB
EC3	69-EC3-BC2	1	BC	215	WB
Station 4					
EC4	69-EC4-CR1	10	CR	150	WB
EC4	69-EC4-CR2	10	CR	170	WB
EC4	69-EC4-CR3	10	CR	150	WB
EC4	69-EC4-CR4	10	CR	150	WB
EC4	69-EC4-SM1	5	SM	350	WB
EC4	69-EC4-FL1	1	FL	315	F
EC4	69-EC4-FL2	1	FL	230	F
EC4	69-EC4-FL3	1	FL	210	F
EC4	69-EC3(4)-FL3	1	FL	350	F
EC4	69-EC4-OY	40	OY	NR	WB

Species code:
AM = Atlantic Menhaden
BC = Blue Crab
CR = Croaker
FL = Summer Flounder
PS = Pumpkin Seed
SM = Striped Mullet
LG = Long-nosed Gar
SP = Spot
PF = Pin Fish
WM = Warmouth
OY = Oyster
WB = Whole Body
F = Fillet
NR = Not Recorded

TABLE 7-13

TERRESTRIAL REFERENCE VALUES AND SOIL TO PLANT TRANSFER COEFFICIENTS
REMEDIAL INVESTIGATION, CTO-0212
MCB CAMP LEJEUNE, NORTH CAROLINA

Contaminant of Concern	Soil to Plant Transfer Coefficient	Soil-to-Plant Coefficient	Terrestrial Reference Value (TRV) mg/kg/day
	(Bv)	(Br)*	
4-Methyl-2-pentanone	NA	NA	NA
Benzene	2.27 (1, 3)	2.27	25 (4)
4,4'-DDE	0.019 (1,2)	0.019	0.05 (7)
4,4'-DDD	0.013 (1,2)	0.013	0.05 (7)
Aluminum	0.004 (5)	0.007 (5)	NA
Barium	0.150 (5)	0.015 (5)	30 (7)
Beryllium	0.010 (5)	0.002 (5)	0.54 (8)
Cadmium	0.550 (5)	0.150 (5)	4.7 (9)
Chromium	0.008 (5)	0.005 (5)	2.7 (10)
Copper	0.400 (5)	0.250 (5)	300 (7)
Iron	0.004 (5)	0.001 (5)	NA
Lead	0.045 (5)	0.009 (5)	27.4 (7)
Manganese	0.250 (5)	0.050 (5)	0.14 (11)
Selenium	0.025 (5)	0.853 (5)	0.025 (6)
Silver	0.4 (5)	0.100 (5)	0.014 (7)
Thallium	0.004 (5)	0.000 (5)	0.23 (6)
Vanadium	0.006 (5)	0.003 (5)	5 (6)
Zinc	1.500 (5)	0.900 (5)	38 (12)

NA - Information not available
* - Br is assumed to be the same as Bv for organics

(1) Travis and Arms, 1988
(2) USEPA, 1986
(3) Howard, 1991
(4) ATSDR, 1992
(5) Baes et al., 1984
(6) HEAST, 1993
(7) IRIS, 1993
(8) IRIS, 1991
(9) USDH, 1992
(10) USDH, 1991
(11) IRIS, 1990
(12) ATSDR, 1989

TABLE 7-14

SURFACE WATER QUOTIENT INDEX FOR SITE 69
REMEDIAL INVESTIGATION, CTO-0212
MCB CAMP LEJEUNE, NORTH CAROLINA

Parameter	Sample Number	Sample Concentration (µg/L)(3)	North Carolina (NCWQS)(1) Quotient Ratio	Region IV Screening Values (USEPA WQSV)(2) Quotient Ratio		USEPA Ambient Water Quality Criteria (USEPA AWQC) Quotient Ratio	
				Acute	Chronic	Acute	Chronic
Unnamed Tributary							
Copper	69-UT1-SW-06	7	2.3	2.4	2.4	2.4	NA
Everett Creek							
Silver	69-EC3-SW-06	4.1	41	1.8	17.8	1.6	4.5
	69-EC4-SW-06	3.2	32	1.4	13.9	1.4	3.5
New River							
Silver	69-NR1-SW-06	4.5	45	2.0	19.6	1.9	4.9
	69-NR2-SW-06	3.5	35	1.5	15.2	1.5	3.8

(1) NCWQS = North Carolina Water Quality Standards

(2) USEPA WQSV = U.S. Environmental Protection Agency Water Quality Screening Values

(3) µg/L = micrograms per liter

NA = Not Available

NOTE: Shaded areas are for Quotient Ratios that exceed one.

TABLE 7-15

SEDIMENT SCREENING VALUES QUOTIENT INDEX FOR SITE 69
REMEDIAL INVESTIGATION, CTO-0212
MCB CAMP LEJEUNE, NORTH CAROLINA

Parameter	Sample Number	Sample Concentration (µg/kg)(2)	SSV(1) QUOTIENT RATIO	
			ER-L(3)	ER-M(4)
Unnamed Tributary				
Benzo(a)pyrene	69-UT2-SD-612	2500	63	1
4,4'-DDE	69-UT2-SD-06	250	125	16.7
	69-UT2-SD-612	250	125	16.7
	69-UT3-SD-062	10	5	0.7
4,4'-DDD	69-UT1-SD-06	14	7	0.7
	69-UT2-SD-06	150	75	7.5
	69-UT2-SD-612	150	75	7.5
PCB-1260	69-UT2-SD-6122	360	7.2	0.9
Everett Creek				
Cadmium	69-EC1-SD-06	5200	1.04	0.6
Mercury	69-EC1-SD-06	170	1.1	0.1
4,4'-DDE	69-EC4-SD-6122	6.6	3.3	0.4

(1) Sediment Screening Values
(2) µg/kg = micrograms per kilogram
(3) ER-L = Effects Range-Low
(4) ER-M = Effects Range-Median

Notes: Shaded areas are for Quotient Ratios that exceed one.
There were no QI ratios greater than one in the New River.

