Final

Remedial Investigation Report
Operable Unit No. 1
(Sites 21, 24 & 78)

Marine Corps Base
Camp Lejeune, North Carolina

Text and Figures
Volume 1 of 2

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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
ATV	all terrain vehicle
AWQC	Federal Ambient Water Quality Criteria
Baker	Baker Environmental, Inc.
BCF	bioconcentration factor
BDC	Beaver Dam Creek
BDDA	Burrow and Debris Disposal Area
bgs	below ground surface
BMDA	Buried Metal Disposal Area
BTEX	benzene, toluene, ethylbenzene, xylenes
BOD	biological oxygen demand
BRA	baseline risk assessment
$CaCO_3$	calcium carbonate
CAMA	Coastal Area Management Act
CC	Cogdel Creek
CCl_4	carbon tetrachloride
CDI	chronic daily intake
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CH	high plasticity clay
$CHCl_3$	chloroform
CL	low plasticity clay
CLEAN	Comprehensive Long-Term Environmental Action Navy
CLP	Contract Laboratory Program
COE	Corps of Engineers
COPC	contaminant of potential concern
COD	chemical oxygen demand
CRAVE	Carcinogen Risk Assessment Verification Endeavor
CRQL	Contract Required Quantitation Limit
CSF	cancer slope factor
DON	Department of the Navy
DQOs	data quality objectives
1,1-DCE	1,1-dichloroethene
1,2-DCE	1,2-dichloroethene
1,1-DCA	1,1-dichloroethane
DD	drainage ditches
DEM	Division of Enviromental Management
ECD	electron capture detector
Eh	oxidation reduction potential
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
FADA	Fly Ash Disposal Area
FFA	Federal Facilities Agreement
FID	flame ionization detector
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
GPR	ground penetrating radar
GW	groundwater well
HA	health advisory
HEAST	Health Effects Assessment Summary Tables
HHAG	Human Health Assessment Group
HHI	Hardin and Huber, Inc.
HI	hazard index
Hoggard-Eure	Hoggard-Eure Associates
HCl	hydrochloric acid
HNO_3	nitric acid
HPIA	Hadnot Point Industrial Area
HQ	hazard quotient
HQW	high quality water
i	hydraulic gradient
IAS	Initial Assessment Study
ICR	incremental cancer risk
ID	inside diameter
IDW	investigative derived wastes
IRA	interim remedial action
IRIS	Integrated Risk Information System
IRP	Installation Restoration Program
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
MCAS	Marine Corps Air Station
MCB	Marine Corps Base
MCL	maximum contaminant level
MEK	methylethyl 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
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
NUS	NUS Environmental Corporation
NWI	national wetlands inventory
OU	operable unit
PAH	polynuclear aromatic hydrocarbon
PA/SI	preliminary assessments/site investigations
PC	permeability constant
PCBs	polychlorinated biphenyls
PCE	tetrachloroethene
PEF	particulate emissions factor
PHA	public health assessment
PID	photoionization detector
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
SARA	Superfund Amendments and Reauthorization Act
SB	soil boring
SCS	Soil Conservation Service
SD	sediment
SM	silty sand
SMCL	Secondary Drinking Water Regulations
SQC	sediment quality criteria
SOPs	standard operating procedures
SSDA	Spiractor Sludge Disposal Area
SSVs	sediment screening values
STP	sewage treatment plant
SVOCs	semivolatile organic compounds
SW	surface water
SWQSVs	surface water quality screening values
T	transmissivity
TAL	target analyte list
Target	Target Environment Services, Inc.
TBC	to be considered
TCA	trichloroethane
TCE	trichloroethene
TCL	target compound list
TCLP	toxicity characteristic leaching procedure
TDS	total dissolved solids
TEF	toxicity equivalency factor
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/l	micrograms per liter
USDI	United States Department of the Interior
USEPA	United States Environmental Protection Agency
USCS	Unified Soil Classification System
USGS	United States Geological Survey
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) 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 (NC 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 is to ensure that environmental impacts associated with past and present activities at the MCB are thoroughly investigated and appropriate CERCLA response/Resource Conservation and Recovery Act (RCRA) corrective action alternatives are developed and implemented as necessary to protect public health and the environment.

As part of the requirements of the FFA, a Remedial Investigation (RI) was conducted at MCB Camp Lejeune Operable Unit (OU) No. 1, which is comprised of Sites 21, 24, and 78. The purpose of this RI was 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 at the sites. This report describes the environmental investigation conducted at OU No. 1 between April 1993 and December 1993, presents environmental findings in addition to baseline human health and ecological risk assessments (RAs), and develops conclusions and recommendations based on the data presented.

Operable Unit Site Descriptions

OU No. 1 is located approximately one mile east of the New River and two miles south of State Route 24. The operable unit is bordered by Holcomb Boulevard to the northwest, Sneads Ferry Road to the northeast, Main Service Road to the southwest, and Cogdels Creek to the southeast. OU No. 1 is approximately 690 acres in size and consists of three separate sites: Site 21, known as the Transformer Storage Lot 140; Site 24, known as the Industrial Fly Ash Dump; and Site 78, known as the Hadnot Point Industrial Area or HPIA. Individual site descriptions are provided below.

Site 21: Transformer Storage Lot 140

Site 21 covers an area of approximately 7 acres and is located within the northwest section of Site 78. The site is bordered by Ash Street to the southwest, Center Road to the southeast, and a wooded area to the northwest. A dirt road surrounds most of the site.

Site 21 consists of several fenced-in areas within the southern portion of the site and a large open area at the northern end of the site. A drainage ditch which surrounds the site collects surface water runoff from the site. It appears that the water only occupies the drainage ditch (mostly at the northern end) during periods of heavy precipitation.

The southern portion of the site is periodically utilized by Marine Corps reserve units for storage of military vehicles.

Site 24: Industrial Fly Ash Dump

Site 24 is located adjacent to the southeastern portion of Site 78. It is located south and east of the intersection of Birch and Duncan Streets and extends south towards Cogdels Creek. Site 24 is a wooded area, approximately 100 acres in size. The site is hilly and unpaved, with site drainage toward Cogdels Creek. Dirt roads, which are interspersed throughout the site, are periodically used for military vehicle maneuvers.

Site 78: HPIA

Site 78, which houses the industrial area of MCB Camp Lejeune, is located between Sneads Ferry Road, Holcomb Boulevard, Duncan Street, and Main Service Road. The site covers an area of approximately 590 acres. The area is comprised of maintenance shops, warehouses, painting shops, auto body shops, and other similar facilities. The majority of the site area is paved, however, there are many lawn areas associated with individual buildings within the site, and there are several acres of woods in the southern portion of the site.

The land within Site 78 is relatively flat. Natural drainage has typically been altered by the installation of drainage ditches, storm sewers, and extensive paving. Surface runoff not intercepted by a manmade structure from the southern portions of the site may drain to Cogdels Creek. Surface runoff from some areas in the northwestern portions of the site may drain to Beaver Dam Creek via stormwater sewers.

Operable Unit Site Histories

The history of each of the three sites with respect to waste storage and disposal activities is presented below.

Site 21: Transformer Storage Lot 140

Site 21 has had a history of pesticide usage and transformer oil disposal. The site was used as a pesticide mixing area and as a cleaning area for pesticide application equipment between 1958 and 1977. This pesticide mixing/cleaning area was reported to be located in the southeast corner of Lot 140, although the exact location is not documented. Chemicals reportedly stored at this site included diazinon, chlordane dust, lindane, DDT dust, malathion, mirex, 2,4-D, silvex, dalpon, and dursban. Small spills, washout and indiscriminate disposal are believed to have occurred in the mixing/cleaning area.

A former transformer oil disposal pit was reportedly located in the northeastern portion of the site. This pit was reportedly used as a disposal area for transformer oil during a one year period between 1950 and 1951. The pit was reported to measure 25 to 30 feet long by 6 feet wide by 8 feet deep. Sand was occasionally placed in the pit when oil was found standing in the bottom of the pit. The total quantity of oil disposed in this pit is unknown.

Site 24: Industrial Fly Ash Dump

Site 24 was used for the disposal of fly ash, cinders, construction rubble, solvents used to clean out boilers, furniture stripping wastes, sewage sludge, or water treatment spiractor sludge between the late 1940s to 1980. Several potential disposal areas have been identified at the site including a spiractor sludge disposal area, a fly ash disposal area, a borrow and debris area, and two buried metal areas.

Site 78: HPIA

The HPIA, constructed in the late 1930s, was the first facility at MCB Camp Lejeune. The area is comprised of approximately 75 buildings and facilities including: maintenance shops, gas stations, administrative offices, commissaries, snack bars, warehouses, and storage yards. Due to the industrial nature of the area, many spills and leaks have occurred over the years.

Most of these spills and leaks have consisted of petroleum-related products and solvents from underground storage tanks (USTs), drums, and uncontained waste storage areas. Presently, there are no known uncontrolled waste disposal activities related to the site.

Physical Characteristics

Surface Water Hydrology

There are three main surface water bodies within OU No. 1: Beaver Dam Creek, Cogdels Creek (and unnamed tributaries), and the New River. Beaver Dam Creek lies north of Site 78 and drains into the New River. Cogdels Creek flows along the southern portion of Site 78 and through a significant portion of Site 24 and drains into the New River. The New River flows in a southerly direction and empties into the Atlantic Ocean through the New River Inlet. The New River and the southern portions of Cogdels Creek are tidally influenced.

Geology

MCB Camp Lejeune is underlain by sediments of the Atlantic Coastal Plain, which consist of interbedded sands, clays, shell beds, sandstone, and limestone, These sediments are layered in interfingering beds and lenses that gently dip and thicken to the southeast.

Shallow soil conditions are generally uniform throughout OU No. 1. In general, the shallow soils consist of unconsolidated deposits of silty and clayey-sand, silt, and clay. These soils represent the Quaternary age "undifferentiated" formation which characterizes the shallow water table aquifer. A laterally continuous confining layer was not observed in the shallow soils in the vicinity of OU No. 1.

With respect to the deeper soil conditions, the stratigraphy between the depths of 25 feet and 150 feet appears to be generally uniform. The dominant soil type in this interval is silty-sand with shell fragments. A laterally continuous confining layer was not observed in the deeper soils in the vicinity of OU No. 1.

Hydrogeology

The surficial aquifer lies in a series of sediments, primarily sand and clay, which commonly extend to depths of 50 to 100 feet. This aquifer is not used for water supply at MCB Camp Lejeune.

The principal water supply aquifer for MCB Camp Lejeune lies in a series of sand and limestone beds located between 50 and 300 feet below land surface. This series of sediments is generally known as the Castle Hayne Formation. The Castle Hayne Formation is approximately 150 to 350 feet thick in this vicinity and contains the most productive aquifer in North Carolina.

Onslow County and MCB Camp Lejeune lie in an area where the Castle Hayne Formation contains freshwater, although the proximity of saltwater in deeper layers just below this aquifer formation and in the New River estuary is of concern in managing water withdrawals from the aquifer.

Groundwater was encountered at varying depths throughout OU No. 1. This variation in groundwater depth may be attributed to topographic changes. In general, groundwater was encountered between 4 and 14 feet below ground surface (bgs). A higher water table was typically encountered near the southwestern portion of OU No. 1 near Cogdels Creek; while a deeper water table was encountered near the northeastern boundary of Site 78.

Three rounds of groundwater level measurements were obtained from the shallow (25 feet), intermediate (between 73 and 78 feet), and deep (between 148 and 158 feet) monitoring wells throughout OU No. 1. Note that intermediate and deep wells only exist at Site 78. Groundwater elevations exhibited some fluctuations over the three month period of monitoring at OU No. 1. The decline in the water table depth appeared to be the result of normal seasonal fluctuations. Typically, a higher water table is noted in the spring, and a lower water table is noted in the fall.

Shallow groundwater appears to flow across OU No. 1 toward the west-southwest, in the general direction of Cogdels Creek and the New River. Based on staff gauge measurements, both Cogdels Creek and Beaver Dam Creek are receiving groundwater discharge, and therefore, are considered as "gaining streams."

Deeper groundwater flow patterns could not be fully evaluated because of the linear distribution of intermediate and deep monitoring wells within the operable unit. The data does suggests, though, that the general groundwater flow direction is also toward the west-southwest. The similar groundwater flow patterns between the shallow and deeper water-bearing zones further suggests that the two zones are hydraulically interconnected. Moreover, this conclusion is further supported by the fact that a laterally continuous confining layer between the two zones is not present in the vicinity of OU No. 1.

Site-specific surficial and deeper aquifer hydraulic characteristics (i.e., hydraulic conductivity, transmissivity, and storativity) were not evaluated during this investigation. Instead, information from a recent investigation performed in the area was evaluated . Based on a recent hydrogeologic investigation at Site 78, the calculated values for hydraulic conductivity, transmissivity, and storativity within the shallow water-bearing zone were 2.8 feet/day, 561 gallons/day/feet, and 0.015, respectively. Very low groundwater flow rates of less than 2.0 gallons per minute (gpm) within the shallow soils were noted. Based on the results of well performance tests conducted in potable water supply wells in the vicinity of Site 78, transmissivity values typically ranged between 32,000 to 54,600 gallons/day/feet. Flow or withdraw rates from wells screened between 140 and 194 feet have produced flows of 50 to 150 gpm, although many Base wells report flows of up to 300 gpm.

Water Supply Wells

Eight potable water supply wells were identified in the vicinity of OU No. 1. Seven of the wells including HP-601, HP-602, HP-608, HP-630, HP-634, HP-637 are no longer in service. These wells were shut down because of detected VOCs such as TCE, PCE, and/or DCE.

The depths of the supply wells range from 160 to 225 feet and their screened intervals range from 45 to 225 feet. All of the wells reportedly utilize the Castle Hayne aquifer. An average yield of 174 gpm is reported for these wells.

Previous Investigations

Investigations dating back to 1983 have been conducted at OU No. 1. The previous investigations and their general findings are summarized on Table ES-1.

TABLE ES-1

SUMMARY OF PREVIOUS INVESTIGATIONS FOR OU NO. 1

Investigation (Date)	Site	Media Investigated (1)	Investigation Type	General Findings
Initial Assessment Study (1983)	21, 24 and 78	GW, SL, SW, SD, AIR, W	Historical Records Search	Further investigation recommended
Confirmation Study (1984 - 1988)	21	GW, SL	Soil sampling, one monitoring well installed	Confirmed pesticides and PCBs in soils, not in groundwater
	24	GW, SW, SD	Monitoring well installations, surface water/sediment sampling	Several metals detected in groundwater, but only two locations exceeded Federal or State water quality standards. Metals detected in surface waters and sediments, but not exceeding standards.
	78	GW	Monitoring well installations, groundwater sampling, supply well sampling, records search, soil gas survey, aquifer test	Confirmed volatile organic compounds related to fuels and/or solvents in groundwater and nearby supply wells. Three groundwater plumes identified. Four supply wells shut down as a result of the findings.
Groundwater Study for Hadnot Point Fuel Farm (Site 22) (1988)	Applicable to Site 78	GW	Monitoring well installations and groundwater sampling	Concluded that fuel losses of gasoline occurred predominantly through leaks in the transfer lines or valves of one or more of 14 underground storage tanks. Floating product contributing to dissolved petroleum compounds in the groundwater. As a result, a product recovery system was designed and installed at the fuel farm.

(1) GW = groundwater
SL = soil
SW = surface water
SD = sediment
W = waste

TABLE ES-1 (Continued)

SUMMARY OF PREVIOUS INVESTIGATIONS FOR OU NO. 1

Investigation (Date)	Site	Media Investigated (1)	Investigation Type	General Findings
Supplemental Characterization Step (1990 - 1991)	78	GW, Shallow SL	Soil and groundwater sampling	Volatile organic compounds were detected in the groundwater (both in the shallow and deeper portions of the aquifer). Volatile and semivolatile organic compounds, pesticides, PCBs, and/or metals were detected in soil at the three areas sampled.
Remedial Investigation for Shallow Soils and Castle Hayne Aquifer (1992)	78	GW, SL	No additional sampling; used data from the Confirmation Study and Supplemental Characterization Step.	Concluded: • Trichloroethene contamination in soil appeared to be associated with an old underground storage tank. • Pesticide contamination was limited and occurred in the surface soil samples only. • Majority of metals were found in all samples and may be indicative of naturally occurring conditions.

(1) GW = groundwater
SL = soil
SW = surface water
SD = sediment
W = waste

TABLE ES-1 (Continued)

SUMMARY OF PREVIOUS INVESTIGATIONS FOR OU NO. 1

Investigation (Date)	Site	Media Investigated (1)	Investigation Type	General Findings
Interim Remedial Action Remedial Investigation for the Shallow Aquifer (1991 - 1992)	78	GW	No additional sampling; used data from previous investigations	Identified the following contaminants of concern: trichloroethene, 1,2-dichloroethene, benzene, toluene, ethylbenzene, xylenes, naphthalene, 2-methylnaphthalene, and inorganics. Risk assessments concluded that benzene and trichloroethene may impact human health if shallow groundwater migrates into the deeper portion of the aquifer, or if the shallow aquifer is utilized in the future as a potable water source.
Pre-Investigation Study (1992)	24, 78	GW	Groundwater sampling, geophysical survey	Geophysical survey identified potential USTs located near Buildings 903, 1502, and 1601. No volatile or semivolatile organics, pesticides, or PCBs detected in Site 24 groundwater. Fuel-related compounds and metals were detected in deeper monitoring wells within/near Site 78.
Aerial Photographic Study (1992)	21, 24, 78	--	Aerial investigation study from 1938 to 1990.	Waste activities and/or several stained areas were identified at all three sites.

(1) GW = groundwater
SL = soil
SW = surface water
SD = sediment
W = waste

Remedial Investigation Activities

The RI field programs at OU No. 1 were initiated to characterize potential environmental impacts and threats to human health and the environment resulting from previous storage, operations, and disposal activities. The RI program consisted of preliminary RI field investigation activities, and the RI field investigation. The RI was designed to supplement previous data findings and to focus on known areas of concern within Site 78 and suspected areas of concern within Sites 21 and 24. The RI focused on various areas of concern within OU No. 1 including: a former pesticide mixing/disposal area and a former transformer oil disposal area at Site 21; several suspected metal, sludge and/or debris disposal areas within Site 24; several suspected sources of contamination within Site 78; Bear Head Creek; Cogdels Creek; and the New River.

Sampling grids were established at all of the above-mentioned areas of concern. The grid points were surveyed by a licensed surveyor prior to initiating the soil investigation. Shallow borings were augered at each grid point, and soil samples were collected at two-foot continuous intervals until the water table was encountered. The majority of the samples were analyzed for full Target Compound List (TCL) organics and Target Analyte List (TAL) inorganics. In areas where a certain contaminant was expected based on previous information, the majority of the samples may have been analyzed for that particular contaminant; however, at least ten percent of samples collected from these areas were analyzed for full TCL organics and TAL inorganics.

The groundwater investigation at OU No. 1 focused on evaluating surficial and deeper groundwater quality. Shallow wells were installed at all three sites. Placement of monitoring wells was based on reported storage/disposal areas, results of a geophysical survey investigation, review of historical aerial photographs, and preliminary results from soil sample results. In addition, the placement of the wells was based on the location of existing wells at each of the three sites. Site 78 had over 30 existing monitoring wells (including shallow, intermediate, and deep). No additional intermediate or deep monitoring wells were installed during the RI.

Groundwater samples generally were analyzed for full TCL organics and TAL inorganics (total and dissolved metals analysis). The groundwater investigation also included several rounds of water level measurements. These measurements included staff gauges which were installed in Beaver Dam Creek and Cogdels Creek.

Surface water and sediment investigations were conducted at Site 21, Beaver Dam Creek, Cogdels Creek, and the New River. Surface and subsurface sediment samples were collected from the middle portion of the stream as well as the stream bank. All surface water and sediment samples were analyzed for full TCL organics and TAL inorganics.

Nature and Extent of Contamination

Site 21: Transformer Storage Lot 140

Soils

Pesticides and PCBs were the dominant contaminants present in soils at Site 21. The most significant pesticide levels were found in surface soils collected in the vicinity of the Former Pesticide Mixing/Disposal Area. These concentrations (ranging from 4.6 µg/kg to 34,000 J µg/kg) are believed to be related to the previous handling practices which were reported by base personnel. PCBs (PCB-1260) were present primarily in surface soils in the vicinity of the Former PCB Transformer Disposal Area. The presence of the PCBs is presumed to be related to the previous disposal practices at the site.

Groundwater

Metals were the most prevalent contaminants in groundwater at Site 21. Concentrations of arsenic, manganese, cadmium, beryllium, chromium, lead, and/or nickel were found above MCLs and/or NCWQSs in seven of the eight shallow wells sampled. The highest concentrations were detected in wells located near the southwestern portion of the site.

VOCs in the groundwater were primarily limited to the northeastern portion of the site. TCE, benzene, toluene, ethylbenzene, and total xylenes were detected in this area at concentrations which exceeded Federal and State standards. This groundwater contamination is most likely related to Site 78, specifically the 900 Series buildings, since the same contaminants were found in this area. Note that pesticides and PCBs, which were found extensively in site soils, were not detected in the groundwater at Site 21.

Surface Water

Surface water samples collected from the drainage ditches which surround Site 21 indicated that limited contamination was present at the site. The only organic contaminant detected in Site 21 surface water was 4,4-DDD. This compound was detected in one sample at a concentration of 0.24 µg/L. Inorganics were detected in the surface water samples but not at concentrations exceeding freshwater standards.

Sediments

Pesticides and PCBs were the dominant contaminants present in sediments at Site 21. Pesticides were detected a total of 66 times, all of which exceeded USEPA Region IV sediment screening values. The highest pesticide levels were found in sediment samples collected from locations downgradient from the suspected pesticide mixing area, along the southwestern portion of the site. PCBs were detected near the Former PCB Transformer Disposal Area. The PCB concentration exceeded the SSVs.

Site 24: Industrial Area Fly Ash Dump

Soils

Analytical results indicated that pesticides and metals were the predominant contaminants impacting soils at Site 24. Pesticide concentrations (highest concentration at 350 µg/kg), were not elevated (as compared to other areas within MCB Camp Lejeune); however, pesticides were present in surface soils throughout the site. The presence of the pesticides appeared to be the result of spraying activities rather than direct disposal due to the relatively low concentrations, widespread detections, and absence of any record of pesticide disposal or pesticide mixing activities at the site.

Detections of metals in surface and subsurface soils were one order of magnitude or higher above base-specific background levels. The presence of metals is most likely attributed to the disposal of fly ash material and various metal debris. The metals that exceeded base-specific background levels (surface and/or subsurface soils) included: aluminum, calcium, barium, copper, chromium, iron, lead, manganese, nickel, and selenium. Samples collected from the Buried Metal Area (BMA grid) exhibited the highest overall concentration of these metals. A few of these elevated metals were detected to depths of 12 feet.

Test pit samples, which were collected in the vicinity of the suspected Buried Metal and Fly Ash Disposal Areas, tested below Federal regulatory levels for toxicity characteristics leaching procedure (TCLP) organics and inorganics. Additionally, the soils classify as nonhazardous under RCRA for ignitability, corrosivity, and reactivity. VOCs (TCE), pesticides (4,4'-DDD and 4,4'-DDT) and several metals were detected in the samples collected from the test pits.

Groundwater

Metals are the predominant contaminants impacting Site 24 groundwater. The most elevated concentrations above Federal or State standards occurred near the suspected Buried Metals Area and the Fly Ash Disposal Area. The metals concentrations support base records indicating that the area was used for the disposal of metal debris and fly ash materials. The most common elevated metals in groundwater at Site 24, chromium, lead, and manganese, were also elevated in site soils. Subsequently, the source of the metals in the groundwater may be attributed to the contaminated soils in the area.

Low levels of the pesticide, heptachlor epoxide, were also detected in three wells at a concentration slightly above the State groundwater standards. The source of the heptachlor epoxide appeared to be related to pesticide spraying (rather than disposal or mixing) activities, since the overall concentrations were relatively low in both the groundwater and soil. Additionally, there is no history of pesticide disposal or mixing operations at the site.

Site 78: HPIA

Soils

SVOCs, pesticides, and metals were the predominant contaminants impacting Site 78 soils. The concentrations of the detected pesticides were generally below 500 µg/kg, with the exception of a few samples exhibiting levels above 1,000 µg/kg at Buildings 1103 and 1502. The higher pesticide concentrations were detected in surface soil samples. The data suggests that the pesticide-impacted soils at Site 78 are the result of routine spraying activities since disposal of pesticides (e.g., buried drums, pesticide mixing) has not been documented at these building locations, and the fact that the overall concentrations are relatively low and comparable to other surface soils within OU No. 1.

SVOCs were present in soils in the vicinity of Buildings 903, 1103, 1502, 1601, and 1608. In general, higher SVOC concentrations and more frequent detections occurred in surface soils. A few detections of SVOCs, however, were also noted in subsurface soils near Building 1601. The most frequently detected SVOCs were PAHs, which included phenanthrene, anthracene, fluoranthene, pyrene, benzo(b) fluoranthene, benzo(k) fluoranthene, benzo(a)pyrene, and benzo(g,h,i)perylene. These compounds are found in petroleum fuels such as fuel oil No. 2, diesel, and kerosene which are used for heating purposes, emergency generators, or refueling base vehicles. Storage of these fuels in aboveground tanks or USTs is common at a number of buildings throughout Site 78. It is possible that the source of the SVOCs is surface (i.e., spills) or subsurface releases (i.e., leaking tanks) of fuels.

Barium, lead, and zinc, were the three most common metals detected at an order of magnitude or more above base-specific background levels. These metals were found predominantly in surface soils collected from Buildings 1103, 1502, and 1608. The specific sources of these metals are unknown since there is no history of disposal at these buildings that would relate to these three contaminants.

Analytical data indicated that VOCs and PCBs are not significantly impacting soils at the five building areas investigated within Site 78. Low levels of toluene and total xylenes were detected at Building 1103 (surface); somewhat higher levels of ethylbenzene and total xylenes were detected in subsurface soils (6 to 7 feet) at Building 1601. The source of the ethylbenzene and xylenes at Building 1601 may be related to releases of fuel from the suspected UST at the building. It is important to note that TCE and 1,2-DCE were detected in the subsurface soil samples collected from well 78GW09-1. PCBs were detected in a single surface sample collected at Building 1300.

Groundwater - Shallow

Shallow groundwater at Site 78 has been impacted by organics and metals. The primary organic contaminants were VOCs, namely BTEX, PCE, TCE, vinyl chloride, 1,1-DCE, cis-1,2-DCE, T-1,2-DCE, and 1,2-dichloropropane. The highest overall concentrations of these compounds were detected near the northeastern portion of Site 78 in the vicinity of the 900 Series buildings and in wells 78GW09-1 and 78GW01 which are located in the southwestern portion of the site. A number of these buildings, reportedly stored/handled petroleum fuels and/or solvents.

Metals were detected throughout the site at concentrations above the Federal and/or State standards. In general, there was no particular area which exhibited excessive metals contamination.

The VOCs detected in shallow groundwater at Site 78 include both halogenated compounds (e.g., PCE, TCE, vinyl chloride, 1,1-DCE, cis-1,2-DCE, T-1,2-DCE, and 1,2-dichloropropane) and nonhalogenated compounds (e.g., BTEX). Halogenated compounds are typically associated with items such as solvents, degreasing agents, and paint strippers. Nonhalogenated compounds on the other hand, especially the lighter compounds such as BTEX, are typically associated with petroleum fuels (e.g., gasoline). A variety of these substances are stored or handled extensively through Site 78 at maintenance facilities, gas stations, fuel farms, and waste storage areas. Subsequently, the presence of VOCs in groundwater through accidental spills or leaking pipelines or tanks at Site 78 is plausible.

Contamination levels in shallow groundwater appears to have decreased over time. Several wells which exhibited elevated VOCs in 1987 and/or 1991 either had nondetectable or significantly lower concentrations in 1993. These wells included 78GW01, 78GW02, 78GW03, 78GW09-1, 78GW10, 78GW11, 78GW17-1, and 78GW19. Several possible explanations may account for the decrease in contaminant levels, including:

- The contaminants may have migrated vertically from the shallow aquifer into the underlying aquifer (contaminants were detected in the deep wells sampled in 1993), or horizontally to other portions of the site.

- The contaminant concentrations may have dissipated over time through natural processes.