TABLE 7-16

TOTAL NUMBER AND PERCENT OF AQUATIC SPECIES IDENTIFIED PER AREA
SITE 69
REMEDIAL INVESTIGATION, CTO-0212
MCB CAMP LEJEUNE, NORTH CAROLINA

SPECIES	UNNAMED TRIBUTARY	EVERETT CREEK			Total Detected	Percent Detected	NEW RIVER			Total Detected	Percent Detected
	UT-1	EC-2	EC-3	EC-4			NR-1	NR-2	NR-3		
FISH SPECIES											
Atlantic menhaden				5	5	4%	40	5		45	6%
Herring				3	3	3%	28	18		46	6%
Spot					0	0%	106	43	70	219	29%
Perch					0	0%		4		4	1%
Stripped mullet				6	6	5%	5	10	81	96	13%
Minnow unidentified	10				0	0%				0	0%
Pin fish				24	24	20%	24	43	60	127	17%
Mahara					0	0%	6	6	44	56	7%
Palemento				1	1	1%	2		2	4	1%
Atlantic croaker				40	40	34%	40	40	66	146	19%
Pig fish				1	1	1%	1			1	0%
Northern puffer					0	0%		2		2	0%
Jack					0	0%		1		1	0%
White perch					0	0%		4		4	1%
Sheeps head					0	0%			1	1	0%
Summer flounder			2	4	6	5%			1	1	0%
Eastern mosquito		33			33	28%				0	0%
American eel	1				0	0%				0	0%
NUMBER OF SPECIES	**2**	**1**	**1**	**8**			**9**	**11**	**8**		
NO. OF INDIVIDUALS	**11**	**33**	**2**	**84**			**252**	**176**	**325**		
OTHER AQUATIC SPECIES											
Blue crab			2		2	100%	1			1	50%
Oyster					0	0%		1		1	25%
NUMBER OF SPECIES	**0**	**0**	**1**	**0**			**1**	**1**	**0**		
NO. OF INDIVIDUALS	**0**	**0**	**2**	**0**			**1**	**1**	**0**		

TABLE 7-16 (Continued)

TOTAL NUMBER AND PERCENT OF AQUATIC SPECIES IDENTIFIED PER AREA
REFERENCE STATIONS
REMEDIAL INVESTIGATION, CTO-0212
MCB CAMP LEJEUNE, NORTH CAROLINA

Species	HADNOT CREEK	Percent Detected	HOLLAND MILL CREEK		Total Detected	Percent Detected
	HC03		HM02	HM03		
FISH SPECIES						
Spot	12	39%		7	7	7%
Stripped mullet	3	10%	11	2	13	13%
Pumpkinseed	0	0%	2		2	2%
Gizzard Shad	0	0%	2		2	2%
Spotted Sunfish	0	0%	2		2	2%
Long-Nosed gar	0	0%	3		3	3%
Atlantic croaker	5	16%			0	0%
Bluefish	3	10%			0	0%
Blue gill	0	0%	1		1	1%
Large mouth bass	0	0%	1		1	1%
Summer Flounder	0	0%	1	4	5	5%
Pinfish	5	16%	1	1	2	2%
Atlantic menhaden	1	3%		61	61	60%
White Perch	1	3%			0	0%
Hogchoker	1	3%		1	1	1%
Black Drum	0	0%	1		1	1%
NUMBER OF SPECIES	**8**	**100%**	**10**	**6**	**13**	**100%**
NO. OF INDIVIDUALS	**31**	**100%**	**25**	**76**	**101**	**100%**

TABLE 7-17

TOTAL NUMBER OF SPECIES AND INDIVIDUALS FOR FISH AT SITE 69
REMEDIAL INVESTIGATION, CTO-0212
MCB CAMP LEJEUNE, NORTH CAROLINA

STATION	NR-1	NR-2	NR-3	EC-2	EC-3	EC-4	UT-1	HC03	HM02	HM03
Fish Species										
Number of Species	9	11	8	1	1	8	2	8	10	6
No. of Individuals	252	176	325	33	2	84	11	31	25	76

NR = New River; EC = Everett Creek; UT = Unnamed Tributary; HC = Hadnot Creek; and
HM = Holland Mill Creek
NC = Not calculated, insufficient data

TABLE 7-18

FISH DISTRIBUTION AND CHARACTERIZATION
SITE 69 - UNNAMED TRIBUTARY, EVERETT CREEK AND NEW RIVER
REMEDIAL INVESTIGATION, CTO-0212
MCB CAMP LEJEUNE, NORTH CAROLINA

Common Name	Scientific Name	Length N.C. (cm)	Length Atlas (cm)	Water Type	Habitat	Spawning	Tolerance	Family	Sources
Atlantic Menhaden	Brevoortia tyrannus	20	46	Brackish or marine, enters freshwater	Rivers, streams	NA	Intermediate	Clupeidae	1,2,3,4
Spot	Leiostomas xanthurus	NA	NA	Brackish or marine, enters freshwater	NA	NA	NA	Sciaenidae	1
Striped Mullet	Mugil cephalus	NA	23-35	Brackish or marine, enters freshwater	Rivers	NA	NA	Mugilidae	1,2
Pinfish	Lagodon rhomboides	NA	38	Marine, seldom enters freshwater	Shallow waters	NA	NA	Sparidae	1,2
Mottled Mojarra	Eucinostomas lefroyi	NA	20	Common in estuaries	Shallow waters			Gerreidae	1,2
Crevalle Jack	Caranex hippos	NA	NA	NA	NA	NA	NA	NA	NA
A. Croaker	Micropogonias undulatus	NA	61	Estuaries, brackish-water or marine	NA	NA	NA	Sciaenidae	1,2
Pumpkinseed	Lepomis gibbosus	20	8-20	Freshwater	Streams Creeks	April through October	Moderately Tolerant	Centrarchidae	1,2,3,4
Silver Perch	Bairdiella chrysoura	NA	NA	Brackish or salt water	NA	NA	NA	Sciaenidae	1
Summer Flounder	Paralichthys dentatus	NA	37	Brackish or marine, enters freshwater	Rivers	NA	NA	Bothidae	1
American Eel	Anguilla rostata	NA	to 147.5	Brackish or freshwater	NA	December	Intermediate	Anguillidae	1,2,3,4,5
Skipjack Herring (herring)	Alosa chrysochloris	NA	to 53	Primarily freshwater; Occasionally enters brackish or marine waters	Large rivers and reservoirs	NA	Intermediate	Clupeidae	3,6
Minnow sp.	NA	NA	NA	NA	NA	NA	NA	NA	NA
Pigfish	Orthopristis chrysoptera	NA	NA	NA	NA	NA	NA	NA	6
Northern Puffer	Sphoeroides maculatus	NA	to 25	Brackish water	Bays and estuaries	NA	NA	Tetraodontidae	2,6
White Perch	Morone americana	NA	to 48	Brackish water; Freshwater	Bays and estuaries; Rivers and lakes	NA	Intermediate	Percichthyidae	3,6

TABLE 7-18 (Continued)

FISH DISTRIBUTION AND CHARACTERIZATION AT SITE 69 - UNNAMED TRIBUTARY, EVERETT CREEK, AND NEW RIVER REMEDIAL INVESTIGATION, CTO-0212 MCB CAMP LEJEUNE, NORTH CAROLINA

Common Name	Scientific Name	Length N.C. (cm)	Length Atlas (cm)	Water Type	Habitat	Spawning	Tolerance	Family	Sources
Sheep's Head	<u>Archosargus</u> <u>probatocephalus</u>	NA	to 76	Muddy, shallow water; Occasionally enters freshwater in Florida	Over oyster beds, Around piles and piers of bridges	NA	NA	Sparidae	2,6
Eastern Mosquito (Mosquitofish)	<u>Gambusia</u> <u>affinis</u>	NA	NA	Fresh or brackish water	Ponds, lakes, ditches, backwaters, sluggish streams	NA	Intermediate	Poeciliidae	2,6

1 Menhinick, 1992.
2 Boschung, 1983.
3 USEPA, 1989d.
4 Raasch, 1991.
5 Kennish, 1986.

Note: No information was located for the following species: Crevalle Jack, minnow sp., and pigfish.

TABLE 7-19

SUMMARY STATISTICS OF BENTHIC MACROINVERTEBRATE SPECIES AT SITE 69 - UNNAMED TRIBUTARY, EVERETT CREEK AND NEW RIVER, AND REFERENCE STATIONS - HADNOT CREEK AND HOLLAND MILL CREEK
REMEDIAL INVESTIGATION, CTO-0212
MCB CAMP LEJEUNE, NORTH CAROLINA

Station	Number of Species	Number of Organisms	Species Density (#/m^2)	Species Diversity	Macroinvertebrate Biotic Index
69-NR1	11	201	1,281	0.718	NA
69-NR2	9	452	2,881	0.407	9.4
69-NR3	9	421	2,683	0.464	NA
69-EC3	3	65	414	0.115	NA
69-EC4	12	236	1,504	0.814	6.3
69-UT1	4	15	96	0.509	8.0
69-UT2	1	1	6	NA	NA
69-UT3	7	25	159	0.690	NA
HM02	4	404	2,575	0.128	NA
HM03	7	97	618	0.538	NA
HC03	8	244	1,555	0.683	NA

NR = New River
EC = Everett Creek
UT = Unnamed Tributary
HC = Hadnot Creek;
HM = Holland Mill Creek
NA = Not Applicable
Species Density (#m^2) is based on a sample area of 0.0523 m^2.

TABLE 7-20

BIOTIC INDEX AND USEPA TOLERANCE TO ORGANIC WASTE AND SENSITIVITY TO METALS FOR BENTHIC MACROINVERTEBRATE SPECIES AT SITE 69
REMEDIAL INVESTIGATION, CTO-0212
MCB CAMP LEJEUNE, NORTH CAROLINA

Species	USEPA[(1)] Metals	Organics	NCDEHNR[(2)] Biotic Index
ARTHROPODA			
Insecta			
Pterygota			
Diptera			
Chironomidae			
Tribelos jucundum	S,C	1	6.6
Crustacea			
Mysidacea			
Mysidae			
Mysidopisis begelowe	NA	NA	NA
Cumacea			
Bodatriidae			
Mancocuma altera	NA	NA	NA
Isopoda			
Idoteidae			
Caecidotea sp.			
Edotea triloba	NA	NA	NA
ANNELIDA			
Polychaeta			
Phyllodocida			
Nereidae			
Nereis succinea	NA	NA	NA
Capitellida			
Capitellidae			
Capitella capitata	NA	NA	NA
Heteromastus filiformis	NA	NA	NA
Oligochaeta			
Tubificida			
Tubificidae			
Isochaetides curvisetosus	NA	2	7.1
Limnodrilus hoffmeisteri	NA	5	9.8
Limnodrilus udekemianus	NA	5	9.7
Aulodrilus limnobius	NA	4	5.2
Goniadidae			

TABLE 7-20 (Continued)

BIOTIC INDEX AND USEPA TOLERANCE TO ORGANIC WASTE AND SENSITIVITY TO METALS FOR BENTHIC MACROINVERTEGRATE SPECIES AT SITE 69
REMEDIAL INVESTIGATION, CTO-0212
MCB CAMP LEJEUNE, NORTH CAROLINA

Species	USEPA[1] Metals	Organics	NCDEHNR[2] Biotic Index
Gylcinde solitaria	NA	NA	NA
Spionida			
Spionidae			
Streblospio benedicti	NA	NA	NA
Hirudinea			
Pisicolidae			
Myzobdella lugubris	NA	NA	NA
Ariciida			
Orbiniidae			
Scoloplos sp.	NA	NA	NA
MOLLUSCA			
Gastropoda			
Prosobranchia			
Neogastropoda			
Nassariidae			
Ilyanassa obsoleta	NA	NA	NA
Bivalvia			
Heterodontida			
Mactridae			
Anatina anatina	NA	NA	NA
RHYNCHOCOELA			
Anopla			
Paleonemertea			
Carinomidae			
Carinoma tremaphoros	NA	NA	NA

[1] Macroinvertebrate Field and Laboratory Methods for Evaluating the Biological Integrity of Surface Waters
[2] Lenat, 1993
NA = Not Available
S = Sensitive to heavy metals
D = Intolerant to organic wastes

TABLE 7-21

SYSTEMATIC LIST OF BENTHIC MACROINVERTEBRATE SPECIES AT SITE 69
REMEDIAL INVESTIGATION, CTO-0212
MCB CAMP LEJEUNE, NORTH CAROLINA