Three of the shallow wells (78GW22-1, 78GW23, and 78GW24-1) showed either increased contaminant levels or compounds not previously detected. These three wells are situated near the northeastern portion of Site 78 where multiple sources of contamination are known to exist (e.g., Hadnot Point Fuel Farm, numerous maintenance shops). These sources are presumed to be continually impacting the groundwater in the area.

Groundwater - Intermediate

The intermediate wells sampled at Site 78 exhibited low levels of VOCs and only a few metals which exceeded Federal and/or State standards. Benzene, TCE, 1,2-DCE, vinyl chloride, and dichloromethane were the most prevalent VOCs detected. The highest VOC concentrations were found in the northeastern and southern portions of the site. Several SVOCs, including naphthalene, acenaphthene, and carbazole, were detected in one well in the northern portion of Site 78. Beryllium, cadmium, lead, manganese, and nickel concentrations in the northeastern portion of the site exceeded the Federal and/or State groundwater standards.

Groundwater - Deep

The analytical data indicated that organic compounds, namely VOCs, were the predominant contaminants in the deep wells. The most prevalent VOCs (i.e., both halogenated and nonhalogenated compounds) included benzene, cis-1,2-DCE, T-1,2-DCE, and TCE. Wells located in the northeastern and southwestern portions of the site exhibited the overall highest concentrations of VOCs. Further, one well located in the southwestern portion of the site exhibited elevated alpha chlordane (pesticide) levels above the State groundwater standards.

Several of the deep wells have exhibited increased levels of VOCs over time. Wells 78GW04-3, 78GW09-3, 78GW24-3, and 78GW32-3, which all indicated nondetectable levels of VOCs in 1991, had positive detections of benzene, TCE, 1,2-DCE, cis-1,2-DCE, and/or T-1,2-DCE in 1993. These wells are situated along a linear direction from southwest to northeast across Site 78. Only one of the deep wells, 78GW31-3, revealed lower concentrations in 1993 compared to 1991. The suggests that the contaminants may be migrating into the deeper water-bearing zone at Site 78. Additional rounds of sampling, however, may be required to support this conclusion.

OU No.1 Surface Water and Sediments

Surface Water

The only contaminants found in Cogdels Creek and New River surface water samples which exceeded surface water standards and/or screening values were inorganics, particularly copper, and lead. Overall, the highest concentrations of these compounds were detected near the Hadnot Point STP (along the southern end of Site 78).

The only contaminants were present in Beaver Creek surface water were inorganics. Copper, lead, and zinc were the only compounds which exceeded surface water standards. Sample location 78-BD-SW07, which exhibited a majority of maximum detections, is located directly east of the northern portion of Site 78. The source of the contamination is probably not operable unit-related.

Sediments

The most prevalent contaminants found in Cogdels Creek and New River sediments were PAH compounds, pesticides (particularly 4,4'-DDD), and several inorganics (lead and zinc were most often in exceedance of screening values). The sample locations that produced a majority of maximum concentrations were 78-CC-SD08 and 78-CC-SD18. Location 78-CC-SD08 indirectly south of the Borrow and Debris Disposal Area at Site 24. Location 78-CC-SD18 is downgradient of OU No. 1 in the New River.

PAH compounds can be found in petroleum fuels such as No. 2 oil, diesel, and kerosene, which are used for heating purposes, emergency generators, or refueling base vehicles. As mentioned earlier, storage of these fuels in aboveground or USTs is a common practice throughout Site 78. It is likely, therefore that the source of SVOCs, and possibly lead, is related to surface or subsurface releases of fuels. Pesticides were detected throughout Site 78 sediments, but in concentrations that were relatively low. This suggests that the presence of pesticides throughout Cogdels Creek and New River sediments are the result of spraying activities rather than disposal practices or spill incidents, since pesticide detections are not exceptionally high or concentrated in any specific area. A number of inorganics were detected at every sediment sample location. Lead and zinc were most often detected in excess of the screening values.

The most prevalent contaminants found in Beaver Creek sediments were PAHs, pesticides, and inorganics (lead was the only inorganic to exceed the screening values). As discussed earlier, storage of petroleum fuels (which contain PAH compounds) in aboveground or USTs is a common practice throughout Site 78. It is likely, therefore that the source of PAHs, and possibly lead, is related to surface or subsurface releases of fuels. Additionally, a second source of the PAHs may be from stormwater runoff from roads. Pesticides were detected throughout Beaver Dam Creek sediments, but in concentrations that were relatively low. As is the case with Cogdels Creek and New River sediments, this data suggests that the presence

of pesticides in Beaver Dam Creek may be the result of spraying activities rather than disposal practices or spill incidents, since pesticides detections are not exceptionally high or concentrated in any specific area.

Baseline Human Health Risk Assessment

The human health risk assessment conducted for OU No. 1 was based on several scenarios. Site 21 was evaluated with respect to exposure to current military personnel (soil); future residents (Beaver Dam Creek surface water and sediments); and future construction worker (soil). Site 24 was evaluated with respect to exposure to current military personnel (soil); future residents (groundwater and Cogdels Creek surface water and sediments). Site 78 was evaluated with respect to Operable Unit groundwater only. The soil data was focused on a limited number of potential source areas within Site 78. Due to the size of Site 78 (approximately 590 acres), this limited amount of soil data was not evaluated in the risk assessment because the results would be too biased.

The human health BRA highlighted the media of interest from the human health standpoint at OU No. 1 by identifying areas with elevated ICR and HI values. Overall, the RA indicated that areas of groundwater throughout OU No. 1 may pose potential risks. The following paragraphs summarize the results of the human health assessment performed for OU No. 1.

The estimated site risks for Site 21 fell within the USEPA's acceptable risk range (i.e., ICR $<$ 1E-04 and HI $\leq$ 1.0). Therefore, the contaminants detected at Site 21 do not appear to present an unacceptable risk to human health and the derivation of remediation levels for protection of human health will not be necessary.

Future potential residential exposure (i.e., children and adults) to surface water and sediments (Beaver Dam Creek and Cogdels Creek) did not produce ICRs in excess of the target risk range or HIs exceeding unity. Therefore, derivation of remediation levels for protection of human health for either of these water bodies will not be necessary.

With respect to Site 24, the majority of the total site risk (greater than 95 percent) was associated with the ingestion and dermal contact of Operable Unit groundwater by future residents. With the exception of the total site risk associated with groundwater exposure to future adult and child residents, all total site risks fall within the USEPA's acceptable risk range. The ICR and HI for future potential adult residents were 2E-03 and 13, respectively.

The ICR and HI for future potential child residents were 7E-04 and 29, respectively. The risk was driven by vinyl chloride, arsenic, vanadium, and chromium. Therefore, OU No. 1 groundwater must be considered a medium of interest for which remediation levels for protection of human health will be needed.

It is important to note that although lead could not be quantitatively evaluated in the Human Health RA, lead was mainly detected in the shallow groundwater and not the deeper portions of the aquifer. Therefore, exposure is unlikely since the shallow groundwater is not conducive to usage.

Ecological Risk Assessment

Aquatic Environment

The aquatic environment was assessed in the ecological risk assessment. Based on the potential habitat and other physical characteristics, the most significant populations of aquatic organisms at the OU No. 1 were in Cogdels Creek and Beaver Dam Creek since the surface water in the drainage ditch at Site 21 was either shallow or nonexistent, and intermittent in flow.

Chromium, copper, lead, and zinc were the only COPCs detected in the surface water in Cogdels Creek at concentrations that exceeded any of the water quality standards. These same four constituents, in addition to silver, several PAHs and pesticides, were detected in sediments at concentrations that potentially may decrease the viability of aquatic life. The PAH and pesticide concentrations may be related to past disposal activities.

Copper and zinc were the only COPCs detected in surface water at Beaver Dam Creek that exceeded any of the water quality standards. Lead, several PAHs and several pesticides were detected in sediment samples from Beaver Dam Creek.

The pesticides noted above appear to be the most significant site-related COPCs that have the potential for decreasing the viability of aquatic organisms at OU No. 1. There is aquatic life inhabiting both Cogdels Creek and Beaver Dam Creek, including fish, tadpoles, and bentho macroinvertebrates. In addition, some terrestrial invertebrates probably inhabit the undeveloped areas within OU No.1. Pesticides are not only potentially toxic to aquatic life through a direct exposure pathway, but as indicated by their high bioconcentration factor

value, they have a high potential to bioconcentrate pesticides in organisms. Therefore, other fauna that feed on these organisms will be exposed to pesticides via this indirect exposure pathway.

Terrestrial Environment

No wetlands were identified at OU No. 1 from available wetland maps, nor are there any known spawning and nursery areas for resident fish species within Cogdels Creek or Beaver Dam Creek. Therefore, the ERA for the terrestrial environment concentrated on plants and terrestrial invertebrates. Based on the soil toxicity data for plants and terrestrial invertebrates (earthworms), the following conclusions can be drawn: 1) lead and chromium were detected in concentrations that may decrease the viability of terrestrial invertebrates and floral species at Site 21; 2) lead and chromium, along with beryllium, copper, mercury, and vanadium were detected in concentrations that potentially may decrease the viability of terrestrial invertebrates and floral species at Site 24; and 3) lead and chromium, along with beryllium and zinc, were detected in concentrations that potentially may decrease the viability of terrestrial invertebrates and floral species at Site 78. Other terrestrial organisms (e.g., rabbits, birds, deer) may be exposed to contaminants in the surface soils and surface water by ingestion. Overall, pesticides appear to be the most significant site-related COPCs that have the potential for decreasing the viability of terrestrial organisms at OU No. 1. Potential adverse impacts to these threatened or endangered species from contaminants at OU No. 1 appear to be low.

Conclusions

Site 21: Transformer Storage Lot 140

With respect to Site 21, it appears that the former activities conducted at the site (i.e., pesticide mixing/disposal and PCB oil disposal) have impacted limited areas of soil and sediments within the site. Groundwater and on-site surface water do not appear to be significantly impacted by the former activities at this site. Overall, it appears that the contaminants detected within Site 21 have not migrated off site.

In general, Site 21 investigation results indicated that soils, surface water and sediment within portions of the site are impacted by organic compounds, predominantly pesticides and PCBs. Pesticides were found throughout the site in both soils and sediment, the analytical

data indicated that the highest concentrations were detected in samples collected in the vicinity of the Former Pesticide Mixing/Disposal Area. Pesticides were not detected in the groundwater. Therefore, the RI results confirmed that pesticides have impacted the soils but not the groundwater within the Former Pesticide Mixing/Disposal Area.

PCBs, specifically PCB-1260, were detected in soil and sediment samples collected at Site 21. PCBs were only detected in the surface samples collected from these two media. The highest concentrations were detected in the vicinity of the Former PCB Transformer Disposal Area. Subsequently, the source of the PCBs at the site appeared to be related to the former disposal of transformer oils.

Surface water was determined not to be a significant medium at this site. Drainage ditches at the site are filled by rainwater runoff only during extended periods of precipitation. The ditches, therefore, are not indicative of true surface water bodies since they are intermittent and do not discharge into other water bodies. In addition, the ditches do not appear to be fully hydraulically interconnected to the shallow water-bearing zone (i.e., the groundwater does not receive direct surface water discharge and vice versa), since the ditches are only periodically filled with surface water runoff. The lack of hydraulic interconnection and the fact that pesticides and PCBs are relatively immobile may account for the absence of these contaminants in the groundwater at the site.

VOCs and SVOCs were not extensively found within the various media sampled at Site 21. VOC and SVOC contamination was limited in soils and absent in surface water and sediment. Groundwater from a single well exhibited VOCs including BTEX and TCE at concentrations which exceeded drinking water standards. The VOCs impacting this well likely migrated from an off-site source (probably from nearby facilities located within Site 78).

The estimated human health site risks for Site 21 fell within the USEPA's acceptable risk range (i.e., ICR $<$ 1E-04 and HI $\leq$ 1.0). The risks were driven by PCBs. Therefore, the contaminants detected at Site 21 do not appear to present an unacceptable risk to human health.

The ecological risk assessment indicated that the detected levels of lead and chromium at Site 21 may decrease the viability of terrestrial invertebrate and flora species.

Site 24: Industrial Fly Ash Dump

Site 24 investigation results indicated that soils and groundwater within portions of the site were impacted by organic compounds (i.e., specifically pesticides) and metals. Pesticides were detected in soil samples (predominantly surface soils) throughout the site but at relatively low concentrations. Concentrations of heptachlor epoxide were also detected in three wells at levels which slightly exceeded the State groundwater standard. Moreover, note that surface water and sediment samples collected in Cogdels Creek at stations located adjacent to Site 24 did not contain any organic contamination, including pesticides. Based on the relatively low concentrations and widespread detections of pesticides found in the soil and groundwater at Site 24, it appears that the pesticides have resulted from routine spraying activities, not direct disposal. This conclusion was supported by the fact that there is no history of pesticide disposal at Site 24.

Metals were also prevalent in site soils and groundwater. Arsenic, cadmium, chromium, lead, manganese, mercury, and nickel were detected at high concentrations (i.e., compared to base-specific background levels) in both soils and groundwater. The detection of these metals in both media was common throughout the site; however, the highest concentrations were detected near the Buried Metal Disposal Areas. Note that surface water samples collected in Cogdels Creek at stations located adjacent to Site 24 exhibited copper, lead, and zinc concentrations above the Federal and State surface water standards. The source of the metals detected at Site 24 appears to be the buried metal debris and fly ash materials which were reportedly disposed of at the site.

The majority of the total site risk (greater than 95 percent) was associated with the ingestion and dermal contact of Operable Unit groundwater. The risk assessment conducted for Site 24 estimated that the ICRs and HIs with respect to a future residents scenario were above the USEPA's acceptable risk ranges. The risk was driven by vinyl chloride, arsenic, vanadium, and chromium. Therefore, OU No. 1 groundwater must be considered a medium of interest for which remediation levels for protection of human health will be needed.

The ecological risk assessment indicated that the detected levels of lead, chromium, beryllium, copper, mercury, and zinc may decrease the viability of terrestrial invertebrates and floral species.

Site 78: HPIA

With respect to Site 78, the environmental data collected within the site confirmed the results from the interim remedial action (IRA) RI (i.e., shallow groundwater contamination). In addition, it appears that the former operational/disposal practices conducted within the industrial area have primarily impacted shallow groundwater. The deeper portions of the operable unit groundwater (i.e., Castle Hayne aquifer) is also contaminated due to vertical migration, but to a far lesser degree compared to shallow groundwater. In addition, former disposal practices also impacted soils, in limited areas. The site groundwater contamination appears to be migrating off site (i.e., vertically). No specific source areas were identified during the RI with the exception of a few suspected USTs and building where solvents are known to have been used.

Pesticides were detected throughout Site 78 in soil and sediment samples. In soils, the concentrations were generally below 500 µg/kg. Pesticides were also detected in sediment samples collected from Cogdels Creek, the New River, and Beaver Dam Creek. Note that no pesticides were detected in groundwater and surface water samples collected at Site 78. Based on the widespread detections of the pesticides, and the relatively low concentration levels observed, it appears that the pesticides present in soil and sediment are the result of routine spraying activities at the Base and do not reflect disposal activities.

Groundwater samples collected from Site 78 indicated elevated levels of VOCs and several metals (including: arsenic, beryllium, barium, cadmium, chromium, lead, manganese, mercury, and nickel) above the standards. The shallow portion of the groundwater aquifer appears to be most impacted by these contaminants. Concentrations of both halogenated and nonhalogenated VOCs were detected primarily in several shallow wells located near the northeastern and the southwestern portions of the site. Metals were detected throughout the site in the shallow groundwater and did not indicate a particular contaminant or pattern trend. Although the shallow water-bearing zone appears to be the most impacted, it should be noted that the deeper water-bearing zone also exhibited VOC contamination. Moreover, groundwater data obtained over the past three years at this site suggests that the VOC contaminant levels in the deep water-bearing zone are increasing with time, which may indicate that the VOC contamination is migrating vertically.

In addition to the groundwater, surface water samples collected from Site 78 also indicated VOCs and metals. Toluene, TCE, and 1,2-DCE were the most frequently detected VOCs in the

surface water (Cogdels Creek only). In terms of metals, aluminum, barium, calcium, chromium, copper, iron, lead, potassium, sodium, vanadium, and zinc were the most frequently detected above the standards in Beaver Dam Creek, Cogdels Creek, and/or the New River. Note that barium, cadmium, chromium, and lead were found in both the groundwater water and surface water at Site 78.

This RI confirmed that fact that a number of potential contaminant sources exist within Site 78 which may be contributing to the elevated VOCs and metals. The primary sources of the VOCs include the numerous confirmed and/or suspected USTs and aboveground storage tanks, maintenance and repair facilities, the Hadnot Point Fuel Farm (Site 22), and waste storage areas. Identifying specific sources of the metals contamination at Site 78 is somewhat more difficult, given the fact that metals are present throughout the site and that they exhibit no particular trend. Some of the potential sources may include buried metal, fly ash debris, and wastes generated by industrial processes.

The risk assessment conducted for the Operable Unit groundwater estimated an ICR above 1E-04 and an HI greater than 1.0 with respect to potential future receptors (this is the same as discussed for Site 24). The risks were driven by vinyl chloride, arsenic, vanadium, and chromium.

Future potential residential exposure (i.e., children and adults) to surface water and sediments (Beaver Dam Creek and Cogdels Creek) did not produce ICRs in excess of the target risk range or HIs exceeding unity. Therefore, derivation of remediation levels for protection of human health for either of these water bodies does not appear to be necessary.

Recommendations

Based on the results of the environmental investigations and risk assessments conducted for OU No. 1, the following recommendations for further action have been made.

- Based on the results of the risk assessments, and on a comparison of contaminant levels to applicable water quality standards, remediation of the surficial aquifer and possibly the deeper portions of the aquifer under OU No. 1 is recommended in order to restore the aquifer and/or reduce further migration of the contaminants. This remedial action should coincide with the interim action currently under design for the

shallow aquifer at Site 78. The action may recommend monitoring of the deeper aquifer.

- Pesticide and PCB-contaminated soil at Site 21 should be addressed in the feasibility study due to potential ecological impacts.

- Metal-contaminated soil at Site 24 should be evaluated in the feasibility study due to potential ecological impacts. In addition, the soil in this area may be contributing to groundwater contamination at Site 24.

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 1994 Site Management Plan for MCB Camp Lejeune, a primary document identified in the FFA, identifies 27 sites requiring Remedial Investigation/Feasibility Study (RI/FS) activities. These 27 sites have been divided into 13 operable units to simplify proceeding with RI/FS activities. This report describes the RI conducted at Operable Unit (OU) No. 1, which is comprised of Sites 21, 24, and 78. These three sites are identified on Figure 1-1.

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, sediment, and surface water) at OU No. 1, 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 21 is known as the "Transformer Storage Lot 140"; Site 24 is the "Industrial Fly Ash Dump"; and Site 78 is commonly referred to as the "Hadnot Point Industrial Area or HPIA." These sites are generally located in the northeastern section of MCB Camp Lejeune north of Main Service Road. The sites are bordered by Holcomb Boulevard on the west and extend east of Duncan Street into the wooded area. The sites are bordered by Sneads Ferry Road to the north and Main Service Road to the south.

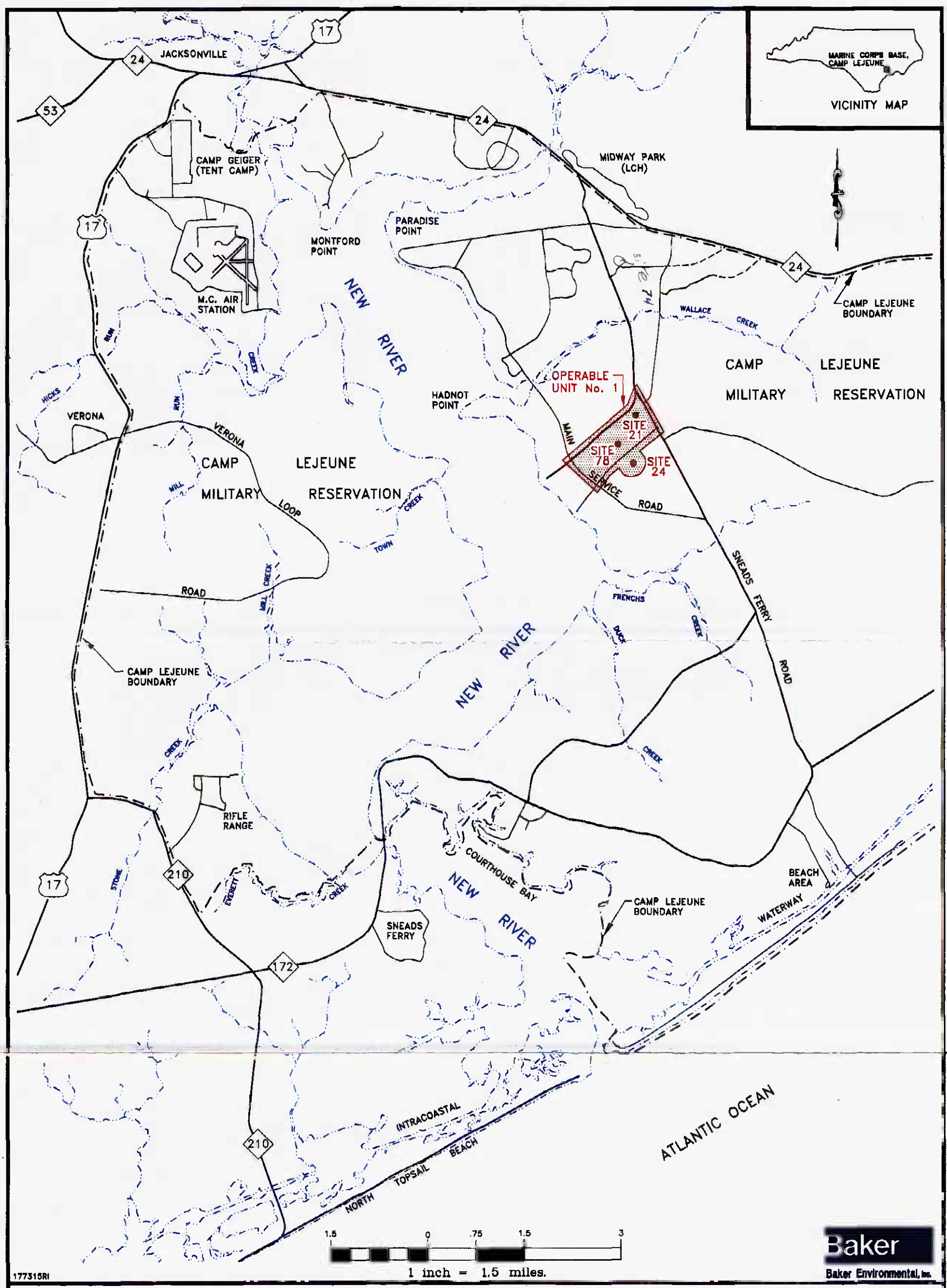

FIGURE 1-1
LOCATION MAP-OPERABLE UNIT No. 1
SITES 21, 24 AND 78
REMEDIAL INVESTIGATION CTO-0177
MARINE CORPS BASE, CAMP LEJEUNE
NORTH CAROLINA

0127LY01Y

This RI Report has been submitted to the USEPA Region IV, the NC DEHNR, MCB Camp Lejeune Environmental Management Department (EMD), and members of the Technical Review Committee (TRC), and to the Naval Facilities Engineering Command, Atlantic Division (LANTDIV) for their review.

1.1 Operable Unit Description

Operable units are formed as an incremental step towards addressing individual site problems. There are currently 27 Installation Restoration Program (IRP) sites on MCB Camp Lejeune which have been grouped into thirteen 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. OU No. 1 includes Sites 21, 24, and 78, which were grouped because the three sites border each other, and share similar aquifers and watersheds.

OU No. 1 is located approximately one mile east of the New River and two miles south of State Route 24 on the main section of MCB Camp Lejeune. The unit is bordered by Holcomb Boulevard to the northwest, Sneads Ferry Road to the northeast, Main Service Road to the southwest, and Cogdels Creek to the southeast. Camp Lejeune Railroad operates rail lines parallel to Holcomb Boulevard which extends into OU No. 1. OU No. 1 is approximately 690 acres in size. Site descriptions and histories of each of the three sites included under OU No. 1 are presented in the next section.

1.2 Site Description and History

This section provides a description of the physical setting of the three sites included under OU No. 1. A detailed history of these sites is also included in this section.

1.2.1 Site Description

1.2.1.1 Site 21 - Transformer Storage Lot 140

Site 21 is located within the northwest section of Site 78 (HPIA). The site is bordered by Ash Street to the southwest, Center Road to the southeast, and a wooded area to the northwest. Figure 1-3 presents a site plan of Site 21. A dirt road surrounds most of the site along with surface drainage ditches. The southern and central portions of the site (approximately

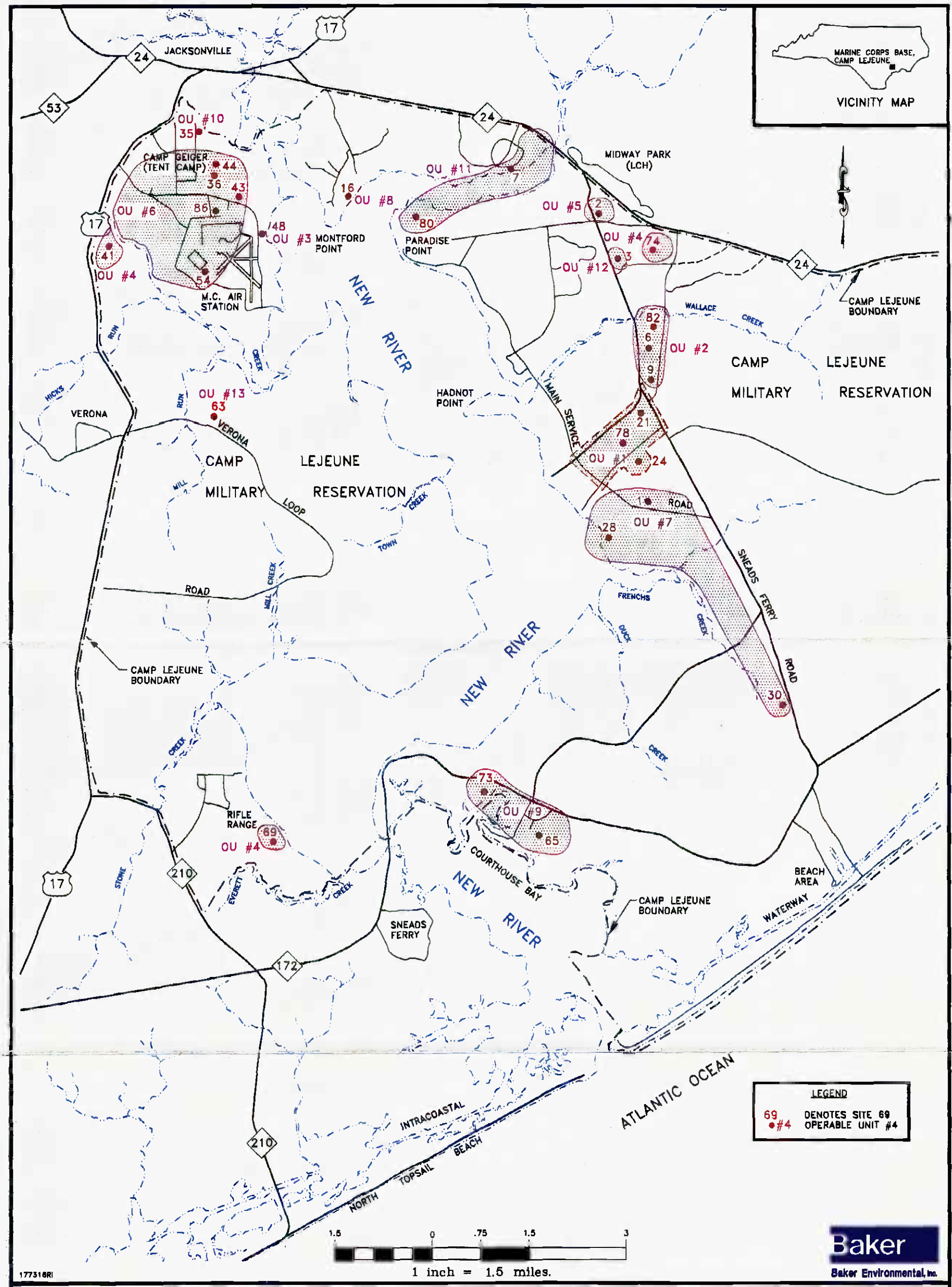

FIGURE 1–2
OPERABLE UNITS AND SITE LOCATIONS AT
MARINE CORPS BASE CAMP LEJEUNE
REMEDIAL INVESTIGATION CTO–0177
MARINE CORPS BASE, CAMP LEJEUNE
NORTH CAROLINA

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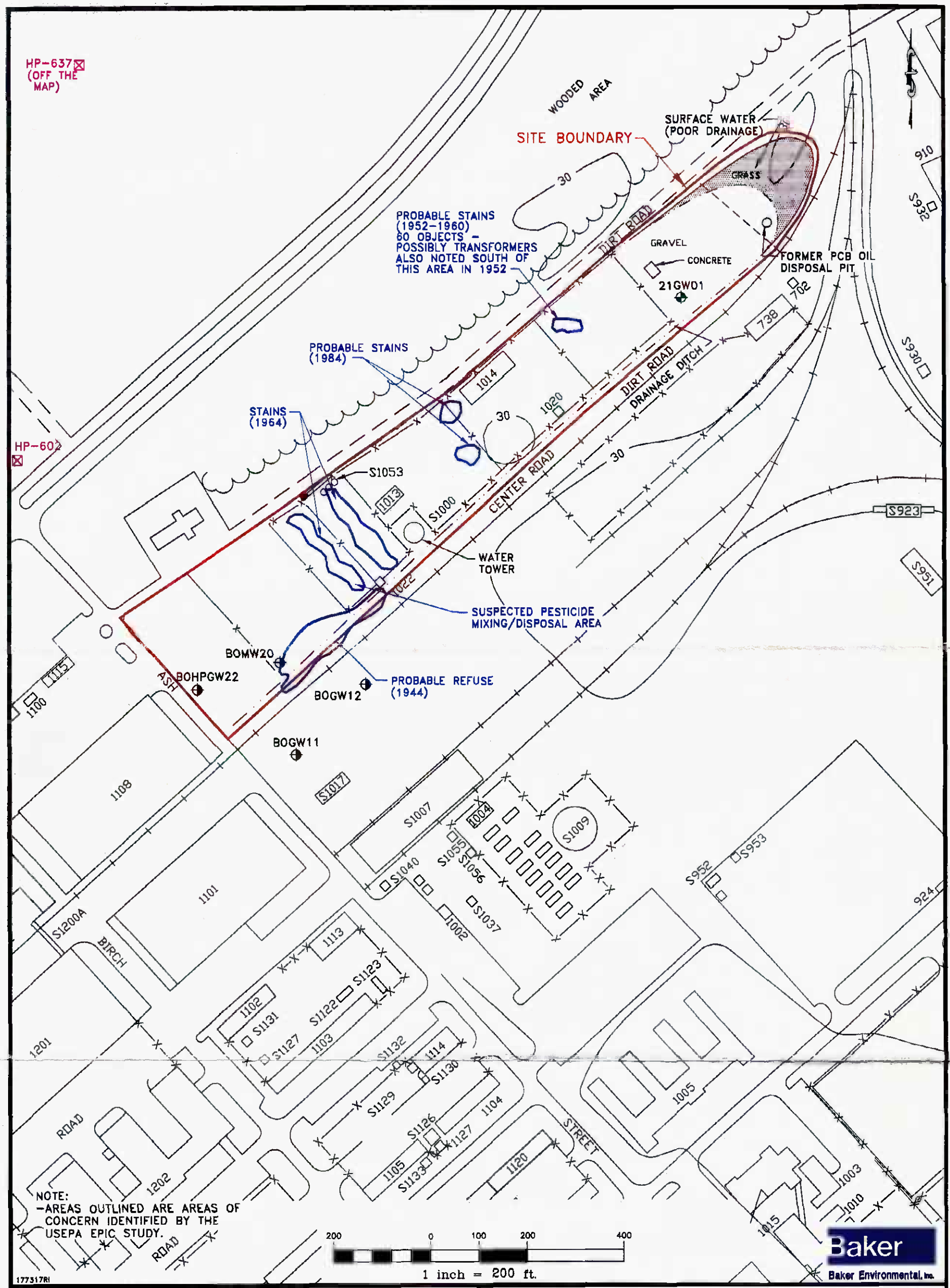


LEGEND

21GW01	EXISTING SHALLOW MONITORING WELL INSTALLED BY ESE, 1984
BOGW11	EXISTING SHALLOW MONITORING WELL
HP-637	WATER SUPPLY WELL (INACTIVE)

SOURCE: LANTDIV, FEBRUARY 1992

FIGURE 1-3
SITE MAP
SITE 21: TRANSFORMER STORAGE LOT 140
REMEDIAL INVESTIGATION CTO-0177

MARINE CORPS BASE, CAMP LEJEUNE
NORTH CAROLINA

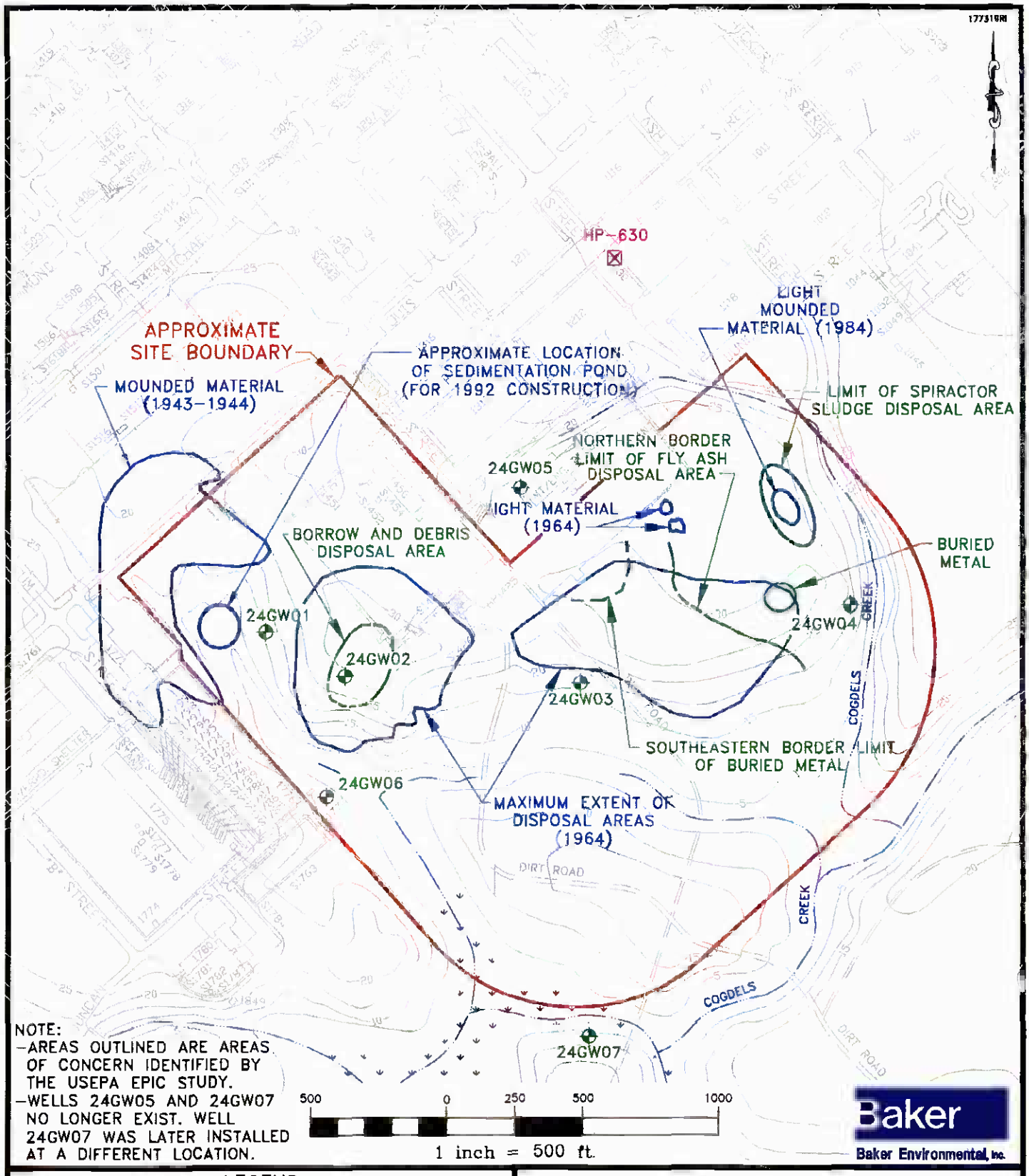
220 feet by 900 feet) have several fenced-in areas, while the northern section (approximately 500 feet long) is an open area. A water tower is located in the fenced portion of the site. Surface cover within the site primarily consists of gravel, sandy soil, and concrete with a few vegetated areas. In the northern portion of the site, a small area, slightly depressed in elevation, is evident. This may have been a former transformer oil disposal pit.

The land within Site 21 is relatively flat and is unpaved. A drainage ditch which surrounds the site collects surface runoff from the site and adjacent roadways. The direction of flow from the drainage ditch is unclear. During the RI field activities, observations of the drainage ditch revealed that it was parched of water, with the exception of the northern end. Therefore, it can be assumed that water only occupies the drainage ditch during periods of heavy precipitation. The southern portion of the site is periodically utilized by Marine Corps reserve units. Currently this portion of the site is being used for storage of military vehicles.

This RI has focused on two areas of concern within Site 21: the Former Pesticide Mixing/Disposal Area and the Former PCB Transformer Oil Disposal Area. As shown on Figure 1-3, the Former Pesticide Mixing/Disposal Area is located near the southwestern portion of the site and the Former Transformer PCB Oil Disposal Area is located near the northeastern portion of the site. Additional areas shown in blue on Figure 1-3, which were identified by the USEPA Environmental Photographic Interpretation Center (EPIC) Study, were also investigated under this RI with the exception of the probable refuse area noted in the southern portion of the site (USEPA, 1992a). Section 1.3.1.2 of this RI discusses the results of the EPIC Study for Site 21.

1.2.1.2 Site 24 - Industrial Fly Ash Dump

Site 24 is located adjacent to the southeast portion of Site 78. Specifically, the site is located south and east of the intersection of Birch and Duncan Streets and extends south toward Cogdels Creek. Figure 1-4 presents a site plan of Site 24, with suspected areas of former disposal shown (based on the 1992 USEPA EPIC Study, see Section 1.3.2.2). The site is a wooded area, approximately 100 acres in size, that is somewhat overgrown. The site is hilly and is unpaved with site drainage toward Cogdels Creek. Dirt roads are interspersed throughout, which lead to the suspected disposal areas. The roads are periodically utilized for military vehicle maneuvers. Several areas indicating past disposal activities are evident throughout the site (i.e., surficial deposits of fly ash and mounding). Site 24 is not currently used for the disposal of wastes.



NOTE:
- AREAS OUTLINED ARE AREAS OF CONCERN IDENTIFIED BY THE USEPA EPIC STUDY.
- WELLS 24GW05 AND 24GW07 NO LONGER EXIST. WELL 24GW07 WAS LATER INSTALLED AT A DIFFERENT LOCATION.

Baker
Baker Environmental, Inc.

LEGEND

24GW01 EXISTING SHALLOW MONITORING WELL INSTALLED BY ESE, 1984-1986

HP-630 WATER SUPPLY WELL (INACTIVE)

SOURCE: LANTDIV, FEB. 1992

FIGURE 1-4
SITE MAP
SITE 24: INDUSTRIAL FLY ASH DUMP
REMEDIAL INVESTIGATION CTO-0177

MARINE CORPS BASE, CAMP LEJEUNE
NORTH CAROLINA

1.2.1.3 Site 78 - HPIA

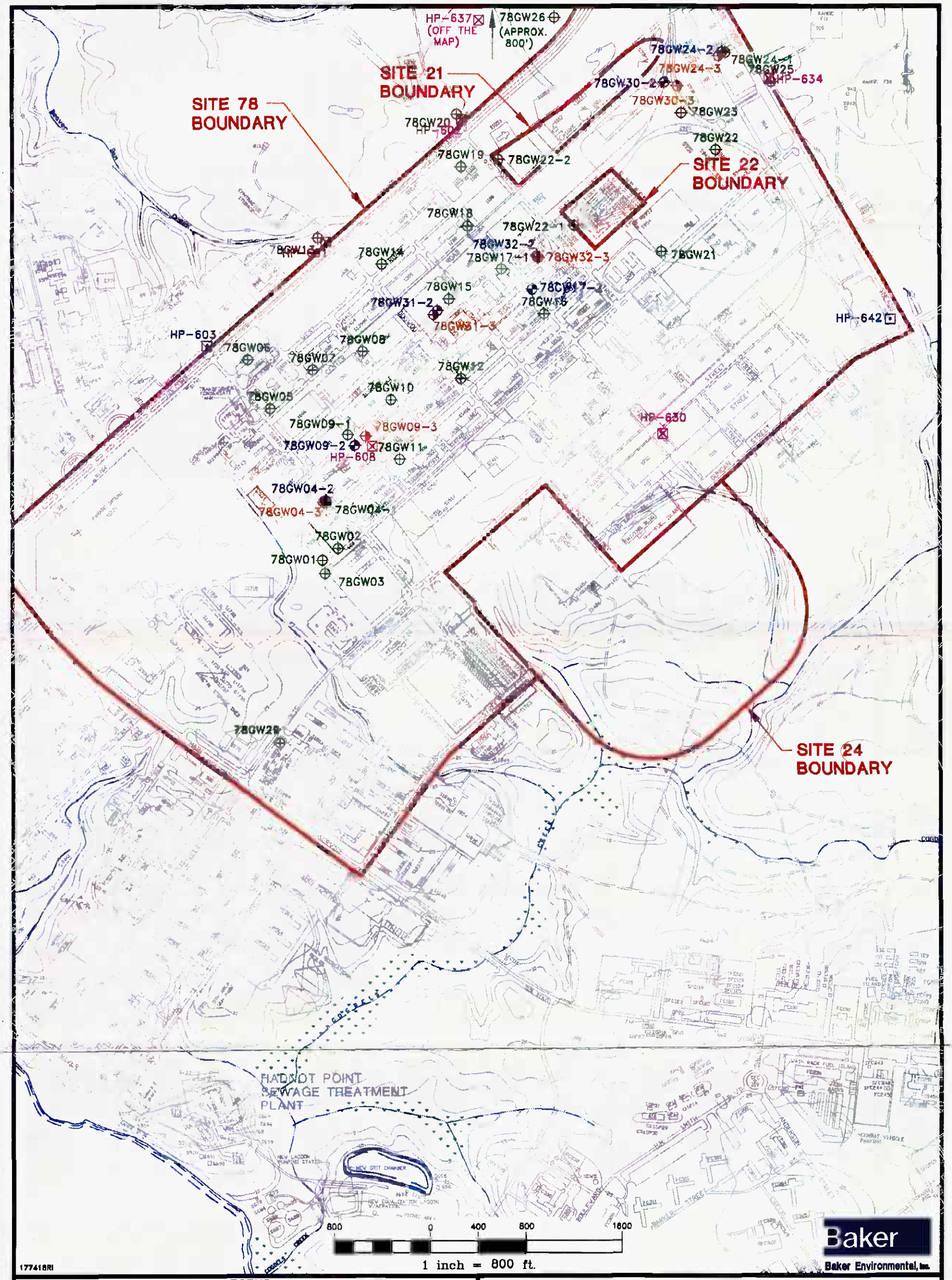
Site 78 is located adjacent to the northwest portion of Site 24 and houses the industrial area of MCB Camp Lejeune. This area is comprised of maintenance shops, warehouses, painting shops, printing shops, auto body shops, and other similar industrial facilities. In general, Site 78 is defined as the area bounded by Holcomb Boulevard to the west, Sneads Ferry Road to the north, Duncan Street to the east, and Main Service Road to the south. Figure 1-5 presents a plan view of Site 78 and the approximate site boundary. Note that the site boundaries for Sites 21 and 24 are also shown on this figure. In addition, the location of the Hadnot Point Fuel Farm (Site 22) is shown on Figure 1-5. Additional information related to Site 22, which is under the Underground Storage Tank (UST) Program, is presented in Section 1.3.3 of this RI. Site 78 covers approximately 590 acres. The majority of the site area is paved (e.g., roadways, parking lots, loading dock areas, and storage lots), however, there are many lawn areas associated with individual buildings within the site and along lengthy stretches of roadways. In addition, there are several acres of woodlands in the southern portion of the site.

The land within Site 78 is relatively flat with surface elevations ranging between 22 to 32 feet above mean sea level (msl). Natural drainage has been altered by the installation of drainage ditches, storm sewers, buildings, and extensive paving. Surface runoff not intercepted by a manmade structure from southern portions of the site appears to drain into Cogdels Creek. Surface runoff from some areas in the northwestern portions of the site appears to drain into Beaver Dam Creek.

Eight potable water supply wells are located in the vicinity of Site 78. The depths of these wells range from 160 feet to 225 feet, and their screen intervals range from 45 feet to 225 feet. All of the wells utilize the Castle Hayne aquifer which serves as the principal water supply aquifer for MCB, Camp Lejeune (Harned, et al., 1989). According to Base personnel, six of the wells are no longer in service. Additional information regarding these supply wells is presented in Section 3.9 of this RI Report.

1.2.2 Site History

The following paragraphs describe the documented history with respect to waste storage and disposal activities of OU No. 1.



LEGEND

- 78GW02 — EXISTING SHALLOW MONITORING WELL INSTALLED BY ESE, 1984–1991
- 78GW04-2 — EXISTING INTERMEDIATE MONITORING WELL INSTALLED BT ESE, 1991
- 78GW04-3 — EXISTING DEEP MONITORING WELL INSTALLED BY ESE, 1991
- HP-603 — WATER SUPPLY WELL (ACTIVE)
- HP-601 — WATER SUPPLY WELL (INACTIVE)

SOURCE: LANTDIV, FEBRUARY 1992

FIGURE 1-5
SITE MAP
SITE 78: HPIA
REMEDIAL INVESTIGATION CTO-0177

MARINE CORPS BASE, CAMP LEJEUNE
NORTH CAROLINA

0177V05Y

1.2.2.1 Site 21 - Transformer Storage Lot 140

Site 21 (Lot 140) has had a history of pesticide usage/storage and transformer oil disposal. Portions of the site were used for pesticide mixing and as a cleaning area for pesticide application equipment from 1958 to 1977. This area was reported to be located in the southeast corner of the lot (the exact location is not documented). Chemicals reportedly stored at this site included diazinon, chlordane dust, lindane, DDT dust, malathion (46% solution), mirex, 2,4-D, silvex, dalapon, and dursban. Small spills, discharge of washout fluids, and indiscriminate disposal are believed to have occurred in this area. In 1977, before these mixing/cleaning activities were moved to a different location, overland discharge of washout fluids was estimated to be approximately 350 gallons per week. It is not clear for how long this discharge of washout fluids occurred (ESE, 1990).

Aerial photographs from 1944, 1964, and 1984 revealed several areas which appear as ground stains possibly from the pesticide mixing. The approximate locations of these stained areas are shown on Figure 1-3 and on the aerial photographs provided in Appendix A. The stains identified on the aerial photographs appear as long narrow dark patches which are adjacent to the suspected pesticide mixing area. The aerial photographs were reviewed as part of the USEPA EPIC Study (Section 1.3.1.2).

A former PCB transformer oil disposal pit was reportedly located in the northeastern portion of the site. The pit was reportedly used as a disposal area for transformer oil during a one year period between 1950 and 1951. The pit reportedly measured 25 to 30 feet long by 6 feet wide by 8 feet deep. Sand was occasionally placed in the pit when oil was found standing in the bottom of the pit. The total quantity of oil disposed in this pit is unknown (ESE, 1990).

Review of the aerial photographs from 1952 through 1960 revealed an area of visibly stained soil south of the former disposal pit. This area is identified (in blue) on Figure 1-3 and is also shown on the aerial photographs in Appendix A. It is unknown whether this stained area is related to the disposal activities. In addition, approximately 60 objects suspected of being transformers were identified south of the stained area in the 1952 photograph.

1.2.2.2 Site 24 - Industrial Fly Ash Dump

Site 24 was used for the disposal of fly ash, cinders, solvents, used paint stripping compounds, sewage sludge, and/or water treatment spiractor sludge from the late 1940s to 1980

(ESE, 1990). Spiractor sludge from the wastewater treatment plant and sewage sludge from the sewage treatment plant were reportedly disposed at this site since the late 1940s. Construction rubble was reportedly disposed at the site in the 1960s. During 1972 to 1979, fly ash and cinders were dumped on the ground surface, and solvents used to clean out boilers were poured onto these piles. Furniture stripping wastes were also reported to be disposed of at this area (ESE, 1990).

Previous reports have identified four separate disposal areas within the site: a spiractor sludge disposal area, a fly ash disposal area, and two borrow and debris areas (Figure 1-4). A recent geophysical survey investigation conducted at the site, confirmed the general location of three of these disposal areas in addition to locating two buried metal areas. One of the borrow and debris areas could not be identified. Based on a review of the USEPA EPIC Study (USEPA, 1992a) aerial photographs of the site, the second borrow and debris area may have only been a mound of material that was present at the site during 1943-1944. No other activities were noted in this area, so it is probable that this area might not have been a disposal area.

Review of several aerial photographs (1943, 1964, and 1984) seemed to correlate with the geophysical investigation. Several mounded material areas were identified on the photographs near the northeastern and western portions of the site. The 1964 aerial photographs revealed two large disturbed areas near the central portion of the site which appear to be disposal areas. Appendix A contains several of the aerial photographs which depict the areas of concern discussed above.

1.2.2.3 Site 78 - HPIA

The HPIA, constructed in the late 1930s, was the first developed area at MCB Camp Lejeune. It was comprised of approximately 75 buildings and facilities including: maintenance shops, gas stations, administrative offices, commissaries, snack bars, warehouses, and storage yards. Table 1-1 provides a summary of some of the buildings within Site 78, their usage, and activities which may have contributed to potential contamination. The information presented on this table is from a previous records search conducted in 1988 (refer to Section 1.3.3.1 of this RI). The locations of the buildings/facilities listed on Table 1-1 are identified on Figure 1-6 as potential or known areas of concern.

There is presently no known uncontrolled disposal of wastes related to the various industrial activities at the site. Due to the industrial nature of the site, many spills and leaks have

TABLE 1-1

POTENTIAL AREAS OF CONCERN WITHIN SITE 78 IDENTIFIED
DURING A 1988 RECORD SEARCH
REMEDIAL INVESTIGATION CTO-0177
MCB, CAMP LEJEUNE, NORTH CAROLINA

Building No.	Building Type	Comments and Concerns
901	Tank Rebuild Facility	History of degreaser; organic solvent usage; POL area
902	Engineering Shop and Armory	Sump and POL area; armory uses organics for weapon cleaning.
903	Warehouse	Identified UST
907	Warehouse	Potential active UST (hydraulic oil)
908	Paint Storage	Storage of large amounts of paint and painting chemicals
909	Equipment Shop	Wastes, solvents, oils; stressed vegetation; degreasers used
910	Welding Shop	Abandoned wash rack
913	Vehicle Maintenance	Battery acid, contaminated soil in bags stored on pallets; used oil drums
915	Warehouse	Solvent drain from wash line; stressed vegetation
916	Warehouse	Drum storage outside of building (kerosene, oil, gasoline)
926	Admin/Warehouse	Past - Kerosene tank leaked; contaminated soil removed
927	Admin/Warehouse	Past - Kerosene tank leaked; contaminated soil removed
928	Auto Maintenance/ Warehouse	Past - Kerosene tank leaked; contaminated soil removed
1011	Warehouse	No chemicals used or stored; oil tank with soil contamination
1012	Warehouse	Leaking kerosene tank; soil contamination
1014	Paint Locker	Paint supply area; solvent storage
1100	Printing Shop	Former service station
1101	Warehouse/Data Processing Office	Solvent usage and outside storage
1103	Paint Storage Facility	Old grease rack; adjacent waste area; solvents
1104	Telephone Shop	Past use of wash pad without oil/water separator
1105	Equipment Storage and Office	Vehicle washing area; sump; oil/water separator
1106	Wood Shop	Potential Active UST (used oil); aerial photography study indicates this as a potential area of concern
1114	Warehouse	Solvent usage; used oil; tanks for used oil, kerosene, diesel fuel, gasoline

Source: ESE, 1988

TABLE 1-1 (Continued)

POTENTIAL AREAS OF CONCERN WITHIN SITE 78 IDENTIFIED
DURING A 1988 RECORD SEARCH
REMEDIAL INVESTIGATION CTO-0177
MCB, CAMP LEJEUNE, NORTH CAROLINA

Building No.	Building Type	Comments and Concerns
1116	AC/S Logistics	Engineers area stores caustics and other organic detergents
1117	Warehouse/Armory	Armory; solvent usage
1202	Maintenance Building	TCE and other solvent usage; suspected waste UST
1203	Maintenance	Vehicle washing; fuel oil tank; anti-freeze spill
1204	Base Telephone Storehouse	Past use of wash pad
1205	Vehicle Service	potential inactive UST (used oil); solvent usage; waste oil; aerial photography study indicates this as a potential area of concern
1206	Vehicle Service	Service area; solvent usage; waste oil; aerial photography study indicates this as a potential area of concern
1300	Cold/Frozen Storage	Refrigeration maintenance shop; solvent storage/usage
1308	Not Specified	Partially buried kerosene storage tank
1310	Auto Maint./Equip. Storage	potential inactive USTs; visible oil in ditch; aerial photography study indicates this as a potential area of concern
1406	Not Specified	Wash/grease rack used since 1942
1407	MT Offices/Whse.	Past spills in wash pit; aerial photography study indicates this as a potential area of concern
1408	Whse./Equip. Storage	Past spills in wash pit; aerial photography study indicates this as a potential area of concern
1450	Vehicle Service	Potential active UST (diesel, used oil); solvent usage; POL areas
1502	Base Maint. Motor Repair	Potential inactive USTs (No. 2 fuel/gasoline/ used oil/diesel); solvents/oils use
1505	Auto Shop	Potential inactive USTs; aerial photography study indicates this as a potential area of concern
1601	Maintenance	Potential inactive UST (used oil); use of chemicals highly suspected
1602 and 1603	Former Maintenance Buildings	Former motor wash and service area
1604	Auto Shop	Potential inactive USTs; aerial photography study indicates this as a potential area of concern
1607	Body Shop	Solvent usage

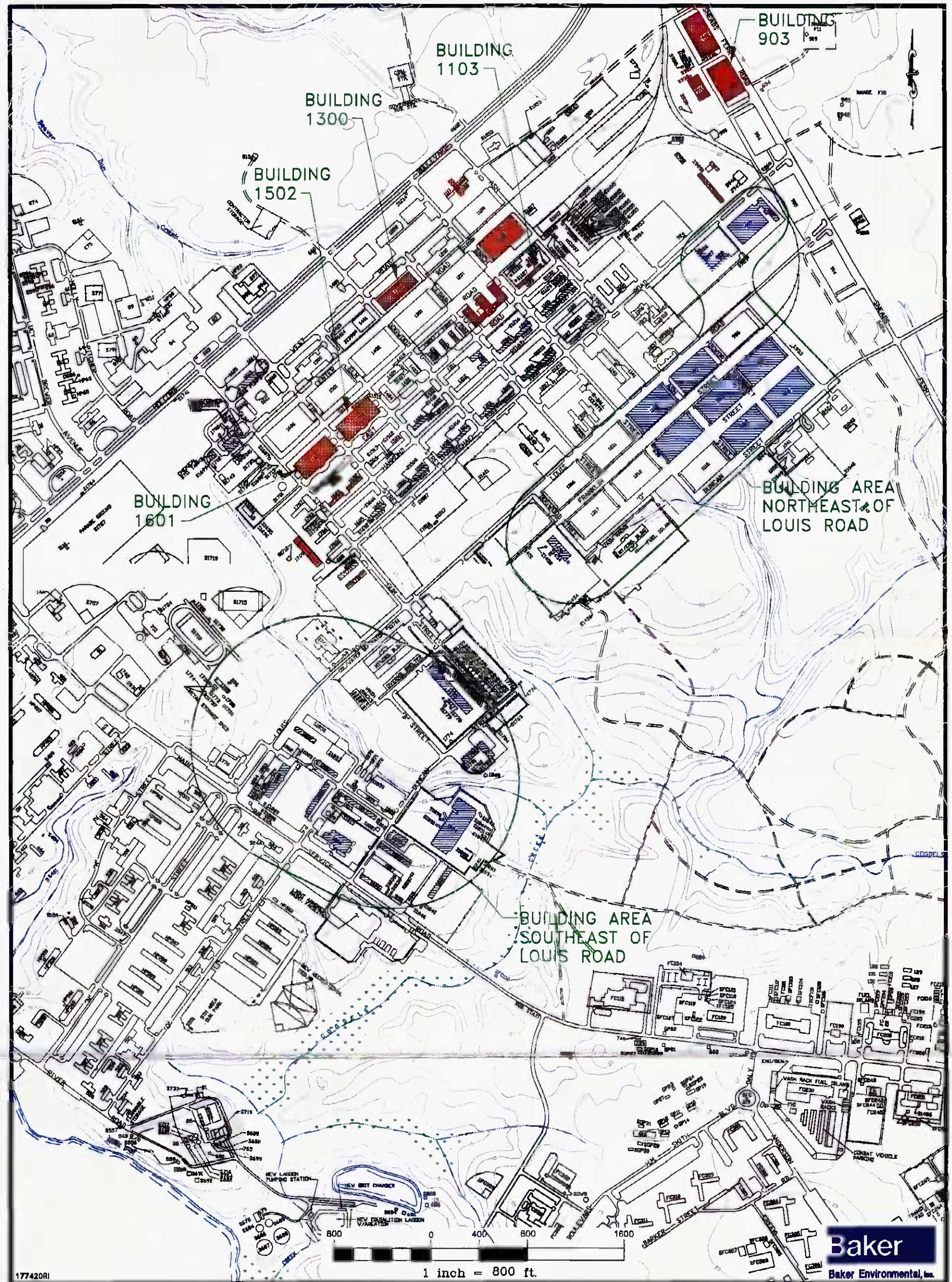
Source: ESE, 1988

TABLE 1-1 (Continued)

POTENTIAL AREAS OF CONCERN WITHIN SITE 78 IDENTIFIED
DURING A 1988 RECORD SEARCH
REMEDIAL INVESTIGATION CTO-0177
MCB, CAMP LEJEUNE, NORTH CAROLINA

Building No.	Building Type	Comments and Concerns
1700	Steam Generator/Machine Repair Shop	Solvent and waste solvent usage and storage (waste tank)
1709	Not Specified	POL areas
1710 and 1711	Vehicle and Armory Maintenance	Solvent usage; wash area; POL area
1750	Heavy Equipment Maint.	Potential inactive UST (used oil); past and present solvent usage
1755	Heavy Equipment Maint.	Potential inactive UST (used oil); past and present use of solvents
1765	Maintenance	Potential active UST (No. 2 fuel oil)
1775	Heavy Equipment Maint.	Potential active USTs (gasoline/used oil/diesel); past/present solvent usage
1780	Heavy Equipment Maint.	Potential active USTs (used oil); past/present solvent usage; waste area
1804	Storage/Maintenance	Potential active USTs (used oil); past vehicle repair; solvent usage now minimal
1808	Storage Building	Past vehicle repair - solvent use; present - no signs of chemical usage
1810	Admin Office	Former vehicle maint. shop - past solvent use likely
1812	Not Identified	Potential inactive UST (No. 2 fuel oil)
1815	Auto Shop	Empty building; potential inactive UST (diesel fuel)
1817	Auto Shop	Previous washing area; contaminated soils
1826	Auto Shop	Old grease rack with drain to ditch; waste oil tank at grease rack
1828	Auto Shop	Waste oil tank contaminated surrounding soils
1841	Heavy Equipment Maint.	Potential inactive USTs (gasoline/used oil/diesel); wide use of solvents
1854	Multipurpose Facility	Potential active USTs (used oil, diesel); past and present solvent usage
1855	Armory	Solvent usage; little waste
1860	Maintenance	Potential active UST (used oil); solvent usage in garage and shop areas
1880	Heavy Equipment Maint.	Potential active USTs (used oil/diesel); large amounts of chemicals used.