Species	Systematic Classification
ARTHROPODA	Phylum
Insecta	Class
Pterygota	Subclass
Diptera	Order
Chironomidae	Family
Tribelos jucundum	Genus Species
Crustacea	Class
Mysidacea	Subclass
Mysidae	Family
Mysidopisis begelowe	Genus Species
Cumacea	Subclass
Bodatriidae	Family
Mancocuma altera	Genus Species
Isopoda	Order
Idoteidae	Family
Caecidotea sp.	Genus Species
Edotea triloba	Genus Species
ANNELIDA	Phylum
Polychaeta	Class
Phyllodocida	Order
Nereidae	Family
Nereis succinea	Genus Species
Capitellida	Order
Capitellidae	Family
Capitella capitata	Genus Species
Heteromastus filiformis	Genus Species
Oligochaeta	Class
Tubificida	Order
Tubificidae	Family
Isochaetides curvisetosus	Genus Species
Limnodrilus hoffmeisteri	Genus Species
Limnodrilus udekemianus	Genus Species
Aulodrilus limnobius	Genus Species
Goniadidae	Family
Gylcinde solitaria	Genus Species

TABLE 7-21 (Continued)

SYSTEMATIC LIST OF BENTHIC MACROINVERTEGRATE SPECIES AT SITE 69
REMEDIAL INVESTIGATION, CTO-0212
MCB CAMP LEJEUNE, NORTH CAROLINA

Species	Systematic Classification
Spionida	Order
Spionidae	Family
Streblospio benedicti	Genus Species
Hirudinea	Class
Pisicolidae	Family
Myzobdella lugubris	Genus Species
Ariciida	Order
Orbiniidae	Family
Scoloplos sp.	Genus Species
MOLLUSCA	Phylum
Gastropoda	Class
Prosobranchia	Subclass
Neogastropoda	Order
Nassariidae	Family
Ilyanassa obsoleta	Genus Species
Bivalvia	Subclass
Heterodontida	Order
Mactridae	Family
Anatina anatina	Genus Species
RHYNCHOCOELA	Phylum
Anopla	Class
Paleonemertea	Subclass
Carinomidae	Family
Carinoma tremaphoros	Genus Species

TABLE 7-22

RESULTS OF THE JACCARD COEFFICIENT (Sj) OF COMMUNITY SIMILARITY AND SΦRENSON INDEX (Ss) OF COMMUNITY SIMILARITY BETWEEN BENTHIC MACROINVERTEBRATE STATIONS AT SITE 69 - UNNAMED TRIBUTARY, HADNOT CREEK, AND HOLLAND MILL CREEK
REMEDIAL INVESTIGATION, CTO-0212
MCB CAMP LEJEUNE, NORTH CAROLINA

Sj

	Station	UT1	UT2	UT3	HM03	HC03	HM02
	UT1	NA	0.00	0.00	0.00	0.00	0.00
	UT2	0.00	NA	0.14	0.14	0.13	0.00
Ss	UT3	0.00	0.25	NA	0.17	0.15	0.10
	HM03	0.00	0.25	0.29	NA	0.25	0.10
	HC03	0.00	0.22	0.27	0.40	NA	0.09
	HM02	0.00	0.00	0.18	0.18	0.17	NA

UT = Unnamed Tributary
HC = Hadnot Creek
HM = Holland Mill Creek

TABLE 7-23

RESULTS OF THE JACCARD COEFFICIENT (Sj) OF COMMUNITY SIMILARITY AND SΦRENSON INDEX (Ss) OF COMMUNITY SIMILARITY BETWEEN BENTHIC MACROINVERTEBRATE STATIONS AT SITE 69 - EVERETT CREEK, HADNOT CREEK, AND HOLLAND MILL CREEK
REMEDIAL INVESTIGATION, CTO-0212
MCB CAMP LEJEUNE, NORTH CAROLINA

Sj

	Station	EC-3	EC-4	HM03	HC03	HM02
Ss	EC-3	NA	0.25	0.25	0.10	0.00
	EC-4	0.40	NA	0.19	0.11	0.07
	HM03	0.40	0.32	NA	0.25	0.10
	HC03	0.18	0.20	0.40	NA	0.09
	HM02	0.00	0.13	0.18	0.17	NA

EC = Everett Creek
HC = Hadnot Creek
HM = Holland Mill Creek

TABLE 7-24

RESULTS OF THE JACCARD COEFFICIENT (Sj) OF COMMUNITY SIMILARITY AND SΦRENSON INDEX (Ss) OF COMMUNITY SIMILARITY BETWEEN BENTHIC MACROINVERTEBRATE STATIONS AT SITE 69 - NEW RIVER, HADNOT CREEK, AND HOLLAND MILL CREEK
REMEDIAL INVESTIGATION, CTO-0212
MCB CAMP LEJEUNE, NORTH CAROLINA

Sj

Ss

Station	NR-1	NR-2	NR-3	HM03	HC03	HM02
NR-1	NA	0.67	0.82	0.20	0.07	0.12
NR-2	0.80	NA	0.80	0.23	0.08	0.13
NR-3	0.90	0.89	NA	0.23	0.08	0.13
HM03	0.33	0.38	0.38	NA	0.10	0.25
HM02	0.13	0.15	0.15	0.18	NA	0.09
HC03	0.21	0.21	0.24	0.40	0.17	NA

NR = New River
HC = Hadnot Creek
HM = Holland Mill Creek

TABLE 7-25

TERRESTRIAL CHRONIC DAILY INTAKE MODEL EXPOSURE PARAMETERS(1)
REMEDIAL INVESTIGATION, CTO-0212
MCB CAMP LEJEUNE, NORTH CAROLINA

Exposure Parameter	Units	White-Tailed Deer	Eastern Cottontail Rabbit	Bobwhite Quail	Red Fox	Raccoon
Food Source Ingestion	NA	Vegetation 100%	Vegetation 100%	Vegetation 100%	Small Mammals 80% Vegetation 20%	Vegetation 40% Fish 60%
Feeding Rate	kg/d	1.6(2)	0.1(3)	0.014(4)	0.446(4)	0.319(4)
Incident Soil Ingestion	kg/d	0.019(1)	0.002(3)	0.001(3)	0.012(4)	0.030(4)
Rate of Drinking Water Ingestion	L/d	1.1(2)	0.119(4)	0.019(4)	0.399(4)	0.331(4)
Rate of Vegetation Ingestion	kg/d	1.6	0.1	0.014	0.089	0.128
Body Weight	kg	45.4(2)	1.229(4)	0.177(4)	4.69(4)	3.99(4)
Rate of Small Mammal Ingestion	kg/d	NA	NA	NA	0.356	NA
Rate of Fish Ingestion	kg/d	NA	NA	NA	NA	0.192
Home Range Size	acres	454(2)	9.29(4)	8.89(4)	1,771(4)	385(4)