Source: ESE, 1988



LEGEND

POTENTIAL AREAS OF CONCERN

AREAS OF CONCERN PREVIOUSLY INVESTIGATED

SOURCE: LANTDIV, FEBRUARY 1992

FIGURE 1-6
POTENTIAL OR KNOWN AREAS OF CONCERN
WITHIN SITE 78
REMEDIAL INVESTIGATION CTO-0177

MARINE CORPS BASE, CAMP LEJEUNE
NORTH CAROLINA

occurred over the years. Most of these spills and leaks have consisted of petroleum-related products and solvents from USTs, drums, and uncontained waste storage areas.

1.3 Previous Investigations

In response to the passage of the CERCLA Act of 1980, 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 IRP, which adopted the USEPA Superfund procedures.

An IAS was conducted at MCB Camp Lejeune by Water and Air Research, Inc. (WAR) in 1983. The IAS identified a number of sites at MCB Camp Lejeune as potential sources of contamination, including the three sites discussed in this RI. The IAS included a review of historical records and aerial photographs, as well as field inspections and personnel interviews to evaluate potential hazards at various sites at MCB Camp Lejeune. The IAS recommended performing further investigations at Sites 21 and 24 to assess potential long-term impacts. Site 78 was later added to the list of sites to be further evaluated. The remainder of this section discusses the previous investigations that were conducted at each of the three sites based on the results of the IAS.

1.3.1 Site 21 Previous Investigations

Previous investigations conducted solely for Site 21 consisted of a Confirmation Study and an Aerial Photographic Study. Both of these are discussed below.

1.3.1.1 Confirmation Study

As a result of the IAS, Environmental Science and Engineering, Inc. (ESE) was contracted by the DON to investigate Site 21. ESE conducted a two part Confirmation Study, which focused on the potential source areas identified in the IAS (WAR, 1983). The Confirmation Study included a Verification Step and a Characterization Step. The findings from the Confirmation Study as they pertain to Site 21 are described below.

Soil Sample Results

In August 1984, ten soil borings were hand augered at this site. Four of the borings were located inside the fenced area and six borings were located outside the fenced area. The exact location of these borings was not documented. Six samples were collected from the four borings located inside the fence and analyzed for organochlorine pesticides and herbicides, and polychlorinated biphenyls (PCBs). Detectable amounts of 4,4'-DDD [0.0006 to 0.0074 microgram per gram (µg/g)], 4,4'-DDE (0.0031 to 0.074 µg/g), and 4,4'-DDT (0.0057 to 0.087 µg/g) were found in all the samples collected from the borings at both sampled depths (from the surface and between 1 to 2 feet). PCBs were not detected in any of the samples. Table 1-2 presents a summary of the range of concentrations detected during the August 1984 sampling event.

Six additional soil samples were collected in 1984 from six borings located outside the fence area. The exact location of these borings was not documented. These samples were collected at the surface and at the 1 to 2 foot range. These samples were analyzed for organochlorine pesticides and herbicides. Three pesticides, 4,4'-DDD (0.0036 to 0.023 µg/g) , 4,4'-DDE (0.0079 to 0.22 µg/g), and 4,4'-DDT (0.014 to 2.1 µg/g) were detected in all of the soil samples collected (ESE,1990). The results are summarized on Table 1-2.

In November 1986, eight additional soil borings were augered outside the fenced area in order to further delineate the extent of apparent soil contamination. The exact locations of these borings were also not documented. Based on site sketches, these borings appear to be located immediately adjacent to the fence, four borings along each length. Soil samples were collected from four depths at each of the borings. Thirty-two soil samples were analyzed for organochlorine pesticides and herbicides, PCBs, and tetrachlorodioxin. The most prevalent detected compounds were 2,4-D, 4,4'-DDD, 4,4'-DDE, and 4,4'-DDT. Thirty out of the 32 samples contained the herbicide 2,4-D. Pesticide, 4,4'-DDD, was detected in the soils down to a depth of five feet. Moreover, pesticides 4,4'-DDE and 4,4'-DDT were detected down to a depth of 3 to 5 feet. PCBs (maximum concentration of 17.1 µg/g) were detected in two soil samples located on the northeast corner of the fenced area (near the suspected pit area). A high concentration of chlordane (76.7 µg/g) was detected along the northwest portion of the site. (ESE, 1990). Table 1-2 presents a summary of this data.

TABLE 1-2

SUMMARY OF DETECTED COMPOUNDS IN
CONFIRMATION STUDY SOIL SAMPLES
SITE 21: TRANSFORMER STORAGE LOT 140
REMEDIAL INVESTIGATION CTO-0177
MCB, CAMP LEJEUNE, NORTH CAROLINA

Detected Compounds	Range of Concentrations (µg/g)		
	Inside of Fence Samples August 1984(1)	Outside of Fence Samples August 1984(1)	Outside of Fence Samples November 1986(3)
Aldrin	ND(2) to 0.0011	ND	ND
4,4'-DDD	ND to 0.0074	ND to 0.023	ND to 0.282
4,4'-DDE	ND to 0.074	0.0079 to 0.22	ND to 1.98
4,4'-DDT	ND to 0.087	0.0140 to 2.1	ND to 5.08
Heptachlor	ND	ND to 0.0027	ND
BHC, D	ND	ND	ND to 0.0297
Chlordane	ND	ND	ND to 76.7
PCBs, total	ND	ND	ND to 17.1
2,4-D	ND	ND	ND to 0.685

(1) August 1984 samples analyzed for organochloride pesticides/herbicides and PCBs.
(2) ND = Not detected above method detection limits.
(3) November 1986 samples analyzed for organochlorine pesticides/herbicides, PCBs, and tetrachlorodioxin.

Groundwater Sample Results

During the Confirmation Study, one shallow monitoring well (21GW01) was installed at Site 21 (approximately 50 feet west of the former oil pit) as shown on Figure 1-3. Specific well construction details for this well are unknown; however the well depth was measured at 25.3 feet during the Baker Environmental, Inc. (Baker) RI. A groundwater sample was collected in July 1984 and analyzed for organochlorine pesticides, organochloride herbicides, and PCBs. No compounds were identified in this sample. The well was sampled again in November 1986 and analyzed for organochloride pesticides, organochloride herbicides, PCBs, volatile organic compounds (VOCs), tetrachlorodioxin, total xylenes, methylethyl ketone (MEK), methyl isobutyl ketone, ethylene dibromide, and oil and grease. Only two parameters, 2,4-D (an organochlorine herbicide) and oil and grease, were detected in the 1986 data at a concentration of 1.17 micrograms per liter (µg/l) and 400 µg/l, respectively (ESE,1990).

1.3.1.2 Aerial Photographic Study Conducted by EPIC

Per the DON's and USEPA Region IV's requests, EPIC conducted an aerial photographic study for Site 21 (the study covered the area of Site 78 which includes Site 21) in 1992. The study covered the period between 1938 and 1990. As depicted on Figure 1-3, piled probable refuse was evident (on the 1944 aerial photograph) along the railroad tracks in the southern portion of the site. Approximately 60 cylindrical objects (possibly transformers) were visible in the north-central portion of the site (1952 finding). A probable stain area north of these objects appeared to be a leaking hose line. This stain continued to be visible in the 1956 and 1960 aerials. Two large stains near the suspected former pesticide mixing area were identified on the 1964 aerial. Two additional probable stain areas were visible in the central portion of the site in the 1984 aerial photograph. Copies of the Site 21 aerial photographs provided by EPIC are presented in Appendix A.

In general, the aerial photographic study corresponded with the previously known information (i.e., the suspected location of the former pesticide mixing). The EPIC Study did not identify the presence of the former transformer oil pit area. It is possible that no aerial photographs were taken during the one year the pit was documented to be used.

1.3.2 Site 24 Previous Investigations

Previous investigations conducted for Site 24 included a Confirmation Study, an Aerial Photographic Study, and a Pre-Investigation Study. These studies are discussed below.

1.3.2.1 Confirmation Study

The findings from the Confirmation Study performed by ESE as they pertain to Site 24 are described below.

Groundwater Sample Results

Five shallow monitoring wells (24GW01 through 24GW05) were installed and sampled in July 1984 to determine the presence or absence of contaminants in the groundwater. The location of these wells is shown on Figure 1-4. Specific well construction details for these wells are not available; however the wells were reported to have been installed at a depth of 25 feet with a 20-foot screen length (from 5 to 25 feet). Two of the wells (24GW01 and 24GW02) were installed on the downgradient side of the Borrow and Debris Disposal Area, two wells (24GW03 and 24GW04) were installed on the downgradient side of the Fly Ash Disposal Area, and one well (24GW05) was installed upgradient of the site. One round of samples was collected from each of the five wells and analyzed for VOCs and the following metals (total): arsenic, chromium, copper, lead, nickel, selenium, and zinc (ESE, 1990).

A summary of the 1984 analytical results is presented in Table 1-3. Chromium, copper, and zinc were detected in both samples collected downgradient of the Borrow and Debris Disposal Areas. Each well contained low levels of either benzene, chloroform, or methylene chloride. The chemical data suggested that, at a minimum, low level contamination at the suspected disposal areas was present (ESE, 1990).

In 1986, two additional shallow monitoring wells (24GW06 and 24GW07) were installed (reported to be 25 feet in depth with 20-foot screen lengths) downgradient of the fill areas as depicted on Figure 1-4. All seven of the monitoring wells (24GW01 through 24GW07) were resampled in December 1986 and analyzed for VOCs and the following metals: arsenic, chromium, hexavalent chromium, copper, lead, nickel, selenium, and zinc. For the most part, the results were consistent with the earlier sampling results (ESE,1990).

TABLE 1-3

SUMMARY OF DETECTED COMPOUNDS FROM THE CONFIRMATION STUDY
SITE 24: INDUSTRIAL FLY ASH DUMP
REMEDIAL INVESTIGATION CTO-0177
MCB CAMP LEJEUNE, NORTH CAROLINA

Detected Compounds	Applicable Groundwater Criteria		Range of Groundwater Concentrations (µg/L)							Applicable Surface Water Criteria	Range of Surface Water Concentrations (µg/L)				Range of Sediment Concentrations (mg/kg)			
	Federal MCL (µg/l)	NC WQS (µg/l)	24-(1,2) GW01	24-(1,2) GW02	24-(1,2) GW03	24-(1,2) GW04	24-(1,2) GW05	24-(2,3) GW06	24-(2,3) GW07	NC Standards for Freshwater (µg/l)	24-(1,2) SW01	24-(1,2) SW02	24-(2) SW03	24-(2) SW04	24-(1,2) SE01	24-(1,2) SE02	24-(2) SE03	24-(2) SE04
Benzene	5	1	ND(5)	ND	ND	ND	ND-3	ND	ND	--	ND	ND	ND	ND	NA(6)	NA	NA	NA
Chloroform	--(4)	0.19	ND-1	ND	ND	ND	ND	ND	ND	--	ND	ND	ND	ND	NA	NA	NA	NA
Methylene Chloride	5	5	ND	ND-2	ND	ND	ND	ND	ND	--	ND	ND	ND	ND	NA	NA	NA	NA
Trans-1,2-Dichloroethene	100	70	ND	ND	ND	ND	ND	ND	ND	--	ND-2.7	ND	ND	ND	NA	NA	NA	NA
TCE	5	2.8	ND	ND	ND	ND	ND	ND	ND	--	ND-7.1	ND	ND	ND	NA	NA	NA	NA
Arsenic	50	50	ND	ND-3	7.1-9.3	16-47.3	5.6-9.3	ND-5.3	7.5	50	ND	ND	ND	4	ND-1.2	ND-0.3	0.968	5.15
Cadmium	5	5	ND	ND	ND	ND	ND	ND	ND	2	ND	ND	ND	ND	ND-0.3	ND-1.9	ND	2.16
Chromium	100	50	ND-6.6	ND-24	98-130	ND-37	ND	ND-14	52-62	50	ND	ND-9.7	ND	ND	1.6-5.68	3.87-29.3	3.36	33.8
Chromium (+6)	--	--	ND	ND	ND	ND	14.2	ND	ND	--	ND	20.6	ND	ND	ND	ND	ND	ND
Copper	1300	1000	ND-4	ND-8.6	16-17.4	3-7	ND-3	ND	ND-3	7	4.5-5.4	ND-2.8	ND	ND	1-4.19	2-7	2.94	21.6
Lead	15	15	ND	ND	ND-58	ND	ND	ND	ND	25	ND	ND	27.4	ND	4-13.2	12.14-180	10.1	162
Nickel	100	100	ND	ND	61-66	ND	ND	ND	ND	88	ND	ND	ND	ND	ND-0.3	ND-1	ND	ND
Selenium	50	50	ND	ND	5.2-7.6	ND-2.2	ND	ND	ND	5	ND	ND	ND	ND	ND	ND	ND	ND
Zinc	5000	2100	ND-26	ND-87	341-502	ND-8	ND	20-62	69-80	50	11.7-28	ND-20	14.8	6.8	6-13.1	14.7-95	19.5	155

(1) 1984 samples
(2) 1986 samples
(3) 1987 samples
(4) -- = Not Established
(5) ND = Not detected above method detection limits.
(6) NA = Not Analyzed

In March 1987, wells 24GW06 and 24GW07 were resampled. The results from well 24GW06 indicated concentrations of arsenic (5.3 µg/l), chromium (14 µg/l), and zinc (62 µg/l)). Well 24GW07 exhibited concentrations of arsenic (7.5 µg/l), chromium (52 µg/l), copper (3 µg/l), and zinc (69 µg/l) (ESE, 1990).

Overall, several different metals were detected in the groundwater samples collected at Site 24 over the 1984, 1986, and 1987 sampling episodes. As shown on Table 1-3, applicable groundwater standards, [namely the Federal Maximum Contaminant Levels (MCLs)/Federal Action Limit (lead) and the North Carolina Water Quality Standards (NCWQS)] were only exceeded at two sample locations, 24GW03 and 24GW07 for chromium (non-hexavalent) and/or lead. These samples were collected in a well downgradient of the Fly Ash Disposal Area and in a well south of the disposal areas (ESE, 1990).

Surface Water and Sediment

In 1984, two surface water and sediment samples were collected in Cogdels Creek downstream of the disposal areas. The exact locations of these samples were not documented. The samples were analyzed for VOCs and the following metals: arsenic, chromium, copper, lead, nickel, selenium, and zinc. A summary of the analytical results are presented in Table 1-3.

The surface water sample (24SW01) collected immediately downgradient of the disposal locations contained trichloroethene (TCE), trans-1,2-dichloroethene (T-1,2-DCE), copper, and zinc. The surface water sample collected from the downstream location (24SW02) also contained copper and zinc (ESE, 1990).

In December 1986, the two sampling stations were resampled and two additional stations were established (24SW03 and 24SW04). The samples were analyzed for the same compounds as in the 1984 sampling round with the addition of hexavalent chromium. These samples contained the same metals at concentrations similar to the 1984 samples. TCE and T-1,2-DCE were not detected in the 1986 sample. The surface water sample collected at the station southwest of the disposal areas contained lead (27.4 µg/l) and zinc (14.8 µg/l) (ESE,1990). As shown on Table 1-3, the North Carolina Standards for Freshwater were only exceeded at one surface water sample location (24SW03) for lead.

Sediment samples were collected from each of the four surface water sampling stations during the same sampling events. The analytical results, as summarized on Table 1-3, indicated that as many as seven metals were detected in the samples. The lowest concentrations of metals

were identified in the sample collected from the station immediately downgradient of the disposal areas. The sample collected from the tributary to Cogdels Creek contained the highest concentrations of metals (ESE,1990).

1.3.2.2 Aerial Photographic Investigation Conducted by EPIC

In 1992, EPIC conducted an aerial photographic study for Site 24. The study covered the period between 1938 and 1990. Significant findings from this study have been summarized below. Copies of the Site 24 aerial photographs are provided in Appendix A.

As shown on Figure 1-4, a large area of mounded material (no other description included) was noted within and adjacent to the northwestern boundary of the site. This material was first visible in 1943. It was not visible on the 1949 aerial or any other aerials. It is possible that this material was soil excavated during the various construction activities which took place in the 1940s.

By 1956, activity was visible in two areas in the central portion of the site. The one area (identified as Borrow and Debris Disposal Area), was excavated and a row of stacked objects was visible near the east edge of the area. The stacked objects remained through 1964. The other area (Fly Ash Disposal Area) appeared to be a disposal area containing multi-toned probable refuse and piles of medium-toned and dark-toned material.

By 1960, both of the "disposal" areas contained piles of dark-toned material (possibly fly ash or sewage sludge). Excavated areas including a linear trench are evident within the Borrow and Debris Area. In the Fly Ash Disposal Area, the dark-toned material appeared to have been dumped and spread out in a fairly uniform depth. Rows of stacked objects were visible north of the dark-toned material.

The 1964 aerial photograph shows evidence of increased activity in the Fly Ash Disposal Area. Dark-toned mounded material was visible in a uniform arrangement (such as that created by emptying numerous consecutive dump truck loads). Piled medium-toned material, possible stains, and pools of probable liquid were also evident in this portion of the disposal area. Two piles of light-toned material were visible near the stacked objects. Dark-and medium-toned material was visible in the Borrow and Debris Disposal Area.

In 1970, the Fly Ash Disposal Area looked as if it had been covered and the area appeared to be revegetated. Vegetation was also visible throughout the Borrow and Debris Disposal Area. A mound of light-toned material (possibly the Spiractor Sludge Disposal Area) was identified north of the Fly Ash Disposal Area in 1984.

By 1988, building construction activities were evident in the northeast corner of the site. By 1990, a building and paved area were visible in this location. Various surface water impoundments were noted throughout the study area from 1984 through 1990.

1.3.2.3 Pre-Investigation Study for the RI/FS

In June 1992, a geophysical investigation was conducted by Weston Geophysical Corporation (Weston). The purpose of the investigation at Site 24 was to delineate the boundaries of the four suspected disposal areas. The investigation was conducted by utilizing surface geophysical techniques including electromagnetic (EM) measurements and ground penetrating radar (GPR).

The geophysical survey identified the following:

- The eastern boundary of the Fly Ash Disposal Area which measures approximately 800 feet in length. The western and southern areas could not be identified due to dense vegetation overgrowth.

- The Spiractor Sludge Disposal Area which encompassed approximately 40,000 square feet.

- One Borrow and Debris Disposal Area was identified as part of the geophysical survey.

- Two additional areas containing buried metal were also identified. The first area is approximately 90 by 30 feet and is located south of the Spiractor Sludge Disposal Area and east of the Fly Ash Disposal Area. The second area of buried metal is located north of the Fly Ash Disposal Area. The dimensions of this disposal area are not known.

In July 1992, Baker collected groundwater samples from several of the existing wells. Monitoring wells 24GW01, 24GW02, 24GW03, 24GW04, and 24GW06 were resampled and

analyzed for full Target Compound List (TCL) organics [i.e., PCBs, pesticides, VOCs, and semivolatile organic compounds (SVOCs)] and Target Analyte List (TAL) inorganics (both total and dissolved). Monitoring wells 24GW05 and 24GW07 could not be located and subsequently were not sampled. Analytical results indicated that no VOCs, SVOCs, pesticides, or PCBs were present. Both total and dissolved inorganics detected, in at least one of the wells, included aluminum, arsenic, beryllium, calcium, iron, magnesium, manganese, mercury, nickel, potassium, selenium, sodium, vanadium, and zinc. The Federal MCL and NCWQS for arsenic of 50 µg/l was exceeded in well 24GW04 (total arsenic of 64.5 µg/l). Manganese (total) concentrations in wells 24GW03 (201 µg/l) and 24GW06 (257 µg/l) exceeded the NCWQS of 50 µg/l. In addition, the total lead concentration of 19.2 µg/l detected in well 24GW06 exceeded the Federal Action Limit and NCWQS of 15 µg/l. Analytical data from the July 1992 sampling event are provided in Appendix B.

1.3.3 Site 78 Previous Investigations

Several investigations and studies have been focused on Site 78. The results of the various studies are discussed below.

1.3.3.1 Confirmation Study

As a result of the IAS, ESE was contracted by the DON to investigate Site 78. ESE conducted a two part Confirmation Study which focused on the potential source areas at Site 78. The Confirmation Study included a Verification Step and a Characterization Step. The findings from both of these steps are described below.

Verification Step

The Verification Step of the Confirmation Study for Site 78 was conducted from April 1984 through January 1985. During this study, groundwater quality investigative efforts were conducted at specific study areas within and adjacent to Site 78 (areas identified by the IAS). As part of this investigation, two shallow monitoring wells were installed near the HPIA Fuel Farm (Site 22) to assess whether fuel-derived contamination was present. Site 22 is located north of Ash Street, west of Michael Road, and east of Site 21. (Note that Site 22 is being remediated under the NC State UST Program; therefore, it was not included as part of this RI. The data from Site 22-related monitoring wells will be considered in this RI since the site appears to be connected to OU No. 1.) One shallow well (22GW1 or referred to as 78GW22-1 in

other sections of this RI report) affiliated with Site 78 was installed within the fuel farm area. A second shallow well (22GW2 or referred to as 78GW22-2 later in this RI report) was installed approximately 500 feet northwest of the fuel farm towards Site 21. The results identified the presence of fuel-related VOCs in the monitoring well near the HPIA Fuel Farm and in water supply well HP-602. Supply well HP-602 is a deep well located near the intersection of Holcomb Boulevard and Ash Street, approximately 1,200 feet northwest of the Fuel Farm. Maximum contaminant levels detected in the shallow aquifer included: benzene at 17,000 µg/l and toluene at 27,000 µg/l. Benzene was also detected in supply well HP-602 at a level of 380 µg/l (ESE, 1990).

As a result of the Confirmation Study, Verification Step findings, MCB Camp Lejeune closed supply well HP-602 and initiated a sampling program between December 1984 and November 1986 that included all water supply wells within the vicinity of Site 78. The results of this sampling identified three additional supply wells (HP-601, HP-608, and HP-634) as being contaminated with VOCs. No compounds were detected in the samples from the other nearby supply wells. Table 1-4 presents a summary of the detected compounds found in the supply wells during this sampling program. Maximum contaminant levels in supply wells HP-601, HP-608, and HP-634 included: TCE at 230 µg/l in well HP-601, TCE at 110 µg/l in well HP-608, and TCE at 1300 µg/l in well HP-634. All three of these TCE concentrations exceeded both the Federal MCL and NCWQS for TCE. Other compounds detected in wells HP-601, HP-608 and HP-634 included benzene, T-1,2-DCE, tetrachloroethene (PCE), and methylene chloride. The four supply wells with detected concentrations were immediately shut down by Camp Lejeune utilities staff. Investigations at Site 78 were given the highest priority within the overall Confirmation Study (ESE,1988).

Characterization Step

The Characterization Step (the final field investigative step in the Confirmation Study process) was performed at Site 78 from 1986 through 1988. The investigation was designed to define the extent of the VOC contamination identified in the Verification Step. The Characterization Step consisted of the following tasks: (1) records search including review of available base records and a physical inspection of each building within Site 78; (2) soil gas survey targeted to those areas identified by the records search as being potential contamination sources; (3) installation of 27 shallow (approximately 25 feet deep), three intermediate (approximately 75 feet deep), and three deep monitoring wells (approximately 155 feet deep); (4) sampling of all Site 78 monitoring wells and nearby water supply wells; and

TABLE 1-4

SUMMARY OF DETECTED ORGANIC COMPOUNDS IN CONFIRMATION STUDY SUPPLY WELL SAMPLES
SITE 78: HPIA
REMEDIAL INVESTIGATION CTO-0177
MCB, CAMP LEJEUNE, NORTH CAROLINA

Detected Compounds	Range of Detected Concentrations (µg/l)				
	Supply Wells				
	601	602	608	634	637
Benzene	ND(1)	50 - 720	3.7 - 4.0	ND	ND
1,2-Dichloroethane	ND	9.2 - 46	ND	ND	ND
Trans-1,2-Dichloroethene	8.8 - 99	7.8 - 630	2.4 - 8.5	2.3 - 700	ND
Ethylbenzene	ND	8	ND	ND	ND
Trichloroethene	26 - 230	2.2 - 1,600	13 - 110	1,300	ND
Tetrachloroethene	4.4 - 5	24	ND	10	ND
Toluene	ND	10 - 54	ND	ND	ND
Trichlorofluoromethane	ND	3	ND	ND	ND
Methylene Chloride	10	ND	14	130	ND
Vinyl Chloride	ND	18	ND	ND	ND

(1) ND = Detected below method detection limit.

(5) aquifer testing to evaluate the hydraulic parameters of the deep aquifer (ESE, 1992). A brief summary of the findings from these tasks follows.