NA - Not Applicable
(1) Scarano, 1993
(2) Dee, 1991
(3) Newell, 1987
(4) USEPA, 1993a

TABLE 7-26

QUOTIENT INDEX RATIOS - SITE 69
REMEDIAL INVESTIGATION, CTO-0212
MCB, CAMP LEJEUNE, NORTH CAROLINA

Contaminant of Concern	Bobwhite Quail	Eastern Cottontail	Red Fox	Whitetailed Deer	Raccoon
4-Methyl-2-pentanone	NA	NA	NA	NA	NA
Aluminum	NA	NA	NA	NA	NA
Barium	2.39E-03	1.91E-03	7.22E-05	6.64E-05	9.43E-05
Chromium	5.54E-03	1.99E-03	2.33E-05	3.95E-05	2.47E-04
Copper	1.17E-06	1.02E-06	9.07E-07	2.56E-07	8.76E-07
Iron	NA	NA	NA	NA	NA
Lead	1.01E-03	5.84E-04	9.86E-06	1.57E-05	3.53E-05
Manganese	1.02E+00	8.95E-01	2.17E-02	2.85E-02	2.74E-02
Silver	6.80E-01	6.30E-01	2.24E-02	2.21E-02	2.65E-02
Thallium	1.81E-03	1.62E-03	1.40E-03	4.05E-04	1.42E-03
Vanadium	3.11E-03	1.10E-03	6.90E-05	3.59E-05	1.93E-04
Zinc	1.39E-02	1.40E-02	1.33E-04	4.02E-04	7.63E-04
4,4'-DDE fish COPC only	*	*	*	*	2.88E-04
4,4'-DDD fish COPC only	*	*	*	*	9.77E-05
Benzene fish COPC only	*	*	*	*	8.93E-08
Beryllium fish COPC only	*	*	*	*	6.46E-06
Cadmium fish COPC only	*	*	*	*	1.75E-05
Selenium fish COPC only	*	*	*	*	7.82E-04
TOTAL	1.73E+00	1.55E+00	4.58E-02	5.16E *-02	5.79E-02

NA - Terrestrial reference value not available, therefore, a quotient index ratio could not be calculated.
* - COPC for fish only, only applicable to raccoon receptor

SECTION 7.0 FIGURES

NOTES:
1. HABITAT AREAS ARE APPROXIMATE AND NOT TO SCALE.
2. THIS ENTIRE AREA IS LOCATED WITHIN A TURKEY MANAGEMENT UNIT.

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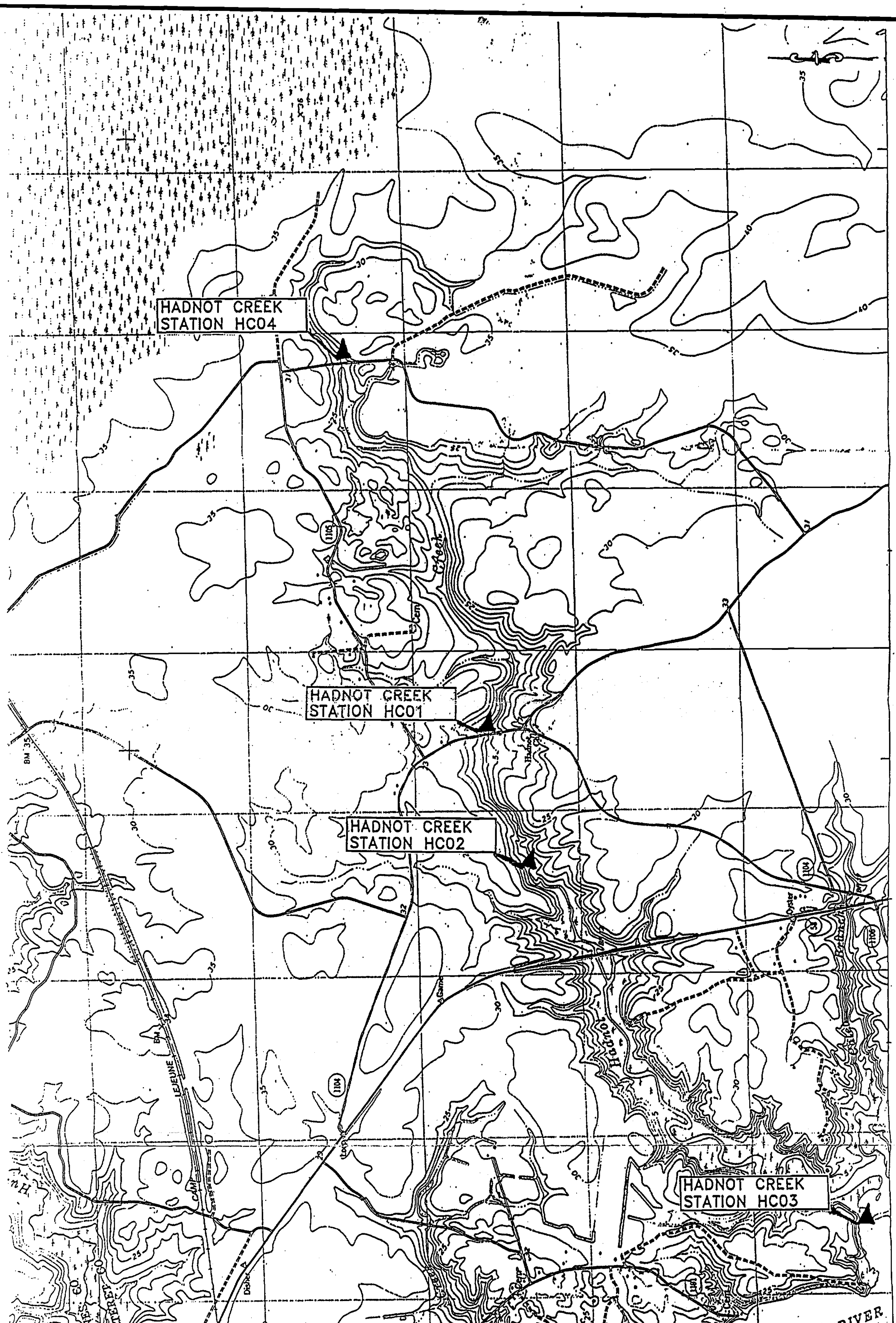
LEGEND