Records Search

A detailed records and physical search within Site 78 was conducted to identify the presence of potential waste solvent disposal activities that could account for the observed VOC contamination in the aquifer. In many cases, the physical facilities of the buildings (i.e., floor drains, sumps, unmarked pipelines, etc.) were inspected. The results of this search, which are presented in the ESE Characterization Step Report, May 1988, identified the presence of several primary potential source areas for waste solvent material within Site 78. These included:

- Buildings 901, 902, 903 - TCE UST, engine degreasing within a large area between Buildings 902 and 903 and along the railroad lines;
- Building 1100 - former service station, solvent usage, drum of 1,1,2,2-PCE reportedly leaked onto the ground;
- Building 1202 - maintenance shop, VOC storage and usage;
- Building 1300 - cold storage facility and maintenance shop, solvent usage;
- Buildings 1502, 1601, 1602 - heavy vehicle maintenance facility, TCE UST, heavy solvent and petroleum, oil, and lubricant storage and usage, ground staining; and
- Buildings 1709, 1710 - combat vehicle maintenance area, paint shop, and general maintenance area, underground waste tanks, bags of soil labeled as "contaminated".

Soil Gas Survey

A soil gas survey was conducted at each potential source area identified in the records search. The soil gas survey was targeted to those areas identified in the record search and utilized to supplement well placement. VOC contamination was detected in the soil gas at the following building areas: Buildings 901, 902, and 903; Building 1100; Building 1202; Building 1300; Buildings 1502, 1601, and 1602; and Buildings 1709 and 1710. A brief description of the soil

gas findings is presented below. The actual results of the soil gas survey are presented in the Characterization Step Report for Site 78 (ESE, 1988).

TCE vapors were detected between Buildings 902 and 903 at a level of 1,497 parts per billion (ppb). A soil gas sample along the railroad line near Building 901 recorded a TCE vapor level of 570 ppb. These findings and the documented history of TCE usage throughout this area strongly suggested that VOC contamination was present in the groundwater (ESE, 1988).

A single value of TCE (152 ppb) was detected to the west of Building 1100 (ESE, 1988).

TCE vapors were detected in several samples collected around the Building 1202 area (mostly along Gibb Road) at values ranging from 15 ppb to 36,700 ppb. The highest vapor concentrations appeared to be between Buildings 1202 and 1201, and across Birch Street, near Building 1102. These areas correspond with use and disposal history of solvents at Building 1202 (ESE, 1988).

A single value of TCE (295 ppb) was detected on the eastern side of Building 1300. Since Building 1300 has a maintenance shop it was included as a separate potential source of contamination (ESE, 1988).

The soil vapors in the area between Building 1601 and 1502 contained high concentrations of TCE. The detected levels were as high as 703,000 ppb (this was the highest soil gas vapor detected during the survey). TCE vapors were detected at most of the sampling locations surrounding Buildings 1601 and 1502 (ESE, 1988).

TCE was identified in the soil vapors in two locations south of Building 1709. These samples were located adjacent to bags of soil marked as contaminated. The detected TCE concentrations in these two samples were 35 ppb and 53,000 ppb. In several of the samples obtained south of Building 1710, an extremely high method detection limit needed to be employed due to dilution of the samples in an attempt to resolve a large unknown peak in the data. It appeared (possibly by visual observation) that a large amount of oil and grease was present in the soil in this vicinity (ESE,1988).

Monitoring Well Installation and Sampling

A total of 34 monitoring wells (27 shallow, 4 intermediate, and 3 deep) were installed during this investigation to enable identification of subsurface geologic units, assess groundwater flow directions, and to evaluate geochemical characteristics of the groundwater at Site 78. The shallow wells included 78GW01 through 78GW26 and 78GW29. The intermediate wells included 78GW04-2, 78GW09-2, 78GW17-2, and 78GW24-2. The deep wells included 78GW04-3, 78GW09-3, and 78GW24-3. Well construction details for these wells (and for other wells installed later at the site) are provided in Table 1-5. The locations of these wells were based on the soil gas survey data and conclusions. The 34 wells plus two shallow monitoring wells previously installed at Site 22 (labeled as 78GW22-1 and 78GW22-2 on Figure 1-5) and five MCB Camp Lejeune water supply wells (HP-601, HP-602, HP-603, HP-608, and HP-634) were sampled and analyzed as part of the Characterization Step (ESE, 1988). Figure 1-5 shows the location of the wells installed during the Characterization Step, the two wells associated with Site 22, the water supply wells, and additional wells installed during a later study of the site.

The shallow wells at Site 78 and the existing monitoring wells at Site 22 were sampled three times: January 1987, March 1987, and May 1987. Analytical results indicated that three primary zones of contamination were present in the shallow aquifer at Site 78, centered in the vicinity of Building 902, Site 22, and Building 1602 (ESE, 1988). Appendix B contains the analytical data from the Characterization Study.

Analysis of shallow groundwater data indicated a need to evaluate deeper aquifer zones. At each of three potential zones of contamination, an intermediate well (approximately 75 feet deep) and a deep well (approximately 150 feet deep) were installed. The potential source areas included: Buildings 901,902, and 903; Building 1202; and Building 1601. The analytical results from one round of sampling of these wells identified VOC contamination only in the deep wells near Buildings 1202 and 1601. Note that MEK was the only VOC detected in these wells. MEK was not detected in any of the shallow groundwater samples (ESE, 1988). The analytical results from the Characterization Study are presented in Appendix B.

Aquifer Testing

A 72-hour pump test was conducted utilizing water supply well HP-642, located in the northeast corner of Site 78. This test was conducted to determine the aquifer coefficients for

TABLE 1-5

SUMMARY OF EXISTING MONITORING WELL CONSTRUCTION DETAILS
SITE 78: HPIA
REMEDIAL INVESTIGATION CTO-0177
MCB, CAMP LEJEUNE, NORTH CAROLINA

Well No.	Well Depth (feet, below ground surface)	Screen Interval Depth (feet, below ground surface)	Well Diameter (inches)
78GW01	25	5 - 25	2
78GW02	20	5 - 20	2
78GW03	25	5 - 25	2
78GW04-1	24.5	4.5 - 24.5	2
78GW04-2	78	65 - 78	4
78GW04-3	153	140 - 153	4
78GW05	25	5 - 25	2
78GW06	25	5 - 25	2
78GW07	25	5 - 25	2
78GW08	25	5 - 25	2
78GW09-1(1)	25	5 - 25	2
78GW09-2	75	55 - 75	2
78GW09-3	150	130 - 150	2
78GW10	25	5 - 25	2
78GW11	25	5 - 25	2
78GW12	25	5 - 25	2
78GW13	25	5 - 25	2
78GW14	25	5 - 25	2
78GW15	25	5 - 25	2
78GW16	25	5 - 25	2
78GW17-1	25	5 - 25	2
78GW17-2	73	53 - 73	2
78GW18	--(2)	--	--
78GW19	25	5 - 25	2
78GW20	25	5 - 25	2
78GW21	25	5 - 25	2
78GW22-1	25	5 - 25	2
78GW23	25	5 - 25	2
78GW24-1	25	5 - 25	2
78GW24-2	76.5	56.5 - 76.1	2
78GW24-3	148	128 - 148	2
78GW25	25	5 - 25	2
78GW26(2)	25	5 - 25	2
78GW29	25	5 - 25	2
78GW30-2	78	65 - 78	4
78GW30-3	153	140 - 153	4
78GW31-2	78	65 - 78	4
78GW31-3	153	140 - 153	4
78GW32-2	77	64 - 77	4
78GW32-3	153	140 - 153	4

Note: (1) Well was not located during the Baker investigation
(2) -- = Information is not available

Source: ESE, 1992

the deeper aquifer zone. The results, which were analyzed by a number of analytical methods, indicated that the aquifer transmissivity ranged from $6.1x10^3$ to $1.3x10^4$ gallons per day per foot (gpd/ft). Storativity ranged from $5x10^{-4}$ to $1x10^{-3}$ (ESE, 1988).

1.3.3.2 Groundwater Study at the Hadnot Point Fuel Farm

O'Brien and Gere Engineers, Inc. conducted a groundwater study at the Hadnot Point Fuel Farm (Site 22) as part of the MCB Camp Lejeune UST Program. Although this study was conducted for Site 22 and not Site 78, the results are applicable to Site 78 given the proximity of the sites (Figure 1-5).

The fuel farm, constructed around 1941, consisted of 14 USTs and one above ground storage tank. These tanks contained either diesel fuel, leaded gasoline, unleaded gasoline, or kerosene. The purpose of this study was to provide follow-up hydrogeologic services to investigate hydrogeology and evaluate the extent of fuel leakage from the USTs and associated transfer lines. The study included the installation of 20 groundwater monitoring wells in the vicinity of the fuel farm, measurement of groundwater elevation and floating product thickness, and sampling and analysis of groundwater for VOCs. The study concluded that fuel losses of gasoline have likely occurred predominantly through leaks in the transfer lines or valves. Laboratory analyses indicate that the floating product has contributed significant levels of dissolved petroleum compounds including benzene, toluene, xylenes, and ethylbenzene (BTEX) into the groundwater. Trace levels of non-petroleum VOCs including TCE and PCE were also detected within the fuel farm.

Following this investigation, O'Brien and Gere conducted a pump test to determine the hydraulic characteristics of the shallow aquifer. Based on these results, O'Brien and Gere designed a product recovery system and contaminated groundwater treatment system for the fuel farm. The system consisted of four recovery wells, a product recovery tank, an oil/water separator, an air stripper, and activated carbon canisters. The entire system began operation in the latter part of 1991. It is important to note that the recovery/treatment system implemented at the fuel farm is addressing a different yet complimentary phase of the groundwater problem at Site 78 (i.e., this system is addressing the recovery of free phase product). Since the fuel farm area is a UST problem, it is not included as part of the CERCLA RI/FS process, but is being handled as a separate study under the UST Program.

1.3.3.3 Supplemental Characterization Step

A Supplemental Characterization Step, performed by ESE at Site 78 from 1990 through 1991, was designed to further evaluate the extent of contamination in the deep portion of the aquifer and to characterize the contamination within the shallow soils at suspected source locations. This study consisted of 30 soil borings at three suspected source locations identified above (Buildings 902, 1202, and 1601) for the characterization of shallow soil contamination, installation of three additional intermediate monitoring wells and three additional deep monitoring wells, and the collection of samples from all new and existing Site 78 monitoring wells and several nearby water supply wells (ESE, 1992).

Shallow Soil Sample Results

Thirty shallow soil borings were performed at Site 78 to evaluate the extent of shallow soil contamination in three areas of concern (Buildings 902, 1202, and 1601) as part of the Supplemental Characterization Step. Ninety-six soil samples (including nine duplicates) were collected. Eight of the samples and one duplicate were analyzed for full TCL organics and TAL inorganics. The other 87 samples were analyzed for TCL VOCs, pesticides, and PCBs, and toxicity characteristic leaching procedure (TCLP) metals.

In general, the soil samples from the Building 902 area identified 1,2-dichloroethene (1,2-DCE) (55 µg/kg and 120 µg/kg) and TCE (120 µg/kg) at one boring location; and phenanthrene (500 µg/kg), fluoranthene (690 µg/kg), and pyrene (530 µg/kg) at another boring location.

The soil samples from Building 1202 contained ethylbenzene (62 µg/kg) and xylenes (580 µg/kg) at one boring location at a depth of 8 to 10 feet (near the water table depth). The boring near Building 1103 identified pesticides including dieldrin, 4,4'-DDE, and 4,4'-DDT at concentrations ranging from 38 µg/kg to 140 µg/kg at a depth of 0 to 2 feet. The boring located near Building 1300 identified PCBs (PCB-1260) at concentrations ranging from 290 µg/kg to 1800 µg/kg to a depth of six feet. Low levels of the pesticides heptachlor epoxide (12 µg/kg) and endosulfan II (16 µg/kg) were detected in this boring at a depth ranging from 2 to 4 feet. Note that samples were collected near Buildings 1103 and 1300 due to their proximity to Building 1202.

The soil samples collected from the Building 1601 area did not reveal any quantifiable volatile or semivolatile contamination. Pesticides (dieldrin, 4,4'-DDE, and 4,4'-DDT) were detected at

a depth of 0 to 2 feet at one boring location near Building 1601. The detected concentrations of these pesticides ranged from 40 µg/kg to 92 µg/kg. Various metals with the exception of silver and mercury were detected in the majority of all of the soil samples collected at the three building areas (ESE, 1992).

Groundwater Sample Results

Twenty-six of the 27 existing shallow groundwater monitoring wells were resampled and analyzed for full TCL parameters as part of the Supplemental Characterization Step. One of the monitoring wells (78GW18) could not be located. In general, the analytical results indicated that BTEX were identified at the Building 902 area, near the railroad tracks south of Building 902, near the fuel farm (Site 22), and near Building 1601. Other VOCs such as TCE were identified in the same areas in addition to the areas near Buildings 1301, 1709, and 1100 (ESE, 1992).

The results from the intermediate and deep monitoring wells indicated that BTEX constituents were detected downgradient of the fuel farm. BTEX contaminants were also detected near the railroad tracks south of Building 902, near Building 1301, and in the area between Buildings 1601 and 1709. Supply well HP-602 had detectable levels of BTEX. Other VOCs were detected in the wells near the railroad tracks, and near Buildings 1202 and 1601. Supply wells HP-634 and HP-637 also had detected levels of VOCs. SVOCs [such as polycyclic aromatic hydrocarbons (PAHs)] were detected near the railroad tracks and near Building 1202 (ESE, 1992).

1.3.3.4 Remedial Investigation for the Shallow Soils and Castle Hayne Aquifer at HPIA

ESE conducted an RI in 1991 to investigate shallow soils and the upper portion of the Castle Hayne aquifer at Site 78. The purpose of this investigation was to delineate the horizontal and vertical extent of contamination within the shallow and deeper water-bearing zones. In addition, soil contamination within the shallow soils at suspected source locations was characterized as to its nature and extent. This RI report used the data from the previous ESE investigations: Confirmation Study (Verification Step and Characterization Step) and the Supplemental Characterization Step (ESE, 1992).

The RI report concluded that while TCE and other VOCs were the primary concern during the soil gas survey, these compounds were detected in only a few of the soil samples collected. The

only TCE detection in soils appeared to be associated with an UST at Building 902, which reportedly was used to store spent solvents.

The detected SVOCs appeared to be related to fuel releases from Building 1202 which is used for vehicle repairs and maintenance. Pesticide contamination was detected in five samples collected from three boreholes. Many of the metals detected were found in all samples analyzed and therefore, may be indicative of the naturally occurring soil matrix and associated clays (ESE, 1992).

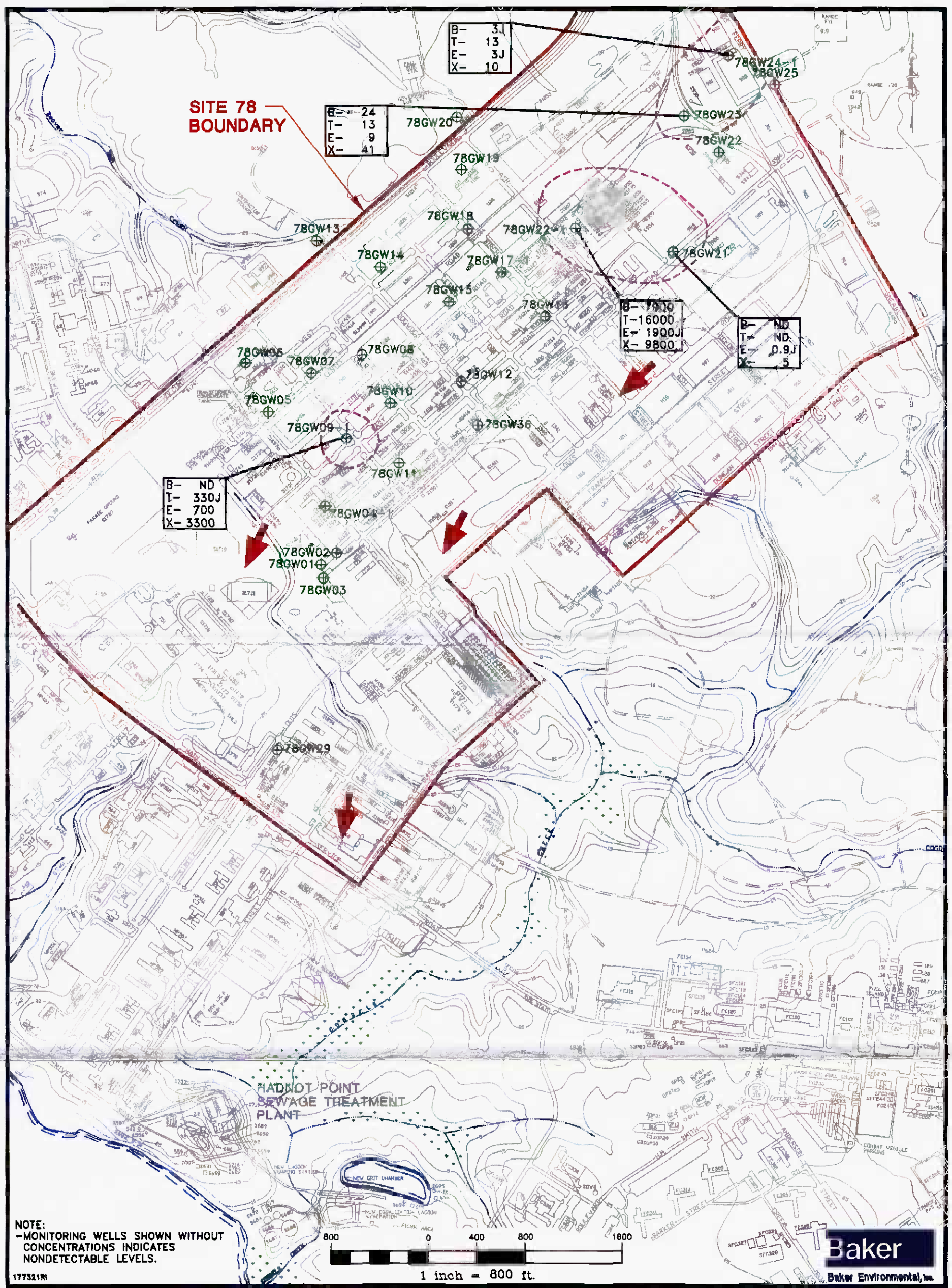
1.3.3.5 Interim Remedial Action Remedial Investigation for the Shallow Aquifer at HPIA

Baker conducted an Interim Remedial Action (IRA) RI for the shallow aquifer at Site 78, the results of which are provided in the Baker (May 1992) RI Report. The objectives of this investigation were:

- To determine the nature and extent of shallow groundwater contamination in the shallow aquifer at two areas of concern within the HPIA
- To qualitatively assess human health risks associated with future potential use of the shallow aquifer
- To document and evaluate existing information pertaining to the shallow aquifer to support the selection of an IRA alternative.

This IRA RI report used the data from previous investigations only; no additional field studies were conducted (Baker, 1992a).

The IRA RI report concluded that three BTEX (Figure 1-7) and two TCE (Figure 1-8) contaminant plumes are present within the shallow groundwater at Site 78; however, one of the BTEX plumes is associated with the HPIA Fuel Farm (Site 22) which is being remediated under a separate investigative program. One of the BTEX/TCE plumes is located east of Cedar Street and extends from the vicinity of the 900 Building area to the tank farm. The plume exhibits solvent contamination and low levels of fuel-related contamination. The other BTEX/TCE plume is believed to originate in the vicinity of Buildings 1502, 1601, and 1602. This plume is contaminated with the same constituents as the plume located east of Cedar



LEGEND

78-GW02 ⊕ EXISTING SHALLOW MONITORING WELL

➡ APPROXIMATE DIRECTION OF GROUNDWATER FLOW

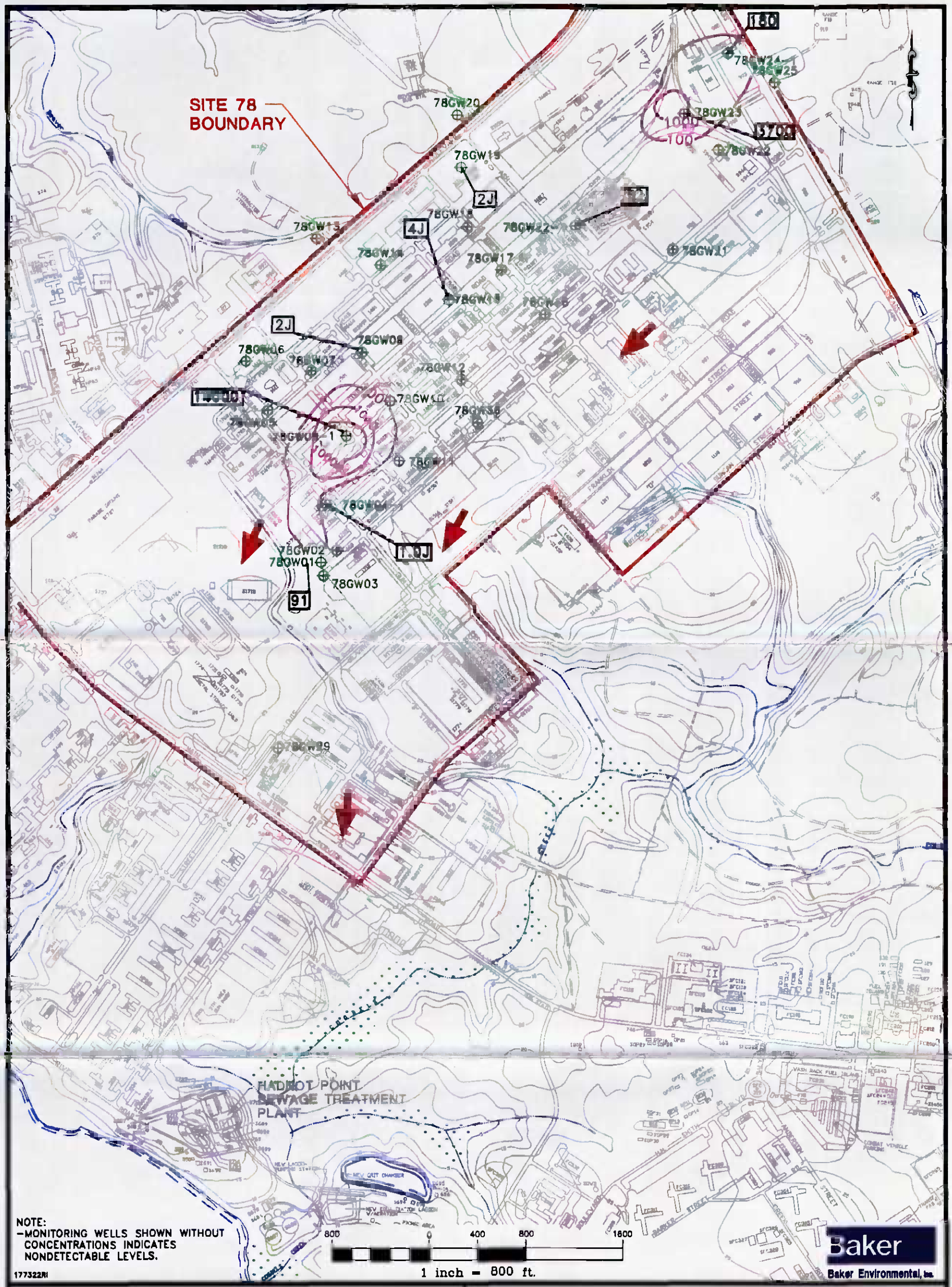
CONCENTRATIONS PRESENTED IN ug/l(ppb) FROM JANUARY 1991 DATA.

SOURCE: LANTDIV, FEBRUARY 1992

B-BENZENE
T-TOLUENE
E-ETHYLBENZENE
X-XYLENES
ND-NOT DETECTED
J -ESTIMATED VALUE
◯ APPROXIMATE AREA OF BTEX GROUNDWATER CONTAMINATION

FIGURE 1-7
BENZENE, TOLUENE, ETHYLBENZENE AND XYLENES (BTEX) DETECTED IN SHALLOW GROUNDWATER(1991)
SITE 78
REMEDIAL INVESTIGATION CTO-0177
MARINE CORPS BASE, CAMP LEJEUNE
NORTH CAROLINA

0177V07Y



LEGEND

78GW02 ⊕ EXISTING SHALLOW MONITORING WELL

91 TCE (TOTAL) CONCENTRATION

APPROXIMATE DIRECTION OF GROUNDWATER FLOW

-100- TCE (TOTAL) CONCENTRATION CONTOUR

J -ESTIMATED VALUE

CONCENTRATIONS PRESENTED IN ug/l(ppb) FROM JANUARY 1991 DATA.
SOURCE: LANTDIV, FEBRUARY 1992

FIGURE 1-8
TOTAL TCE DETECTED IN SHALLOW GROUNDWATER(1991)
SITE 78
REMEDIAL INVESTIGATION CTO-0177
MARINE CORPS BASE, CAMP LEJEUNE
NORTH CAROLINA

0127/V08Y

Street with the exception of total lead. Lead is a contaminant of concern at the site since it is above naturally occurring levels (Baker, 1992a).

As part of this IRA RI, a qualitative risk assessment was performed to identify receptors and exposure pathways, quantify exposure levels, and evaluate human and/or environmental risk. The contaminants of concern for the site were identified as solvents (TCE and 1,2-DCE), BTEX, SVOCs (naphthalene and 2-methylnaphthalene), and inorganics (antimony, arsenic, beryllium, chromium, lead, manganese, mercury, nickel, and iron). The qualitative risk assessment concluded that benzene and TCE may impact human health if shallow groundwater migrates into the deep aquifer (potable water), or if the shallow aquifer is utilized in the future as a potable water source (Baker, 1992a).

1.3.3.6 Interim Remedial Action Feasibility Study for the Shallow Aquifer at HPIA

Based on the results of the IRA RI for the shallow aquifer, Baker prepared a FS Report. The FS developed and evaluated several IRA alternatives for the impacted shallow groundwater. The preferred alternative involved two on-site pump and treat systems to contain the two solvent-contaminated plumes at the site. Following extraction, the groundwater was to be treated on site via air stripping, carbon adsorption, and metals removal, then discharged to the Hadnot Point Sewage Treatment Plant (STP). This IRA alternative was accepted by the USEPA, the NC DEHNR, and the public. The extraction/treatment systems have been designed and construction will be initiated in 1994 (Baker, 1992b).

1.3.3.7 Pre-Investigation Study for the RI/FS

Pre-investigation activities were conducted at the site in order to help design the scope for the RI/FS activities and to verify the location of several suspected USTs within Site 78. The pre-investigation activities included a geophysical survey and groundwater sampling. Both of these activities are described below.

In June 1992, Weston conducted a geophysical survey investigation of several suspected UST areas at Buildings 903, 1202, 1502, 1601, and 1709. Potential USTs were identified at Buildings 903, 1502, and 1601. No tanks were identified near Building 1202 or Building 1709. The results of the geophysical survey are included in Appendix C.

In July 1992, Baker collected a round of groundwater samples from several existing intermediate and deep monitoring wells: 78GW09-2, 78GW09-3, 78GW24-2, 78GW24-3, 78GW31-2, 78GW31-3, 78GW32-2, and 78GW32-3. These particular wells were selected for sampling in order to obtain groundwater data from the deeper aquifers in areas where the shallow aquifer has been impacted. In addition, water supply wells HP-602 and HP-637 were sampled. The results of this sampling were to be used as pre-investigation scoping information for the field investigation relating to this RI. The samples were analyzed for full TCL and TAL parameters. BTEX was detected in monitoring wells 78GW32-2 and 78GW32-3. These wells are located directly downgradient of the Fuel Farm (Site 22). Benzene was detected at 2 µg/l in supply well HP-602 (near the intersection of Holcomb Boulevard and Ash Street) which exceeds the NCWQS of 1.0 µg/l. Total xylenes were detected in supply well HP-637 (upgradient corner of the site) at 5 µg/l which is below the Federal MCL and the NCWQS. The metals detected in one or more of the wells sampled (78GW9-2, 78GW9-3, and supply well HP-602) included aluminum, barium, calcium, copper, iron, lead, magnesium, manganese, sodium, and zinc. Elevated levels of total lead (94 µg/l) were detected above the Federal Action Limit (15 µg/l) and NCWQS (15 µg/l) in supply well HP-602. Appendix B provides a summary of the analytical data.