▭	WETLAND (PALUSTRINE)
⊠	WETLANDS(ESTUARINE)
▧	PINE FOREST (VARIOUS AGES)
▭	PINE/HARDWOOD FOREST
▨	HARDWOOD FOREST
▤	OPEN AREA
▦	OPEN WATER
▒	ECOTONE ALONG FENCE

FIGURE 7-1
BIOHABITAT MAP – 1/2 MILE RADIUS
SITE 69 – RIFLE RANGE CHEMICAL DUMP
REMEDIAL INVESTIGATION CTO-0212

MARINE CORPS BASE, CAMP LEJEUNE
NORTH CAROLINA

0176IN13X



212508RI

Baker

Baker Environmental, Inc.

FIGURE 7-2.1
FISH AND BENTHIC MACROINVERTERBRATE
SAMPLING LOCATION IN HADNOT CREEK
REMEDIAL INVESTIGATION CTO-0212

MARINE CORPS BASE, CAMP LEJEUNE
NORTH CAROLINA

SOURCE: N.C. DIVISION OF MARINE FIDHERIES, REPORT AFC-9, NOV. 1975.

01761N142

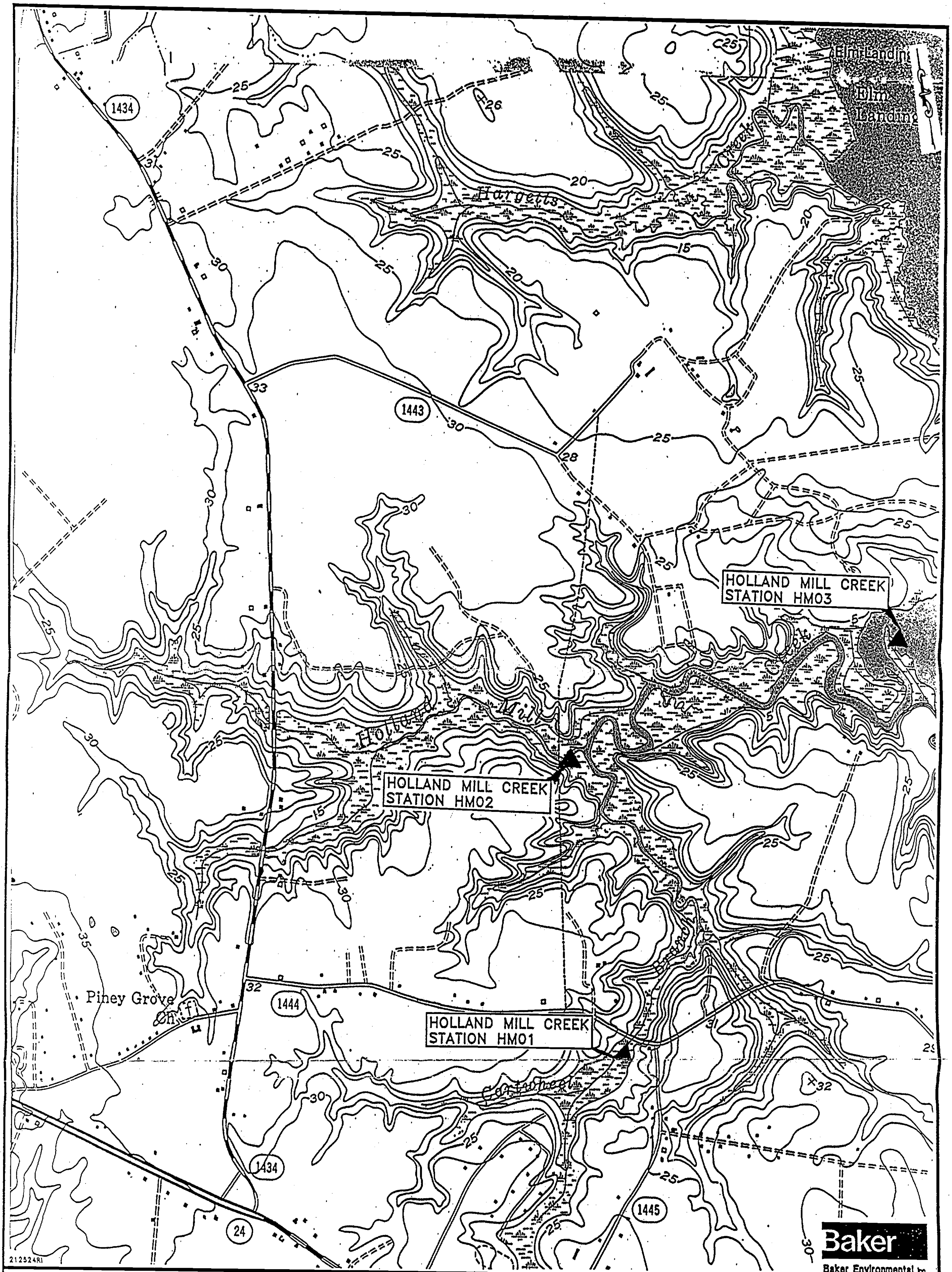
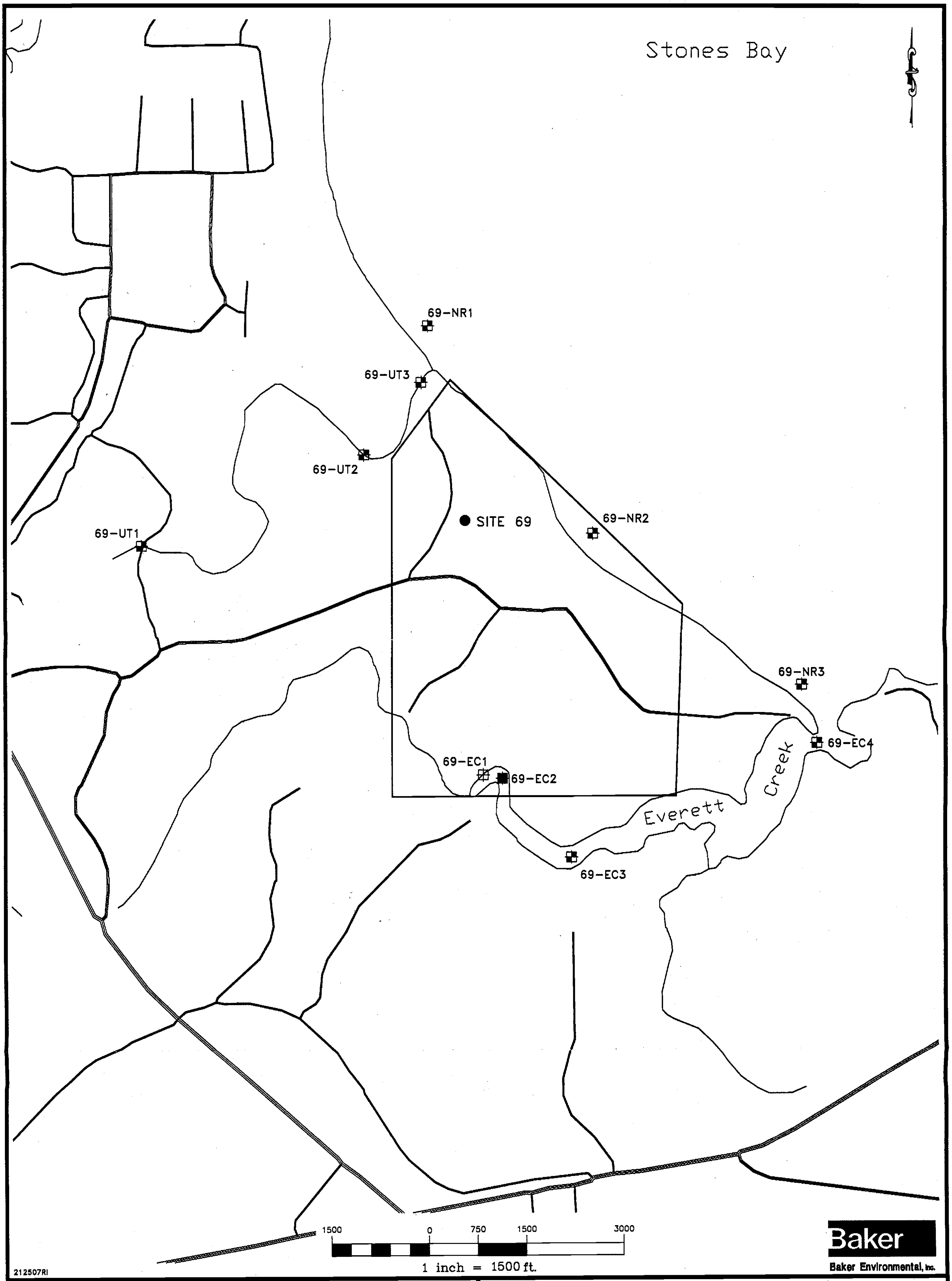


FIGURE 7-2.2
FISH AND BENTHIC MACROINVERTERBRATE
SAMPLING LOCATION IN HOLLAND MILL CREEK
REMEDIAL INVESTIGATION CTO-0212

MARINE CORPS BASE, CAMP LEJEUNE
NORTH CAROLINA

SOURCE: N.C. DIVISION OF MARINE FIDHERIES, REPORT AFC-9, NOV. 1975.

01761N152



LEGEND

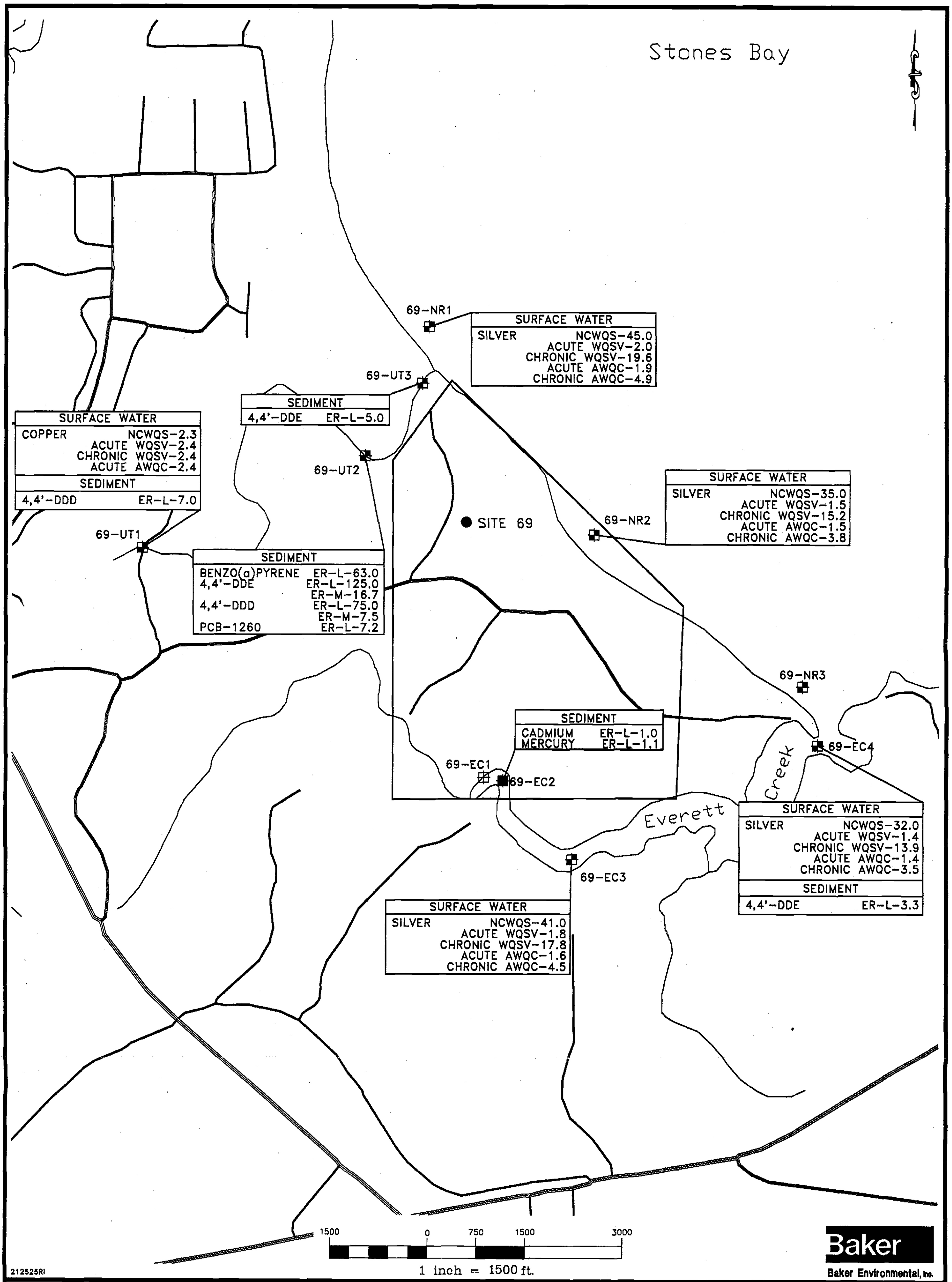
UT – UNNAMED TRIBUTARY
EC – EVERETT CREEK
NR – NEW RIVER