1.3.3.8 Aerial Photographic Investigation Conducted by EPIC

Per the DON's and USEPA Region IV's requests, the USEPA EPIC conducted an aerial photographic study for Site 78 in 1992. The study covered the period between 1938 and 1990.

The study concluded that possible staining dating back to 1944 was evident near numerous equipment maintenance/wash racks throughout the site at motor pools and maintenance areas. From the 1949 aerial, liquid and/or stains were visible emanating from buildings and in random areas throughout the study area.

In general, the findings from the EPIC Study tend to correlate with the results of records search included as part of the Confirmation Study conducted between 1986-1988. Copies of the Site 78 aerial photographs are provided in Appendix A.

1.4 Report Organization

The following sections are presented in this RI report.

- Executive Summary
- 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 Risk Assessment
- Section 7.0 - Ecological Risk Assessment
- Section 8.0 - Conclusions and Recommendations
- Section 9.0 - References

Section 2.0 describes the field sampling activities conducted during the RI at OU No. 1. 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 information. This section also discusses quality control conducted during the sampling events.

Section 3.0 addresses the physical features of OU No. 1. This section discusses the surface features, meteorology, surface water hydrology, geology, soils, hydrogeology, demography and land use, the ecology in and around OU No. 1, and water supply wells identified within the vicinity of OU No. 1.

Section 4.0 presents the nature and the extent of the contamination found at OU No. 1. 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 extent of contamination, a summary of the contaminants detected and a discussion of the potential sources.

Section 5.0 characterizes the contaminants found at OU No. 1. This characterization includes: potential routes of contaminant migration, contaminant persistence, and contaminant migration.

Section 6.0 contains the baseline human health risk assessment conducted for the operable unit; whereas Section 7.0 presents the ecological risk assessment.

Section 8.0 includes the Conclusions and Recommendations. This section summarizes the nature and extent of contamination, contaminant fate and transport, and the risk assessments. In addition, the conclusions address any data limitations and recommended remedial actions.

Section 9.0 includes references cited in this report.

This RI report is being submitted in five volumes: the text and figures are presented in two volumes and the appendices are presented in three volumes.

2.0 STUDY AREA INVESTIGATION

The field programs at Sites 21, 24, and 78 (OU No. 1) were initiated to characterize potential environmental impacts and threats to human health and the environment resulting from previous storage, operations, and disposal activities. This section discusses the site-specific objectives identified for each site (Section 2.1) along with the preliminary RI field investigation activities (Section 2.2) and the RI field activities (Section 2.3) 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 the 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 the information. This information is presented in tabular form; Site 21 - Transformer Storage Lot 140 is addressed on Table 2-1; Site 24 - Industrial Area Fly Ash Dump is addressed on Table 2-2; and Site 78 - HPIA is addressed on Table 2-3.

2.2 Preliminary RI Field Investigation Activities

The following sections discuss preliminary RI field investigation activities conducted by Baker. These activities were conducted prior to initiating the full RI.

2.2.1 Geophysical Survey Investigation

A geophysical survey investigation was conducted in June 1992 at Sites 24 and 78. The investigation was conducted by Weston Geophysical Corporation (Weston). The purpose of the investigation at Site 24 was to delineate the boundaries of four suspected disposal areas: the Spiractor Sludge Disposal Area; the Fly Ash Disposal Area; Borrow and Debris Disposal Area; and the Buried Metal Disposal Areas. The purpose of the investigation at Site 78 was to

TABLE 2-1
SUMMARY OF REMEDIAL INVESTIGATION OBJECTIVES
SITE 21
REMEDIAL INVESTIGATION CTO-0177
MCB CAMP LEJEUNE, NORTH CAROLINA

Medium or Area of Concern	RI Objective	Criteria for Meeting Objective	Investigation/Study
1. Soil	1a. Assess the extent of soil contamination at the former pesticide mixing area.	Characterize contaminant levels in surface and subsurface soils at former mixing area.	Soil Investigation
	1b. Assess the extent of soil contamination at former transformer oil pit.	Characterize contaminant levels in surface and subsurface soils at the former transformer oil pit.	Soil Investigation
	1c. Assess the extent of soil contamination at areas identified by EPIC Study (Figure 1-3).	Characterize contaminant levels in surface and subsurface soils at areas identified by EPIC Study.	Soil Investigation
	1d. Assess human health and ecological risks associated with exposure to surface soils at the site.	Characterize contaminant levels in surface and subsurface soils at the site.	Soil Investigation Risk Assessment
	1e. Determine whether pesticide and/or PCB contamination from soils is migrating to groundwater.	Characterize groundwater quality in pesticide and PCB areas.	Groundwater Investigation
2. Groundwater	2a. Assess health risks posed by potential future usage of the shallow groundwater.	Evaluate groundwater quality and compare to ARARs and health-based action levels.	Groundwater Investigation Risk Assessment
	2b. Evaluate hydrogeologic characteristics for fate and transport evaluation and remedial technology evaluation, if required.	Estimate hydrogeologic characteristics of the shallow aquifer (flow direction, transmissivity, storativity, etc).	Groundwater Investigation (Field Investigation/Review of Existing Data)
	2c. Determine whether groundwater is contaminated with site-related constituents.	Evaluate groundwater quality and compare to ARARs.	Groundwater Investigation

TABLE 2-1 (Continued)
SUMMARY OF REMEDIAL INVESTIGATION OBJECTIVES
SITE 21
REMEDIAL INVESTIGATION CTO-0177
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 in Site Drainage Ditch Risk Assessment
	3b. Assess potential ecological impacts posed by contaminated sediments.	Qualitatively evaluate stress to benthic and fish communities.	Surface Water Investigation Sediment Investigation
	3c. Determine the extent of sediment contamination for purposes of identifying areas potentially requiring remediation.	Identify extent of sediment contamination where contaminant levels exceed risk-based action levels or EPA Region IV TBCs for sediment.	Sediment Investigation in Site Drainage Ditch Risk Assessment
4. Surface Water	4a. Assess the presence or absence of surface water contamination in the site drainage ditch.	Determine surface water quality, if present, in the site drainage ditch.	Surface Water Investigation

TABLE 2-2
SUMMARY OF REMEDIAL INVESTIGATION OBJECTIVES
SITE 24
REMEDIAL INVESTIGATION CTO-0177
MCB CAMP LEJEUNE, NORTH CAROLINA

Medium or Area of Concern	RI Objective	Criteria for Meeting Objective	Investigation/Study
1. Soil	1a. Assess the extent of soil contamination at the spiractor sludge disposal area.	Characterize contaminant levels in surface and subsurface soils.	Soil Investigation
	1b. Assess the extent of soil contamination at the fly ash disposal area.	Characterize contaminant levels in surface and subsurface soils.	Soil Investigation
	1c. Assess the extent of soil contamination at the buried metal areas.	Characterize contaminant levels in surface and subsurface soils.	Soil Investigation
	1d. Identify the buried metal at the buried metal areas.	Characterize the soils within the buried metal areas.	Soil Investigation - Test Pitting Geophysical Investigation
	1e. Assess the extent of soil contamination at the borrow and debris disposal area.	Characterize contaminant levels in surface and subsurface soils.	Soil Investigation Geophysical Investigation
	1f. 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 the shallow 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 the shallow aquifer (flow direction, transmissivity, storativity, etc).	Groundwater Investigation (Field Investigation/Review of Existing Data)

TABLE 2-2 (Continued)
SUMMARY OF REMEDIAL INVESTIGATION OBJECTIVES
SITE 24
REMEDIAL INVESTIGATION CTO-0177
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 in Cogdels Creek, and New River Risk Assessment
	3b. Assess potential ecological impacts posed by contaminated sediments.	Evaluate stress to benthic and fish communities.	Surface Water Investigation 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
4. Surface Water	4a. Assess the presence or absence of surface water contamination in Cogdels Creek.	Determine surface water quality along Cogdels Creek.	Surface Water Investigation
	4b. Assess impacts to Cogdels Creek from groundwater discharge from Operable Unit No. 1.	Determine surface water quality in Cogdels Creek.	Surface Water Investigation
		Assess groundwater quality and flow directions within Operable Unit No. 1.	Groundwater Investigation

TABLE 2-3
SUMMARY OF REMEDIAL INVESTIGATION OBJECTIVES
SITE 78
REMEDIAL INVESTIGATION CTO-0177
MCB CAMP LEJEUNE, NORTH CAROLINA

Medium or Area of Concern	RI Objective	Criteria for Meeting Objective	Investigation/Study
1. Soil	1a. Assess the extent of soil contamination at suspected UST areas (Buildings 903, 1502, and 1601).	Characterize BTEX and TPH levels in surface and subsurface soils at suspected UST locations (Buildings 903, 1502, and 1601).	Soil Investigation
	1b. Assess the extent, if any, of soil contamination at suspected pesticide-contaminated areas (Buildings 1103 and 1601).	Characterize pesticide levels in surface and subsurface soils at suspected areas (Buildings 1103 and 1601).	Soil Investigation
	1c. Assess the extent, if any, of soil contamination at suspected PCB-contaminated area (Building 1300).	Characterize PCB/pesticide levels in surface and subsurface soil at suspected area (Building 1300).	Soil Investigation
	1d. Assess human health and ecological risks associated with exposure to surface soils.	Characterize contaminant levels in surface and subsurface soils.	Soil Investigation Risk Assessment
	1e. Assess the presence or absence of soil contamination at other potential areas of concern not previously investigated (northeast and southeast of Louis Road and along Michael Road).	Characterize contaminant levels in surface and subsurface soils.	Soil Gas Investigation Soil Investigation
	1f. Determine whether or not the suspected USTs are sources of groundwater contamination.	Characterize BTEX and TPH levels in surface and subsurface soils at suspected UST locations (Buildings 902, 1502, and 1601).	Soil Investigation Groundwater Investigation

TABLE 2-3 (Continued)
SUMMARY OF REMEDIAL INVESTIGATION OBJECTIVES
SITE 78
REMEDIAL INVESTIGATION CTO-0177
MCB CAMP LEJEUNE, NORTH CAROLINA

Medium or Area of Concern	RI Objective	Criteria for Meeting Objective	Investigation/Study
2. Groundwater	2a. Assess health risks posed by potential future usage of the shallow/intermediate 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 the shallow aquifer (flow direction, transmissivity, storativity, etc).	Groundwater Investigation (Field Investigation/Review of existing data)
	2c. Assess the presence or absence of groundwater contamination at other potential areas of concern not previously investigated.	Characterize contaminant levels in surface and subsurface soils and potentially in groundwater.	Soil Gas Investigation Soil Investigation Groundwater Investigation
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 in Beaver Dam Creek, Cogdels Creek, and New River Risk Assessment
	3b. Assess potential ecological impacts posed by contaminated sediments.	Qualitatively evaluate stress to benthic and fish communities.	Surface Water Investigation Sediment Investigation
	3c. Determine the extent of sediment contamination for purposes of identifying areas of possible 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 Geophysical Investigation

TABLE 2-3 (Continued)
SUMMARY OF REMEDIAL INVESTIGATION OBJECTIVES
SITE 78
REMEDIAL INVESTIGATION CTO-0177
MCB CAMP LEJEUNE, NORTH CAROLINA

Medium or Area of Concern	RI Objective	Criteria for Meeting Objective	Investigation/Study
4. Surface Water	4a. Assess the presence or absence of surface water contamination in Beaver Dam Creek and Cogdels Creek.	Determine surface water quality along Beaver Dam Creek and Cogdels Creek.	Surface Water Investigation
	4b. Assess impacts to Beaver Dam Creek and Cogdels Creek from groundwater discharge from Operable Unit No. 1.	Determine surface water quality in the creeks.	Surface Water Investigation
		Assess groundwater quality and flow directions from within Operable Unit No. 1.	Groundwater Investigation

identify suspected UST areas at Buildings 903, 1502, and 1601. A copy of Weston's Geophysical Report summarizing the geophysical techniques employed, the geophysical profiles, and the results is provided in Appendix C. A discussion of the results is also provided as follows.

2.2.1.1 Geophysical Survey of Site 24 - Industrial Area Fly Ash Dump

Four suspected disposal areas had been identified previously at Site 24 based on existing information. Three of the areas, the Spiractor Sludge Disposal Area, the Fly Ash Area, and one of the Borrow and Debris Disposal Areas, were investigated as part of this geophysical survey. Access to a second suspected borrow/debris disposal area was restricted due to ongoing construction activities and therefore was not investigated. Based on a review of the EPIC aerial study, this area was probably a staging area for excavated soil (indicated as mounded material on Figure 1-4) and does not appear to be an area of concern.

A brief summary of the findings from the geophysical survey per area of concern follows:

Spiractor Sludge Disposal Area

Disposal of spiractor sludge was suspected in the northeast corner of Site 24, in an area south of Duncan Street and west of Cogdels Creek. A geophysical survey grid was established in this area, extending from the Maintenance/Engineering Building parking lot, south and east to Cogdels Creek. Lines of geophysical coverage and surface features at Site 24 are shown in Figure A3-1 (Appendix C).

Electromagnetic (EM) measurements showed a distinct increase in conductivity levels (5 to 10 millimhos/meter [mmhos/m]) in an area west of Cogdels Creek and south and east of the tree line. The area of increased conductivity, interpreted to be due to the disposal of sludge, is delineated on Figure A3-1 (Appendix C). Background levels in this portion of the site, immediately south of the parking lot and within the wooded areas, ranged between 2 to 4 mmhos/m. Figure A3-2 (Appendix C) shows the east-west and north-south conductivity profiles across the sludge area with levels above 5 mmhos/m highlighted.

Fly Ash Disposal Area and Buried Metal Areas

Disposal of fly ash was suspected over a wide area in the south-central section of Site 24. The geophysical survey grid was extended for the spiractor sludge area to the south and west as shown on Figure A3-1 (Appendix C). However, due to dense vegetation and understory, geophysical coverage was restricted to the eastern limits of ash disposal.

EM measurements showed elevated conductivity levels over most of this area as shown on Figure A3-1 (Appendix C). Conductivity values in the range of 5-10 mmhos/m extended from the tree line on the north, into the wooded portion of the site on the south. Levels of conductivity only slightly above background indicate that this area may have been used for limited disposal of fly ash.

A distinct increase in conductivity above 10 mmhos/m, interpreted to be more representative of fly ash deposits, was measured at the western limits of the geophysical coverage. Figure A3-3 (Appendix C) shows the east-west conductivity profiles across the fly ash area with levels above 10 mmhos/m highlighted. The estimated boundary of fly ash disposal shown on Figure A3-1 (Appendix C) corresponds to increased levels of conductivity.

Several locations of buried metal were detected along the geophysical traverses and are indicated on Figure A3-1 (Appendix C). Most are isolated occurrences except for three areas which are characteristic of more widespread burial of metal and debris. These areas are centered at geophysical grid coordinates 0+90W/5+50S, 2+00W/7+25S, and 5+00W/O+40S.

Borrow and Debris Disposal Area

An area of borrow and subsequent disposal of waste is suspected in the western portion of Site 24, in an area south of Building 1450. A geophysical survey grid was established for this area, extending from the parking lot, to the south and west. Coverage to the north extended to the construction site. Lines of geophysical coverage and surface features at this portion of Site 24 are shown on Figure A3-4 (Appendix C).

EM measurements showed an increase in conductivity levels (greater than 10 mmhos/m) for an area extending southwest of the parking lot toward well 24GW02. Figure A3-5 (Appendix C) showed the conductivity profiles across the debris area with levels above

10 mmhos/m highlighted. The area of increased conductivity, interpreted to be due to disposal, is delineated on Figure A3-4 (Appendix C). Background levels in this portion of the site ranged between 3-5 mmhos/m. Three locations of isolated buried metal were detected west of the parking lot.

Site 24 Geophysical Survey Summary

At Site 24, the extent of spiractor sludge disposal was correlated with slightly elevated values of conductivity above measured background levels. The eastern boundary of fly ash disposal was defined by a distinct increase in conductivity, characteristic of fly ash material. Disposal at the borrow area was also delineated by increased values of conductivity. Locations of buried metal at all three disposal areas were identified for subsequent investigation via test pits.

2.2.1.2 Geophysical Survey of Site 78 - HPIA

Several buildings within Site 78 had been identified as suspected sites of USTs. These included Buildings 1502, 1601, 903, 1202, and 1709. Due to the presence of potential sources of interference in this industrialized area, EM and magnetometry techniques were not applicable, and GPR was utilized to determine the absence/presence of any tanks. GPR also offered better resolution capabilities for delineating the tank locations and establishing depths of burial.

At each building, a geophysical survey grid was established and served as lines of coverage for the radar. Surface features, such as buildings, roads, utilities, etc., were related to the grid and shown on the figure (Appendix C) of results along with interpreted subsurface conditions, i.e., tanks, buried utilities, and other buried objects.

A summary of the findings from the GPR with respect to each of the buildings of concern follows:

- Four to six USTs were delineated at three locations surrounding Building 1502 (Figures A3-6, A3-8 in Appendix C).

- One to three USTs were delineated at two locations surrounding Building 1601 (Figures A3-9, A3-10, and A3-11 in Appendix C).

- A single, small UST was reported to exist somewhere between Buildings 902 and 903 (Figure A3-12 in Appendix C).

- The presence of USTs at Buildings 1202 and 1709 was not confirmed, although two shallow, large unidentified objects were detected near Building 1709 (Figures A3-14 and A3-15, in Appendix C).

2.2.2 Groundwater Sampling

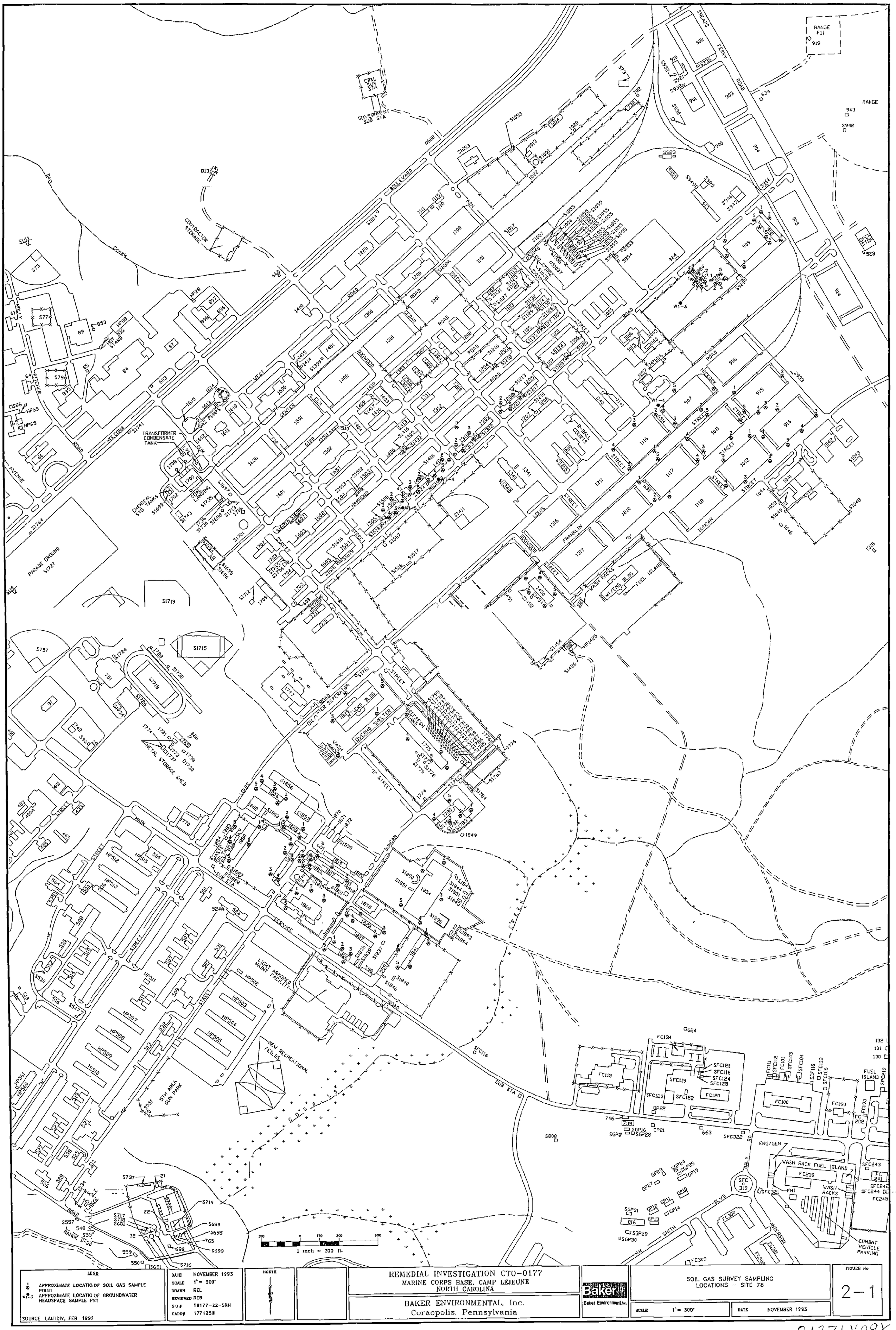
As part of the pre-investigation activities for this RI, groundwater samples were collected in July 1992 from selected monitoring wells at Sites 24 and 78, and potable water supply wells HP-602 and HP-637. The purpose of sampling these wells was to provide current groundwater quality data which could be used to develop sampling strategies for the RI field investigation. Results of the groundwater quality data for both sites were discussed in Section 1.3 of this report. Additionally, a summary of results is presented in table form in Appendix B.

2.3 RI Field Investigations

The majority of the RI field investigations performed at OU No. 1 commenced in April 1993 and continued through June, 1993. An additional well replacement activity was conducted at Site 78 in December 1993. The field program implemented at OU No. 1 consisted of: a soil gas investigation (Site 78 only); a preliminary site survey; a soil investigation which included drilling and soil sampling and test pit sampling (test pits at Site 24 only); a groundwater investigation which included drilling/monitoring well installation, groundwater sampling, and static water level measurements; a surface water/sediment investigation; a monitoring well and staff gauge survey (vertical and horizontal control); decontamination procedures; and investigative derived waste (IDW) handling. The following sections discuss these investigative activities.

2.3.1 Soil Gas Investigation

A soil gas investigation was conducted at Site 78 at the selected building locations as shown on Figure 2-1. During the investigation, samples of soil gas (i.e., vadose zone) and groundwater (i.e., headspace) were analyzed on site via a gas chromatograph. The following 36 building areas were investigated as part of the survey: 907, 908, 909, 915, 916, 926, 927, 928, 1011, 1012, 1106, 1116, 1117, 1205, 1206, 1310, 1407, 1408, 1450, 1505, 1604, 1765, 1775, 1480,



LEND

- ⊕ APPROXIMATE LOCATIO OF SOIL GAS SAMPLE POINT
- ⊕ WI-3 APPROXIMATE LOCATIO OF GROUNDWATER HEADSPACE SAMPLE PNT

SOURCE LANTDIV, FEB 1992

DATE	NOVEMBER 1993
SCALE	1"= 300'
DRAWN	REL
REVIEWED	REB
SO #	19177-22-SRN
CADD #	177125RI

NORTH

REMEDIAL INVESTIGATION CTO-0177
MARINE CORPS BASE, CAMP LEJEUNE
NORTH CAROLINA

BAKER ENVIRONMENTAL, Inc.
Coraopolis, Pennsylvania

Baker Environment, Inc.

SOIL GAS SURVEY SAMPLING LOCATIONS – SITE 78

SCALE 1"= 300' DATE NOVEMBER 1993

FIGURE No 2-1

01271V09X

1804, 1808, 1810, 1815, 1817, 1826, 1828, 1829, 1841, 1854, 1860, and 1880 [note that Buildings 1750 and 1755 were razed and replaced by Building 1829; also, Building 1812 could not be located by Baker or Camp Lejeune personnel and, therefore, was not investigated]. The 36 buildings were not included in any previous investigations to determine whether they are a source of contamination at Site 78. The survey was conducted to investigate potentially contaminated areas which may have resulted from previous and/or present waste (e.g., solvents, petroleum, etc.) usage/storage. The resulting information was utilized to position additional shallow groundwater monitoring wells to determine the extent of shallow groundwater contamination within Site 78. The survey was conducted by Target Environmental Services, Inc., (Target) and was supervised by Baker personnel. A copy of Target's report is provided in Appendix D. The following provides a brief description of the soil gas field procedures (from Target's report) and results.

2.3.1.1 Sampling Procedures and Analytical Program

The soil gas survey conducted at Site 78 was performed in several phases of work. Initially, Baker personnel located five sample points around each of the buildings identified above. The proposed sample points were selected based on visual observations of potential areas of concern at each building (e.g., waste storage areas, underground or above ground tanks, drainage areas, etc.). These locations were marked with paint or flagged by Baker personnel to assist Target with locating the points. Additionally, five groundwater samples were also collected for headspace analysis. The groundwater samples were collected at areas which indicated the highest levels of contamination based on the soil gas analysis.

Prior to the collection of each soil gas sample, the entire sampling system was first purged with ambient air drawn through an organic vapor filter cartridge. The majority of the soil gas samples were collected by manually using a drive rod to produce a 1/2 inch hole. To produce the sampling hole at locations 1854-1 and 1854-4, a van-mounted hydraulic probe was used to advance connected 3-foot sections of 1-inch diameter threaded steel casing equipped with a disposal drive tip down to the sampling depth. A stainless steel probe was inserted to the full depth of the hole and sealed off from the atmosphere. Where pavement was present, a rotary hammer was employed for penetration prior to using the drive rod.

Following isolation of the sampling zone, a sample of in situ soil gas was then withdrawn through the stainless steel probe and used to purge atmospheric air from the sampling system. A second sample of soil gas was withdrawn through the probe and encapsulated in a pre-

evacuated glass vial at two atmospheres of pressure [14 pounds per square inch (psi)]. The self-sealing vial was detached from the sampling system, packaged, labeled, and stored for laboratory analysis.

Prior to the day's field activities all soil gas sampling equipment, slide hammer rods and probes were decontaminated by washing with soapy water and rinsing thoroughly. Internal surfaces were flushed dry using a pre-purified nitrogen or filtered ambient air, and external surfaces were wiped clean using clean paper towels.

To collect the groundwater samples, the hydraulic probe was used to advance connected 3-foot sections of 1 inch diameter threaded steel casing to the sampling depth. An electric hammer drill was used to penetrate pavement where necessary. Once the steel casing was in place, water was allowed to fill the pipe. A teflon sampling tube was placed down the pipe and ground water was collected from just below the water surface. Samples were placed in 40 milliliter (ml) bottles and acidified to pH 2 using a 50 percent hydrochloric acid-water mixture, sealed, labeled and stored on ice pending laboratory analysis.

Prior to the day's field activities and after collection of each sample, the steel casing and teflon sampling tube were decontaminated by washing with Alconox (a biodegradable, laboratory grade detergent), rinsing with distilled water and drying with nitrogen gas or filtered ambient air.

All of the soil gas samples and the headspaces of the groundwater samples collected during the field phase of the survey were subjected to dual analyses on Target's on-site laboratory grade gas chromatograph. One analysis was conducted according to EPA Method 602 (modified) on a gas chromatograph equipped with a flame ionization detector (FID), and using direct injection. The analytes selected for standardization in this analysis were:

- vinyl chloride
- benzene
- toluene
- ethylbenzene
- meta- and para-xylene
- ortho- xylene

These compounds were chosen because of their utility in evaluating the presence of fuel products, or petroleum based solvents.

The second analysis was conducted according to EPA Method 601 (modified) on a gas chromatograph equipped with an electron capture detector (ECD), and using direct injection. Specific analytes standardized for this analysis were:

- 1,1-dichloroethene (1,1-DCE)
- methylene chloride
- trans-1,2-dichloroethene (T-1,2-DCE)
- 1,1-dichloroethane (1,1-DCA)
- cis-1,2-dichloroethene (c-1,2-DCE)
- chloroform
- 1,1,1-trichloroethane (1,1,1-TCA)
- carbon tetrachloride
- trichloroethene (TCE)
- 1,1,2-trichloroethane (1,1,2-TCA)
- tetrachloroethene (PCE)

The chlorinated hydrocarbons in this suite were chosen because of their common usage in industrial solvents, and/or their degradational relationship to commonly used compounds.

The analytical equipment was calibrated using a 3-point instrument-response curve and injection of known concentrations of the target analytes. Retention times of the standards were used to identify the peaks in the chromatograms of the field samples, and their response factors were used to calculate the analyte concentrations. The groundwater samples were prepared for analysis by pouring 15 ml of sample into a 30 ml EPA clean vial, and sealing with a teflon-faced butyl rubber septum. The vial was heated for 10 minutes to volatilize hydrocarbons from the water. The headspace of the sample was then directly injected into the gas chromatograph.