69-EC3 ▣	SURFACE WATER/SEDIMENT/FISH/SHELLFISH/ BENTHIC SAMPLING STATION
69-EC1 ⊞	SURFACE WATER/SEDIMENT SAMPLING STATION ONLY
69-EC2 ■	FISH/SHELLFISH/BENTHIC SAMPLING STATION ONLY

FIGURE 7-3
ECOLOGICAL AND AQUATIC
SAMPLING LOCATIONS
REMEDIAL INVESTIGATION CTO-0212

MARINE CORPS BASE, CAMP LEJEUNE
NORTH CAROLINA

01761N162



LEGEND

UT – UNNAMED TRIBUTARY
EC – EVERETT CREEK
NR – NEW RIVER
69–EC3 SURFACE WATER/SEDIMENT/FISH/SHELLFISH/BENTHIC SAMPLING STATION
69–EC1 SURFACE WATER/SEDIMENT SAMPLING STATION ONLY
69–EC2 FISH/SHELLFISH/BENTHIC SAMPLING STATION ONLY

FIGURE 7–4
QUOTIENT INDEX RATIO EXCEEDANCES IN SURFACE WATER AND SEDIMENT – SITE 69
REMEDIAL INVESTIGATION CTO–0212

MARINE CORPS BASE, CAMP LEJEUNE
NORTH CAROLINA

01761N17Z

8.0 CONCLUSIONS

1. Shallow groundwater has been impacted with volatile organic compounds by former disposal operations. The VOC contamination, which is dominated by 1,2-DCE, is present in the southern portion of the site, near monitoring wells 69-GW15 and 69-GW02. In this area, VOCs are above State and Federal drinking water standards. VOCs were also detected in off-site shallow wells, but at much lower levels. Offsite contaminant levels are below State and Federal drinking water standards. The horizontal extent of the VOC plume in the shallow aquifer has been defined, and is primarily present under the former disposal area.

2. The vertical extent of VOC contamination (i.e., primarily 1,2-DCE) in groundwater appears to be centered in the upper portion of the Castle Hayne Aquifer. VOC levels in the upper portion of the Castle Hayne appear to decrease rapidly as the plume migrates offsite to the east-southeast. Offsite VOC levels in the upper portion of the Castle Hayne are below State and Federal groundwater standards.

3. Groundwater quality in the intermediate zone of the Castle Hayne Aquifer has been slightly impacted by the VOCs. Low levels of 1,2-DCE were detected in wells GW03DD and GW15DW at concentrations below State and Federal drinking water standards. No offsite intermediate zone wells exhibited contamination.

4. VOCs have not migrated to the deep zone of the Castle Hayne aquifer.

5. Although VOCs are present in both the shallow and Castle Hayne Aquifers, the vertical and horizontal extent of contamination is limited in area. Based on existing data, the plume is estimated to cover an area of approximately three to four acres.

6. The source of the VOCs may be associated with buried debris near well cluster 69-GW15. This area contains a significant amount of buried metallic debris, based on the results of the geophysical surveys. It is possible that the source of VOCs may continue to impact groundwater quality; however, VOC levels in wells 69-GW02 and 69-GW03 appear to be decreasing.

7. Elevated total metals in shallow groundwater are not believed to be indicative of past disposal operations. This conclusion is based on the following: metal concentrations in soil are similar to levels typically encountered throughout MCB Camp Lejeune; there is no pattern or plume to suggest that the total metals are elevated due to a source; total metals in groundwater are similar to some of the background wells throughout the base; and dissolved metals in groundwater are not elevated.

8. On-site ponded water in the southern portion of the site is contaminated with VOCs. The ponded water appears to be hydraulically connected to the shallow aquifer.

9. Offsite surface water bodies have not been impacted by the site.

10. Under current human health exposure scenarios, there are no adverse human health risks mainly because groundwater in this area is not utilized for potable supply, and because access to the site is restricted.

11. Under future potential human health exposure scenarios involving residential use of the area, adverse human health risks would result due to groundwater exposure. Future residential use of the area is unlikely since the site is suspected of containing buried CWM.

12. There are no significant ecological risks to aquatic or terrestrial receptors associated with Site 69. Although environmental media concentrations exceeded ARARs/TBCs, aquatic biosurveys indicate fish and benthic macroinvertebrate populations that are representative of typical estuarine and tidal freshwater systems that are not adversely impacted by contaminant sources.

13. Based on the human health and ecological risk assessments, groundwater is the only medium of concern at Site 69. Although there is no current groundwater exposure pathway that would result in adverse human health risks, VOCs are migrating into the Castle Hayne Aquifer. The Castle Hayne is utilized extensively throughout MCB Camp Lejeune and the surrounding communities as a source of water.

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