Total FID VOC values were generated by summing the areas of all integrated chromatogram peaks, and calculated using the instrument response factor for toluene. Injection peaks which also contain the light hydrocarbon methane, were excluded to avoid the skewing of total FID volatiles values due to injection disturbances and biogenic methane. For samples with low hydrocarbon concentrations, the calculated total FID VOC concentration is occasionally lower than the sum of the individual analytes. This is because the response factor used for the total FID VOC calculation is a constant, whereas the individual analyte response factors are

compound specific. It is important to understand that the total FID VOC levels reported are relative, not absolute, values.

The tabulated results of the laboratory analyses of the soil gas samples are reported in micrograms per liter (µg/l) in Tables 1 through 4 in Appendix D of this RI. Although "micrograms per liter" is equivalent to "parts per billion (ppb)" in water analyses, they are not equivalent in gas analyses, due to the difference in the mass of equal volumes of water and gas matrices. The xylenes concentrations reported in Tables 1 and 2 in Appendix D of this RI are the sum of the m- and p-xylene and the o-xylene concentrations for each sample.

2.3.1.2 Quality Assurance/Quality Control (QA/QC) Evaluation

Field QA/QC Samples

Soil gas field control samples were collected at the beginning and end of each day's field activities and after every twentieth soil gas sample. These QA/QC samples were obtained by inserting the probe tip into a tube flushed by a 20 psi flow of pre-purified nitrogen and encapsulating as described above. The laboratory results of the analysis of these samples are reported in Tables 1 through 4 in Appendix D of this RI. Concentrations of all analytes were below the reporting limit in all field control samples.

Equipment rinsate blanks were collected at the beginning and end of the day's ground water sampling activities. These QA/QC samples were obtained by collecting bottled distilled water through the teflon sampling tube. The laboratory results of the analysis of these samples are reported in Tables 1 and 3 in Appendix D of this RI. Concentrations of all analytes were below the reporting limit in all rinsate blanks.

Laboratory QA/QC Samples

A duplicate laboratory analysis was performed on every tenth field sample. Laboratory blanks of nitrogen gas were also analyzed after every tenth field sample. The results of these analyses are reported in Tables 1 through 4 in Appendix D of this RI. All duplicate analyses were within acceptable limits. Concentrations of all analytes were below the reporting limit in all laboratory blanks.

2.3.1.3 Results

Results of the soil gas survey are summarized on Table 2-4 and in Target's report which is provided in Appendix D. As shown on Table 2-4, the VOC concentrations ranged from not detected (ND) at several locations to 350.5 µg/l at Building 927. The most frequently detected VOCs included vinyl chloride, toluene, ethylbenzene, xylenes, TCE, PCE, 1,2-DCE, and 1,1-DCA. A brief summary of the compounds detected with the highest total VOC concentrations (i.e., sum of all detected volatiles) is presented below. Figure 2-2 depicts the locations of the buildings (i.e., sample points situated around the buildings) which exhibited the highest concentrations (not all buildings identified on figure) as discussed below. Soil gas samples collected near the following buildings exhibited the overall highest concentrations of VOCs.

- Building 907 - Sample 907-4 with 53.5 µg/l total VOCs contained vinyl chloride and 1,1-DCA.

- Building 927 - Sample 927-3 with 350.5 µg/l total VOCs contained ethylbenzene, and xylenes.

- Building 928 - Sample 928-1 with 26 µg/l total VOCs contained toluene and xylenes.

- Building 1206 - Sample 1206-4 with 10.9 µg/l total VOCs contained vinyl chloride, toluene, ethylbenzene, and xylenes. The sample with 35.2 µg/l total VOCs contained vinyl chloride, ethylbenzene, and xylenes.

- Building 1407 - Sample 1407-4 with 243.7 µg/l total VOCs contained vinyl chloride only.

- Building 1505 - Sample 1505-5 with 229.8 µg/l total VOCs contained vinyl chloride, and BTEX.

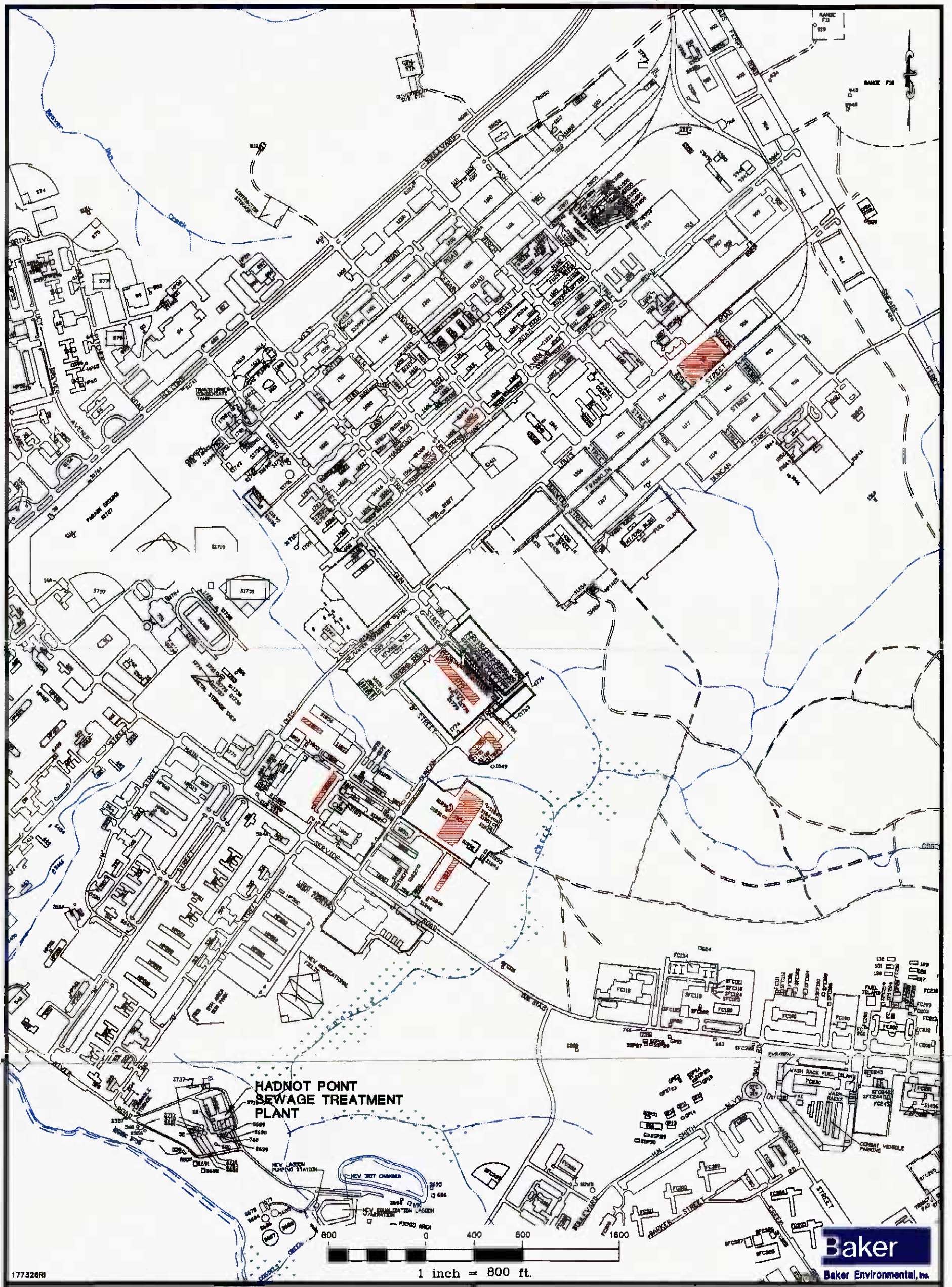
- Building 1775 - Sample 1775-3 with 43.5 µg/l total VOCs contained vinyl chloride, 1,1-DCE, ethylbenzene, and xylenes.

- Building 1780 - Sample 1780-4 with 25.8 µg/l total VOCs contained ethylbenzene, and xylenes.

TABLE 2-4
SOIL GAS SAMPLE RESULTS
TOTAL VOLATILE ORGANIC COMPOUNDS
REMEDIAL INVESTIGATION CTO-0177
MCB CAMP LEJEUNE, NORTH CAROLINA

Soil Gas Sample Number	Total VOC Concentration (µg/l)	Soil Gas Sample Number	Total VOC Concentration (µg/l)	Soil Gas Sample Number	Total VOC Concentration (µg/l)	Soil Gas Sample Number	Total VOC Concentration (µg/l)
907-1	1	1012-1	ND	1450-1	1.2	1815-1	ND
907-2	3.7	1012-2	1.1	1450-2	6.3	1815-2	1
907-3	1.1	1012-3	ND	1450-3	1.5	1815-3	1
907-4	53.5	1012-4	ND	1450-4	1.4	1815-4	ND
907-5	ND	1012-5	1.1	1450-5	1.6	1815-5	ND
908-1	ND	1106-1	ND	1505-1	ND	1817-1	ND
908-2	ND	1106-2	2.7	1505-2	3.3	1817-2	3.7
908-3	2.8	1106-3	ND	1505-3	6.2	1817-3	ND
908-4	3.3	1106-4	ND	1505-4	ND	1817-4	3
908-5	ND	1106-5	ND	1505-5	229.8	1817-5	ND
909-1	2.9	1116-1	ND	1604-1	1.4	1826-1	ND
909-2	ND	1116-2	2.1	1604-2	ND	1826-2	5.7
909-3	3.1	1116-3	1.7	1604-3	1.8	1826-3	1
909-4	1.4	1116-4	ND	1604-4	2	1826-4	ND
909-5	4.4	1116-5	1.5	1604-5	1.2	1826-5	9.2
915-1	1	1117-1	1.1	1765-1	3	1828-1	ND
915-2	2.7	1117-2	2.9	1765-2	3.6	1828-2	7.2
915-3	1.5	1117-3	1.7	1765-3	7.2	1828-3	1.9
915-4	5.8	1117-4	1.1	1765-4	NA	1828-4	2.9
915-5	3	1117-5	ND	1765-5	1	1828-5	ND
916-1	1.2	1205-1	5.3	1775-1	2.4	1829-1	1.5
916-2	7.6	1205-2	1.1	1775-2	2.6	1829-2	ND
916-3	1	1205-3	1.1	1775-3	43.5	1829-3	5.4
916-4	3	1205-4	7.4	1775-4	1.4	1829-4	3
916-5	4.1	1205-5	5.3	1775-5	1.2	1829-5	2.5
926-1	ND	1206-1	9.6	1780-1	2.9	1841-1	14
926-2	ND	1206-2	6.1	1780-2	ND	1841-2	4.6
926-3	ND	1206-3	1.8	1780-3	ND	1841-3	1.1
926-4	ND	1206-4	10.9	1780-4	25.8	1841-4	ND
926-5	1.8	1206-5	35.2	1780-5	1.1	1841-5	16.6
927-1	ND	1310-1	ND	1804-1	ND	1854-1	7.9
927-2	7.4	1310-2	2.5	1804-2	ND	1854-2	10.3
927-3	350.5	1310-3	ND	1804-3	22.6	1854-3	NA
927-4	1.1	1310-4	8.6	1804-4	1.1	1854-4	2.6
927-5	ND	1310-5	8.4	1804-5	ND	1854-5	1.1
928-1	26	1407-1	ND	1808-1	ND	1860-1	1.5
928-2	ND	1407-2	ND	1808-2	ND	1860-2	ND
928-3	1.2	1407-3	ND	1808-3	ND	1860-3	4.8
928-4	ND	1407-4	243.7	1808-4	ND	1860-4	ND
928-5	ND	1407-5	ND	1808-5	ND	1860-5	ND
1011-1	ND	1408-1	5.8	1810-1	165	1880-1	ND
1011-2	7.9	1408-2	1.1	1810-2	9.9	1880-2	ND
1011-3	1.1	1408-3	ND	1810-3	ND	1880-3	ND
1011-4	1.5	1408-4	ND	1810-4	ND	1880-4	1.4
1011-5	4.5	1408-5	ND	1810-5	ND	1880-5	ND

Notes: NA = Sample not collected or analyzed
Total VOC concentration is equal to the sum of all detected volatiles including halogenated (e.g., vinyl chloride, TCE) and non-halogenated (e.g., BTEX) compounds.



LEGEND

927 VOC CONCENTRATIONS DETECTED VIA SOIL GAS AT BUILDING

SOURCE: LANTDIV, FEBRUARY 1992

FIGURE 2-2
AREAS OF CONCERN IDENTIFIED
BY SOIL GAS SURVEY
SITE 78
REMEDIAL INVESTIGATION CTO-0177
MARINE CORPS BASE, CAMP LEJEUNE
NORTH CAROLINA

0177X10Y

- Building 1804 - Sample 1804-3 with 22.6 µg/L total VOCs contained ethylbenzene, and xylenes.

- Building 1810 - Sample 1810-1 with 165 µg/L total VOCs contained toluene, ethylbenzene, and xylenes.

- Building 1841 - Sample 1814-5 with 16.6 µg/L total VOCs contained PCE, 1,1-DCE, ethylbenzene, and xylenes.

- Building 1854 - Sample 1854-2 with 10.3 µg/L total VOCs contained vinyl chloride, toluene, and 1,1-DCA.

A few general trends were noted based upon the review of the preliminary data. PCE (expected to be a primary contaminant of concern at Site 78) was detected in several of the buildings in the area southeast of Louis Road. The buildings included 1817, 1828, 1841, 1826, and 1780. PCE was also detected in buildings northeast of Louis Road including Buildings 908, 909 and 1011. Vinyl chloride (another expected contaminant of concern) was detected at the majority of the buildings. The highest vinyl chloride levels were found at Buildings 908, 909, 915, 916, 1205, 1407, 1505, 1604, 1775, 1765, 1829, and 1860. Subsequently, additional monitoring wells were installed within Site 78 based on the results of the soil gas investigation. A discussion of these wells are presented in Section 2.3.4.3.

2.3.2 Preliminary Site Survey

Prior to initiating the drilling and sampling programs at OU No. 1, a preliminary survey of each site was conducted to locate the proposed soil borings and monitoring wells. The proposed locations were established by using the horizontal and vertical control points near the site which are tied into the North Carolina State Plane Coordinate System (NCSPCS). Hoggard-Eure Associates (Hoggard-Eure), a registered surveying firm in the State of North Carolina, was retained to perform the survey.

2.3.3 Soil Investigation

The soil investigation performed at OU No. 1 was intended to assess the nature and extent of contamination which may have resulted from previous disposal practices or site activities.

Additionally, the investigations were performed to assess human health, ecological, and environmental risks associated with exposure to surface and subsurface soils. The following describes the drilling procedures, sample locations, sample methods, and analytical program for each site investigated.

2.3.3.1 Site 21 Soil Investigation

The soil investigation conducted at Site 21 focused on two main areas of concern; the Former Pesticide Mixing/Disposal Area and the Former PCB Transformer Disposal Area. According to Camp Lejeune records, portions of Lot 140 were used as a pesticide mixing area, and as a cleaning area for pesticide application equipment from 1958 to 1977. The area was reportedly located near the southeastern corner of the lot. Moreover, the second area of concern, the Former PCB Transformer Disposal Area, was reportedly located in the northeastern portion of the site. Subsequently, the drilling and sampling program conducted at Site 21 focused on these two areas of concern. The drilling procedures, soil sample locations, sampling procedures, and analytical program for this soil investigation are summarized below.

Drilling Procedures

Drilling activities at Site 21 commenced on May 5, 1993, and continued through May 8, 1993. Hardin and Huber, Inc. (HHI) was retained to perform the drilling services. The boreholes were advanced by a truck-mounted drill rig using 3-1/4-inch inside diameter (ID) hollow stem augers. Split-spoon samples were collected from inside the augers according to ASTM Method D 1586-84 (ASTM, 1984). Additionally, samples were also obtained with a hand auger at locations where underground utilities were suspected or where drilling locations were inaccessible with a drill rig. Soil cuttings obtained during the drilling program were contained and handled according to the procedures outlined in Section 2.3.8. Moreover, drilling and sampling activities were performed using Level D personal protection [note that upgraded levels of protection (i.e., Level D to Level C personal protection) were not required during the drilling and sampling programs].

Two types of borings were installed during the investigation: 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 slightly 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

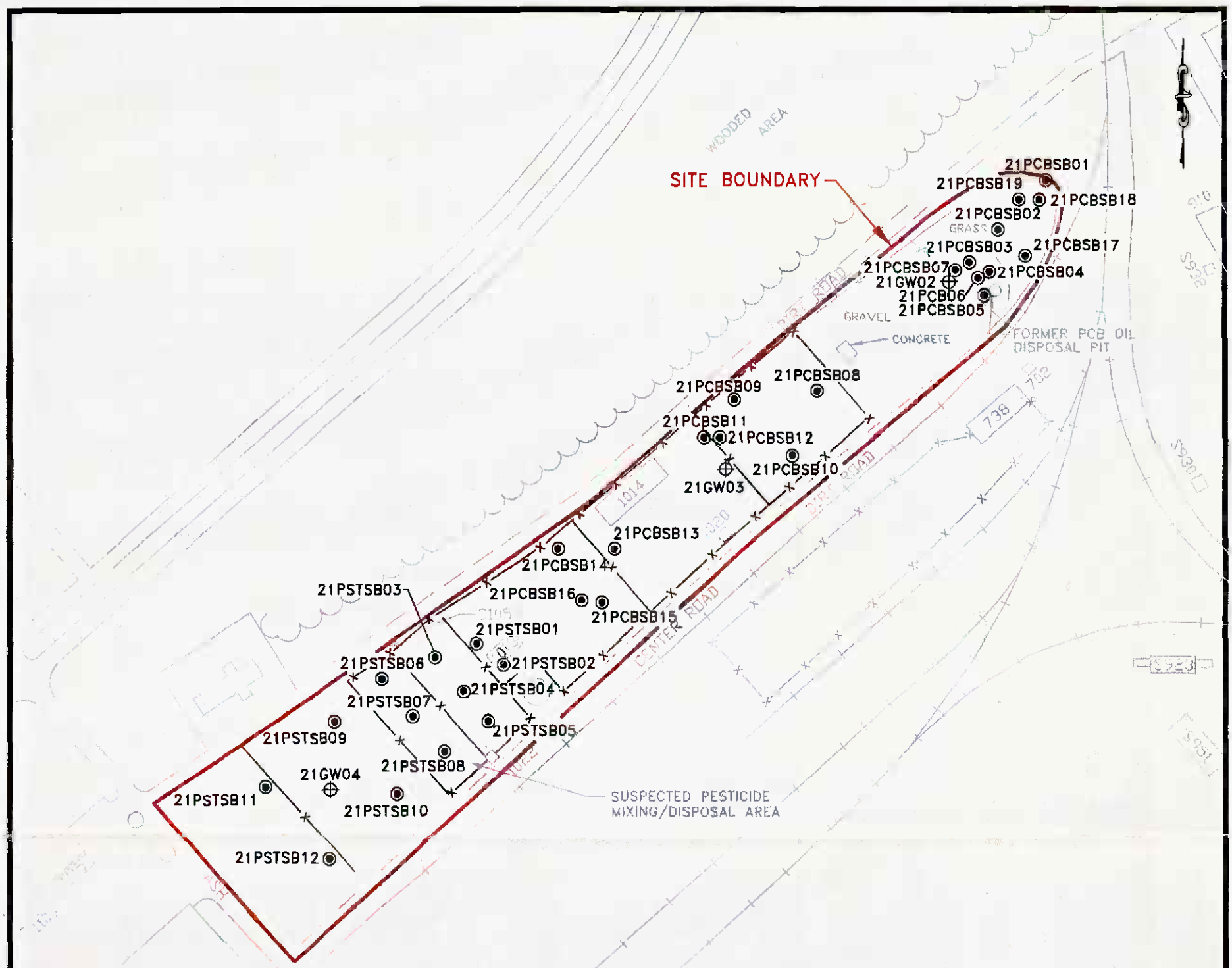
exploratory borings were collected from the surface (ground surface to 6 inches) and then at continuous two-foot intervals (starting at one foot) until the borings were terminated at the approximate depth of the water table (varied from 4 to 14 feet below ground surface [bgs]). In some cases where potential wetting fronts were suspected (i.e., perched water table), an additional split-spoon was driven below the water table to confirm groundwater depth. Soils obtained from borings advanced for monitoring well installation were obtained at continuous two-foot intervals (from the ground surface) to just below the water table, then at approximate five-foot intervals thereafter until the borings were terminated (approximately 15 to 20 feet bgs). This sampling scheme was employed because surface soils were not subject to analytical testing from monitoring well borings. A summary of the boring numbers, boring depths, and sampling intervals is provided in Appendix G (G.1).

Each split-spoon soil sample was classified in the field by the site geologist. Soils were classified using a general Unified Soil Classification System (USCS) lithologic description. 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 E and the Test Boring and Well Construction Records in Appendix F.

Soil Sampling

Soil Sample Locations

Soil samples were collected throughout Site 21 as depicted on Figure 2-3. The sampling distribution was intended to evaluate the vertical and horizontal extent of contamination at both areas of concern. Selection of sample locations was based on review of historical aerial photographs, Camp Lejeune historical records, and previous investigation data. Review of these documents indicated several suspected areas which may have been used for the disposal and mixing of pesticides and possibly the disposal of transformer oil. A total of 13 borings [one advanced for monitoring well installation (21GW04)] were advanced to assess the Former Pesticide Mixing/Disposal Area and a total of 18 borings [two advanced for monitoring well installation (21GW02 and 21GW03)] were advanced to assess the Former PCB Transformer Disposal Area. Moreover, three additional borings (21PCBSB17, 21PCBSB18, and 21PCBSB19) were advanced to further evaluate the extent of contamination near the Former



NOTES:
- -PST GRID (BORINGS PSTSB01-PSTSB12) LOCATED WITHIN FORMER PESTICIDE MIXING/DISPOSAL AREA.
- -PCB GRID (BORINGS PCBSB01-PCBSB19) LOCATED WITHIN FORMER PCB TRANSFORMER DISPOSAL AREA.

200 0 100 200 400

1 inch = 200 ft.

177305RI

Baker Environmental, Inc.

LEGEND

21PCBSB01 SOIL BORING

21GW02 SOIL BORING ADVANCED FOR MONITORING WELL

SOURCE: LANTDIV, FEBRUARY 1992

FIGURE 2-3
SOIL BORING LOCATIONS
SITE 21
REMEDIAL INVESTIGATION CTO-0177

MARINE CORPS BASE, CAMP LEJEUNE
NORTH CAROLINA

PCB Transformer Disposal Area based on analytical data from "quick" turnaround surface samples (i.e., sample analyzed within seven days) collected from boring 21PCBSB04. The preliminary, unvalidated data received from the laboratory indicated an elevated level of PCB-1260 (greater than 20,000 µg/kg). Finalized data received by Baker, however, indicated a much lower concentration (2,100 µg/kg) of PCB-1260 which is more representative of actual contamination levels.

Soil Sampling Procedures

Surface (ground surface to 6 inches) and subsurface (deeper than one foot) soil samples were retained for laboratory analysis. Surface samples were collected for human health and ecological risk assessment evaluation while subsurface samples were collected to evaluate the nature and extent (both horizontal and vertical) of potentially impacted soils. A summary of the sample numbers, sample depths, and parameters analyzed is provided in Appendix G (G.1).

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 6-inches bgs so that the soil cuttings could be retained for the grab sample. The first few inches of top soil or matted roots were removed prior to advancing the augers (some areas were covered with grass or humus material). Deeper subsurface grab samples were collected with a split-spoon sampler in accordance with ASTM Method D 1586-84. The augers, split-spoon samplers, and hand auger buckets were decontaminated prior to sample collection according to the procedures outlined in Section 2.3.7.

Typically, two samples per borehole were submitted for analysis. In some cases, a third sample from a 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 boring was deeper than 10 feet. In general, samples retained for laboratory analysis were collected from the surface and just above the water table. A sample was also submitted from just 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, PCBs, pesticides) were first thoroughly mixed and then placed in the appropriate laboratory containers.

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

Analytical Program

The analytical program initiated for the soil investigation at Site 21 focused on the suspected contaminants of concern which were based on previous disposal practices and site activities. In general, soils collected in the vicinity of the Former Pesticide Mixing/Disposal Area were analyzed for TCL pesticides and herbicides; soils collected in the vicinity of the Former PCB Transformer Disposal Area were analyzed for PCBs. Moreover, a selected number of samples (over 10 percent) were analyzed for full TCL organics (VOCs, SVOCs, PCBs, and pesticides) and TAL metals. Appendix G (G.1) summarizes the boring numbers, sample depths, and parameters analyzed for each boring.

In addition to analyzing for the contaminants of concern, four borings were advanced (two within the Former PCB Transformer Disposal Area and two within the Former Pesticide Mixing/Disposal Area) for the collection of soils for analysis of engineering parameters (i.e., chemical properties). Chemical engineering parameters included: full (organics and metals) TCLP, organic chloride, total fluoride, organic nitrogen, and alkalinity; and RCRA hazardous waste characteristics including corrosivity, ignitability, and reactivity. These parameters were analyzed to assist in evaluating potential applicable technologies (e.g., thermal destruction, solidification/fixation). Engineering parameter samples consisted of composites of individual grab samples collected from 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 mixed prior to filling the sample jars).

Quality Assurance and Quality Control

Field QA/QC samples were also collected during the soil investigation. These samples were obtained to: 1) ensure that decontamination procedures were properly implemented (e.g., equipment rinsate samples); 2) evaluate field methodologies (e.g., duplicate samples); 3) establish field background conditions (e.g., field blanks); and 4) evaluate whether cross-contamination occurred during sampling and/or shipping (e.g., trip blanks). 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).

Several 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 VOC analysis only).

Table 2-5 summarizes field QA/QC sample types, sample frequencies, the number of QA/QC samples, and parameters analyzed.

Field QA/QC samples were collected according to the procedures outlined in the USEPA Region IV SOPs (note that equipment rinsate samples were collected daily, but were analyzed every other day in accordance with 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 flame FID or PID to monitor for airborne contaminants. Moreover, samples (i.e., split-spoon samples) were screened with a PID or FID 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 E and F. Note that prior to daily monitoring, the field instruments were calibrated and documentation was recorded in a field logbook and on calibration forms.

2.3.3.2 Site 24 Soil Investigation

Site 24 was reportedly used for the disposal of fly ash, cinders, solvents, used paint stripping compounds, sewage sludge, and water treatment spiractor sludge from the late 1940s to 1980

TABLE 2-5

SUMMARY OF FIELD QUALITY ASSURANCE/QUALITY CONTROL
SAMPLING PROGRAM FOR THE SOIL INVESTIGATION
SITE 21
REMEDIAL INVESTIGATION CTO-0177
MCB CAMP LEJEUNE, NORTH CAROLINA

QA/QC Sample (1)	Frequency of Collection	Number of Samples	Analytical Parameters (3)
Trip Blanks (2)	One per Cooler	7	TCL Volatiles
Field Blanks (4)	One per Event	1	TCL Organics/TAL Inorganics
Equipment Rinsates (5)	One per Day	2	TCL Organics/TAL Inorganics
Field Duplicates (6)	10% of Sample Frequency	9	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 TCL volatiles only.
(3) Parameters analyzed according to CLP Protocol.
(4) Field blank collected from a potable water source 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 the sampling event. Accordingly, the number of samples presented represents the number of samples analyzed.
(6) Field duplicate samples collected from soil borings presented in Appendix N.

(ESE, 1990). The site is not currently being used for disposal activities. The soil investigation conducted at Site 24 focused on four main areas of concern: Spiractor Sludge Disposal Area; Fly Ash Disposal Area; Borrow and Debris Disposal Area; and Buried Metal Areas. The following sections describe the drilling and sampling procedures and analyses employed at Site 24.

Drilling Procedures

Drilling activities at Site 24 commenced on April 27, 1993, and continued through May 7, 1993. The boreholes were advanced by using the same methods as those described in Section 2.3.3.1 for Site 21 [i.e., truck-mounted or all terrain vehicle (ATV) drill rig using 3-1/4-inch ID augers]. Drilling and sampling activities were performed using Level D personal protection [note that upgraded levels of protection were not required during the drilling and sampling program].

As described in Section 2.3.3.1, two types of borings were installed during the investigation; exploratory borings (i.e., boring installed for sample collection only) and boring advanced for monitoring well installation. The sampling intervals and methods employed for soils collected at Site 24 were the same as those described for Site 21. Typically, two samples per boring were submitted for chemical analysis. Samples from the exploratory borings for chemical analysis were obtained from the surface and just above the water table. Samples from the monitoring well borings were obtained from just above and below the water table. A summary of the boring numbers, boring depths, and sampling intervals is provided in Appendix G (G.2).

Additionally, each split-spoon soil sample was classified visually by the site geologist as described in Section 2.3.3.1. Lithologic descriptions of site soils are provided on the Test Boring Records in Appendix E and the Test Boring and Well Construction Records in Appendix F.

Soil Sampling

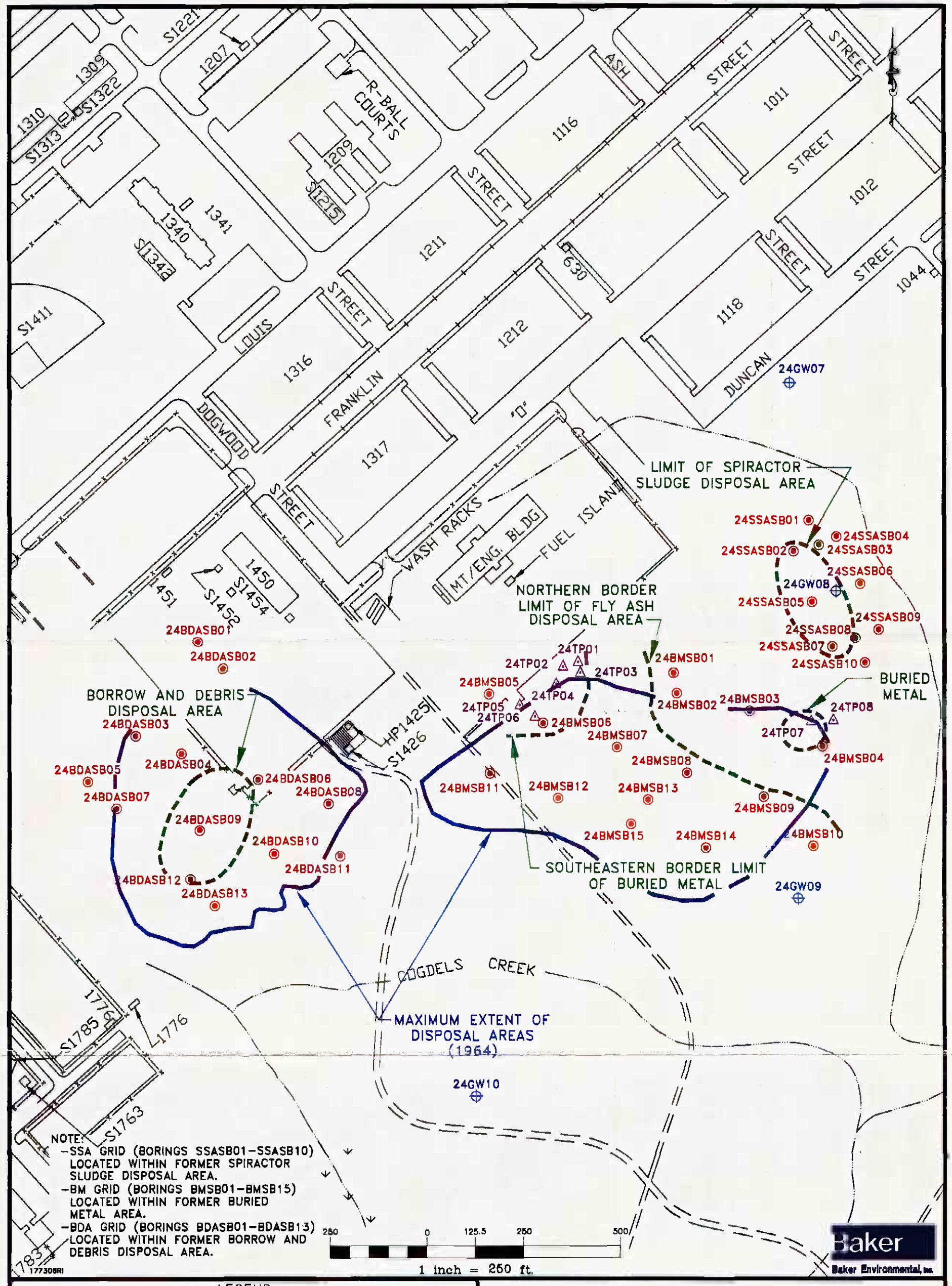
Soil Sample Locations

Soil samples were collected throughout Site 24 as depicted on Figure 2-4. As described above, four main areas of concern were identified at Site 24. The selection of sample locations was based on review of historical aerial photographs provided by EPIC (USEPA, 1992a), Camp Lejeune historical records, previous investigation data (which included pre-investigation sampling conducted by Baker in July 1992), and a pre-investigation geophysical survey. Overall, review of these documents confirmed the four areas of concern (Spiractor Sludge Disposal Area; Fly Ash Disposal Area; Borrow and Debris Disposal Area; and the Buried Metal Disposal Areas) which may have been used for the disposal of various wastes (e.g., fly ash, cinders, solvents, and used paint stripping compounds). Because these areas of concern had different types of wastes disposed, each area was investigated separately.

As shown on Figure 2-4, 11 borings (including one installed for the installation of a monitoring well) were installed within the Spiractor Sludge Disposal Area, 17 borings (including two installed for the installation of monitoring wells) were installed within the Buried Metal Disposal Areas and Fly Ash Disposal Area, and 13 borings were installed within the Borrow and Debris Disposal Area. The Fly Ash Disposal Area and the Buried Metal Disposal Areas were considered as one area for the sampling program because they are essentially continuous sites. The borings were installed and samples collected to adequately characterize the nature and extent of contamination. Note that no additional borings were installed at any of the four areas of concern investigated [per the Final RI/FS Field Sampling and Analysis Plan (FSAP)] to further assess the extent of contamination because the "quick" turnaround samples (i.e., samples analyzed within seven days) did not exhibit excessive amounts of contamination. Furthermore, note that samples collected from monitoring well boring 24GW07 served as site-specific background samples.

Soil Sampling Procedures

Surface and subsurface soil samples were obtained via a drill rig (i.e., split-spoon samples) or a hand auger as described in Section 2.3.3.1 for Site 21. Typically, two samples per borehole were submitted for analysis. In some cases, a third sample from a borehole was also submitted for analysis if indications of contamination (i.e., elevated PID readings or visual contamination) were noted or if the boring was deeper than 10 feet. In general, samples



LEGEND

24BDASB01 — SOIL BORING

24GW07 — SOIL BORING ADVANCED FOR MONITORING WELL

24TP01 — TEST PIT SAMPLE

SOURCE: LANTDIV, FEBRUARY 1992

FIGURE 2-4
SOIL BORING AND TEST PIT LOCATIONS
SITE 24
REMEDIAL INVESTIGATION CTO-0177
MARINE CORPS BASE, CAMP LEJEUNE
NORTH CAROLINA

0127IV12Y

retained for laboratory analysis were collected from the surface and just above the water table. A sample was also submitted from just below the water table at borings advanced for monitoring well installation (no surface sample submitted for these borings) so that groundwater results could be correlated with soil conditions. Soil samples retained for analysis were prepared and handled according to the procedures outlined on Section 2.3.3.1 (same procedures as those described for Site 21). A summary of the sample numbers, sample depths, and parameters analyzed is provided in Appendix G (G.2).

Analytical Program

The analytical program initiated for the soil investigation at Site 24 focused on the suspected contaminants of concern. The selection of chemical analysis for each boring was based on previous disposal activities in the area. In general, samples were analyzed for full TCL organics and TAL inorganics with selected samples analyzed for TAL inorganics only. A summary of the boring numbers, sampling intervals, and parameters analyzed is provided in Appendix G (G.2).

In addition to analyzing for the contaminants of concern, samples from within the four areas were also analyzed for RCRA hazardous waste characteristics (corrosivity, ignitability, and reactivity) and full TCLP in order to determine if the materials are characteristically hazardous. These samples were collected near the center of each disposal area. Additionally, these samples were analyzed for chemical engineering parameters (same as those described in Section 2.3.3.1) to provide information for evaluating potential applicable treatment technologies, if required.

Quality Assurance and Quality Control Samples

Field QA/QC samples were also collected during the soil investigation at Site 24 (including: duplicate samples; equipment rinsate samples; and trip blanks). Table 2-6 summarizes field QA/QC sample types, sample frequencies, the number of QA/QC samples, and parameters analyzed. Field QA/QC samples were collected according to the procedures outlined in the USEPA Region IV SOPs (note that equipment rinsate samples were collected daily, but were analyzed every other day in accordance with USEPA Region IV SOPs).

TABLE 2-6

SUMMARY OF FIELD QUALITY ASSURANCE/QUALITY CONTROL SAMPLING PROGRAM FOR THE SOIL INVESTIGATION
SITE 24
REMEDIAL INVESTIGATION CTO-0177
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	0	TCL Organics/TAL Inorganics
Equipment Rinsates (5)	One per Day	5	TCL Organics/TAL Inorganics
Field Duplicates (6)	10% of Sample Frequency	8	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 TCL volatiles only.
(3) Parameters analyzed according to CLP Protocol.
(4) Field blank collected during Site 21 investigation (see Table 2-5).
(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.
(6) Field duplicate samples collected from soil borings presented in Appendix N.

Test Pit Sampling

Test pit sampling activities were conducted at Site 24 to further investigate the nature and extent of contamination, and to visually identify the reported buried waste material. Information obtained by the EPIC Study and results from the geophysical investigation were used to locate test pit sample locations. These areas were surveyed with several points facilitating as center points for excavation activities. Test pits were then excavated outward from the surveyed points. In order to standardize the design and layout in the field, and to protect against underestimation of the disposal areas, test pits were excavated utilizing the survey point as the midpoint.

In general, test pit operations were performed as an exploratory excavation to assess the contents of past disposal/burial operations. Test pits varied in length and depth, and were primarily dependent on:

- Space limitations imposed by the site (i.e., wooded areas and terrain limited movement of the backhoe).

- The capabilities and limitations of the excavation equipment (i.e., depth of excavation was limited to the length of the boom on the backhoe).

- The amount and type of material encountered (i.e., large amount of very fine fly ash, which caused test pit walls to cave in after achieving a certain depth).

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. Air monitoring and field screening procedures implemented at Site 24 were the same as those described for Site 21 (Section 2.3.3.1). Measurements obtained in the field (i.e., screening of split-spoon samples) were recorded in a field logbook. Air monitoring was performed with a radiation meter, combustible gas indicator, and FID or PID. No readings were obtained from air monitoring instrumentation above background.

Test Pit Sample Locations

Based on studies conducted by EPIC, (i.e., aerial photographic investigation) past history, and previous activities at Site 24, points were surveyed throughout the four areas identified as potential disposal/burial areas. All samples collected were suspected to be within the disposal areas, as the primary purpose was to confirm the presence or absence of contamination. No samples were collected outside the suspected disposal area as part of the test pit activities. Test pit sample locations are shown on Figure 2-4.

Eight test pits (24TP01 through 24TP08) were excavated as part of this RI. Sampling locations within each excavation were determined in the field based on visual observations and air monitoring results. Samples were collected from areas containing suspected disposal material (i.e., spiractor sludge, fly ash, debris, and buried metal). Samples (24TP04, 24TP06, and 24TP07) were collected where suspected waste was present. In addition, a sample was collected from the bottom of each test pit to provide information on the vertical extent of contamination.

Test Pit Sampling Procedures

Exploratory test pit excavation operations were performed on May 9, 1993 throughout Site 24. Upon delineation of work zones, activities commenced with a Case 580 backhoe (excavator) equipped with a three-foot wide bucket to excavate soils to the desired sampling depth. Test pits were excavated approximated six to ten feet in length and six feet in depth. Subsequent to visual inspection and sample collection, a sample number was affixed to each sample container.

Grab sampling techniques were implemented for collection of waste material and soil. Samples were collected directly from the backhoe bucket. Test pit sample locations were chosen based on visual observation (i.e., indications of waste material) or readings obtained from real time air monitoring instrumentation. All test pits had samples collected from the base of the pit to confirm the vertical extent of contamination. In addition, three test pits had samples obtained from suspected waste. All information regarding sample depth and findings were recorded in field log books and transcribed to test pit logs. Appendix G (G.3) provides a summary of test pit sample numbers, sample depths, and analytical parameters tested. No geological characterization was performed on test pits, as several soil borings and well

installation boreholes in the area provided a detailed subsurface description. Excavated soil was stockpiled adjacent to the test pit and immediately backfilled upon completion.

Test Pit Sample Analytical Program

Samples collected from the test pits were shipped for laboratory analysis to NUS Laboratory. Sample analysis of suspected waste material included RCRA characteristics (ignitability, corrosivity, and reactivity) and full TCLP analysis. In addition, samples collected from the base of the test pit were analyzed for TCL organics and TAL inorganics using CLP protocols.

2.3.3.3 Site 78 Soil Investigation

Site 78 encompasses the industrial area of MCB Camp Lejeune. A number of the buildings within Site 78 were used for the storage/usage of solvents, petroleum, oil, lubricants, pesticides, and PCBs. The soil investigations conducted at Site 78 focused on the following areas of concern: (1) suspected UST locations at Buildings 903, 1502, and 1601 identified during the pre-investigation geophysical survey; (2) Building 1300; and (3) Buildings 1103 and 1608. Building 1300 was investigated because a previous investigation indicated low levels of PCBs (PCB-1260) in a boring to a depth of six feet. Furthermore, Buildings 1103 and 1601 were investigated because a previous investigation indicated low levels of pesticides (dieldrin, 4,4'-DDT, and 4,4'-DDE) in borings near both of the buildings. Building 1608 had no prior history of a waste storage/usage but was included in the investigation because of its close proximity to Building 1601. The purpose of the sampling programs initiated at these three areas of concern, therefore, was to confirm the presence or absence of contamination and to assess the areal extent. A summary of the drilling procedures, sample locations, sampling procedures, and analytical program related to this soil investigation is presented below.

Drilling Procedures

Drilling activities at Site 78 commenced on May 8, 1993, and continued through May 19, 1993. HHI was retained to perform the drilling services. The boreholes were advanced by employing the same methods as those described in Sections 2.3.3.1 and 2.3.3.2 for Sites 21 and 24 (i.e., truck-mounted drill rig using 3-1/4-inch ID augers). Additionally, samples were also obtained with a hand auger at locations where underground utilities were suspected or where drilling locations were inaccessible with a drill rig. Drilling and sampling activities were performed using Level D personal protection [note that upgraded levels of protection (e.g.,

Level D to Level C personal protection) were not required during the drilling and sampling program].

As described in Sections 2.3.3.1 and 2.3.3.2, two types of borings were installed during the investigation; exploratory borings (i.e., boring installed for sample collection only) and borings advanced for monitoring well installation. The sampling intervals and methods employed for soils collected at Site 78 were the same as those described for Sites 21 and 24. A summary of the boring numbers, boring depths, and sampling intervals is provided in Appendix G.

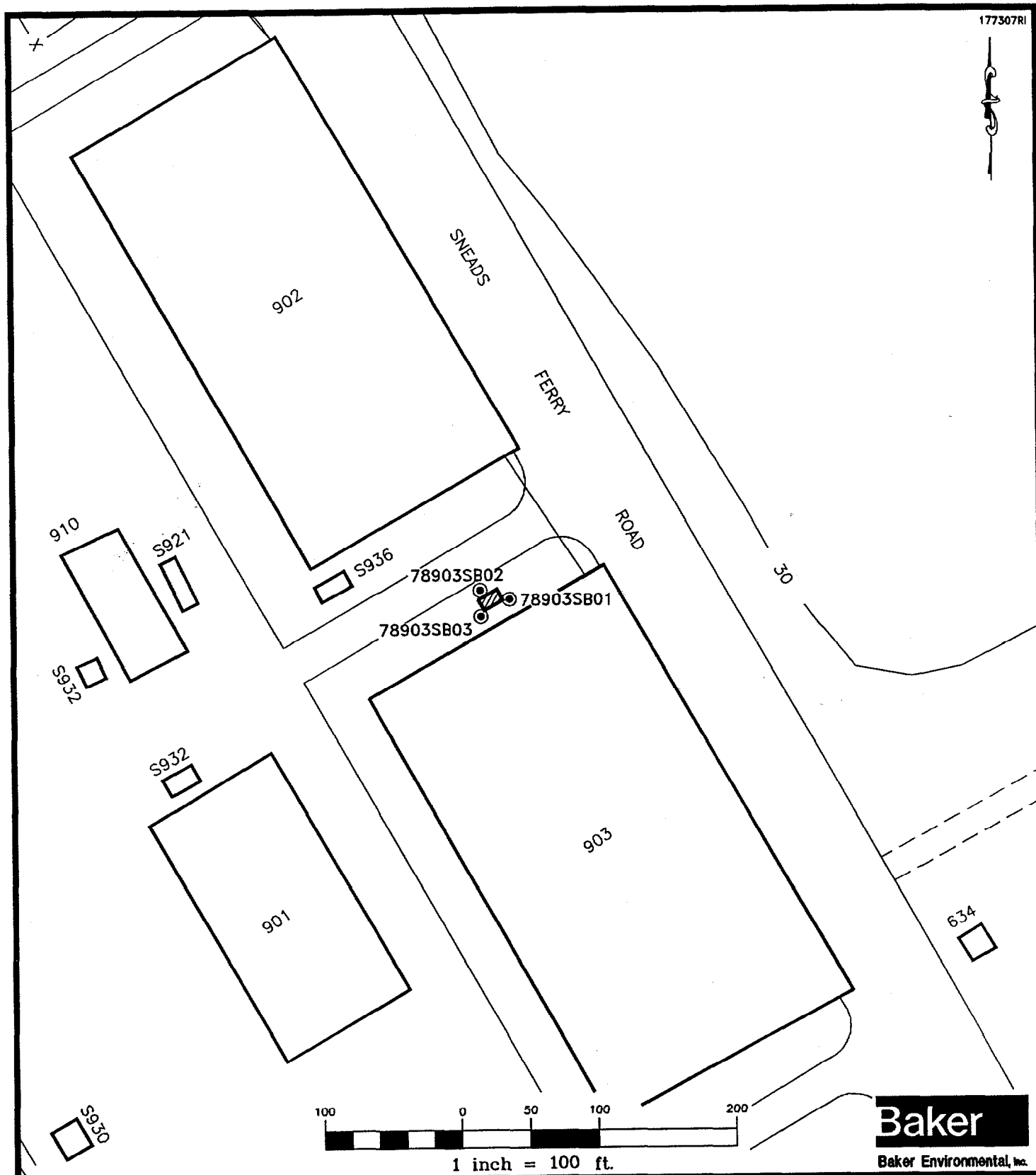
Each split-spoon sample was classified visually by the site geologist as described in Section 2.3.3.1. Lithologic descriptions of soils collected at Site 78 are provided on the Test Boring Records in Appendix E and the Test Boring and Well Construction Records in Appendix F.

Soil Sampling

Soil Sample Locations

As mentioned above, five main areas (Building 1608 included with 1601) of concern were identified at Site 78 based on the results of previous analytical data, the geophysical investigation, and Camp Lejeune historical records. Boring locations are shown on Figures 2-5A (Building 903), 2-5B (Buildings 1502, 1601, and 1608), 2-5C (Building 1103), and 2-5D (Building 1300). As shown on Figures 2-5A through 2-5D, approximately three borings were installed at each UST area, and approximately five borings per building were installed at Buildings 1103, 1300, and 1601 to assess PCB and/or pesticide contamination. Samples collected from boring 78-BB-SB (surface and subsurface) served as site-specific background samples.

Note that no additional borings were installed at any of the buildings investigated (per the Final RI/FS FSAP, if necessary) to further assess the extent of contamination because the "quick" turnaround samples did not exhibit excessive amounts of contamination. Additional borings for monitoring well installation, however, were installed based on the results of the soil gas survey and for the replacement of monitoring well 78GW09-1. These boring/monitoring wells are discussed in Section 2.3.4.3.



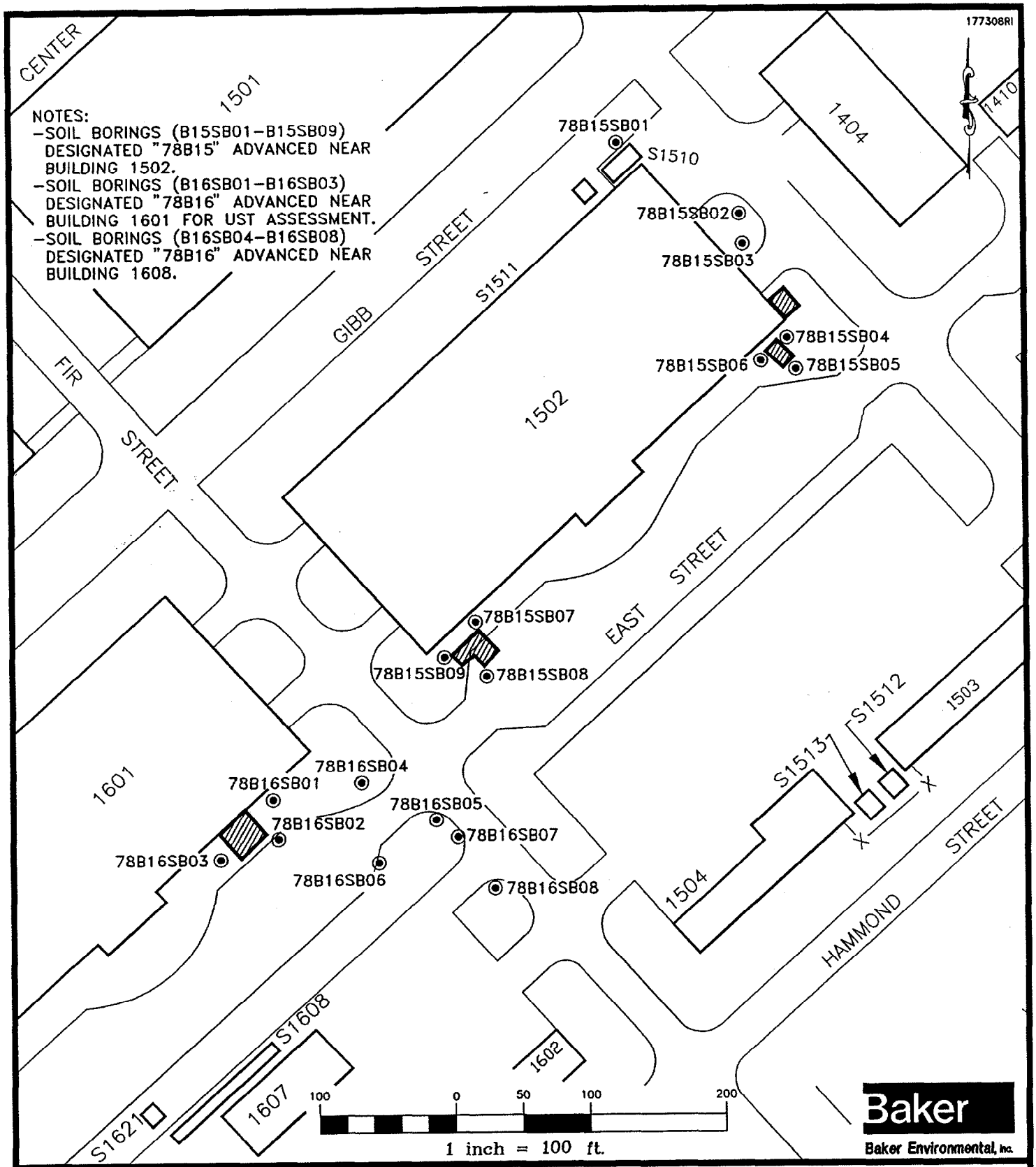
LEGEND

SUSPECTED UST AREA

78903SB01 SOIL BORING

SOURCE: LANTDIV, FEB. 1992

FIGURE 2-5A
SOIL BORING LOCATIONS
BUILDING 903
SITE 78
REMEDIAL INVESTIGATION CTO-0177
MARINE CORPS BASE, CAMP LEJEUNE
NORTH CAROLINA



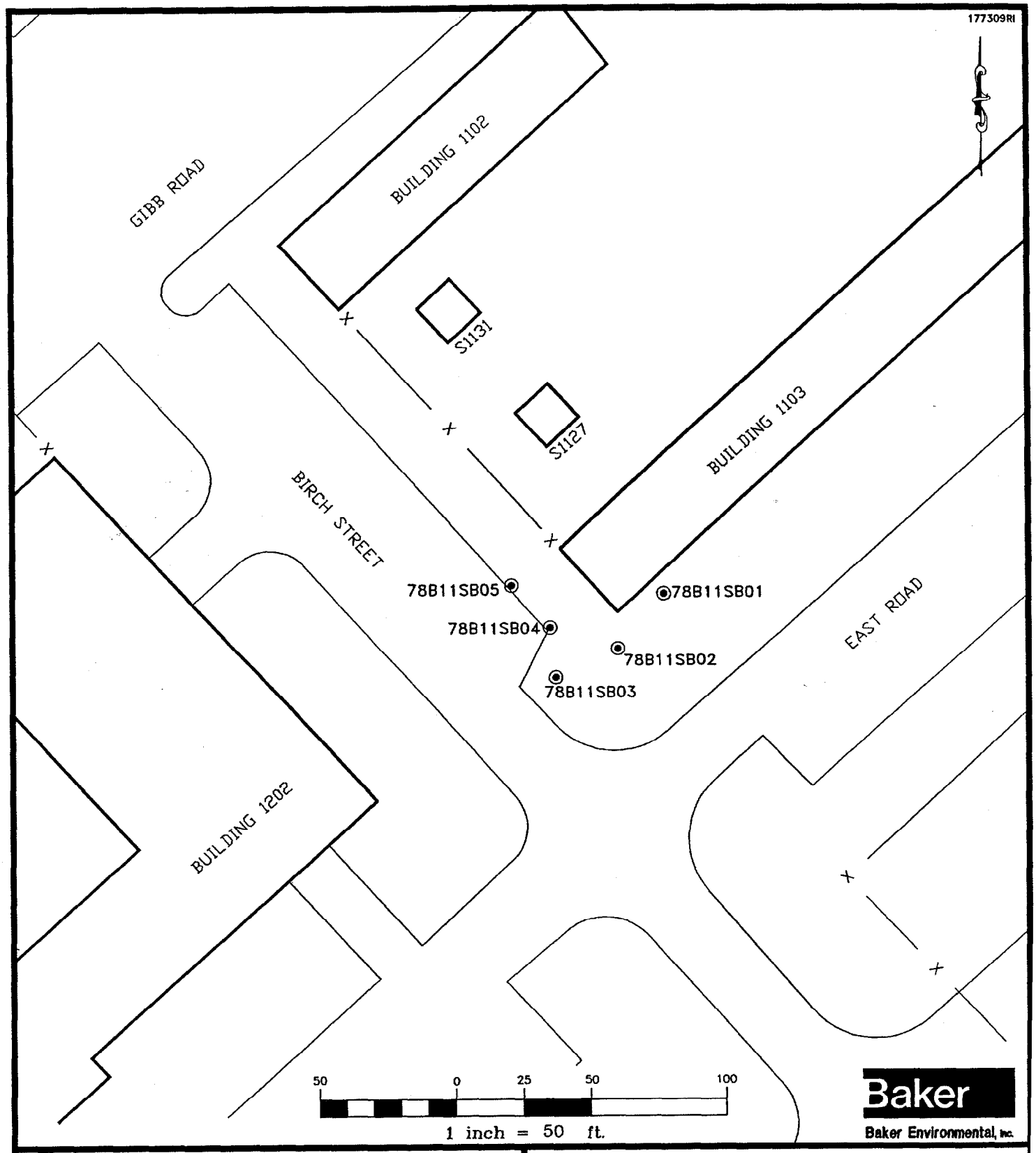
LEGEND

SUSPECTED UST AREA

78B15SB01 SOIL BORING

SOURCE: LANTDIV, FEB. 1992

FIGURE 2-5B
SOIL BORING LOCATIONS
BUILDINGS 1502, 1601 AND 1608
SITE 78
REMEDIAL INVESTIGATION CTO-0177
MARINE CORPS BASE, CAMP LEJEUNE
NORTH CAROLINA

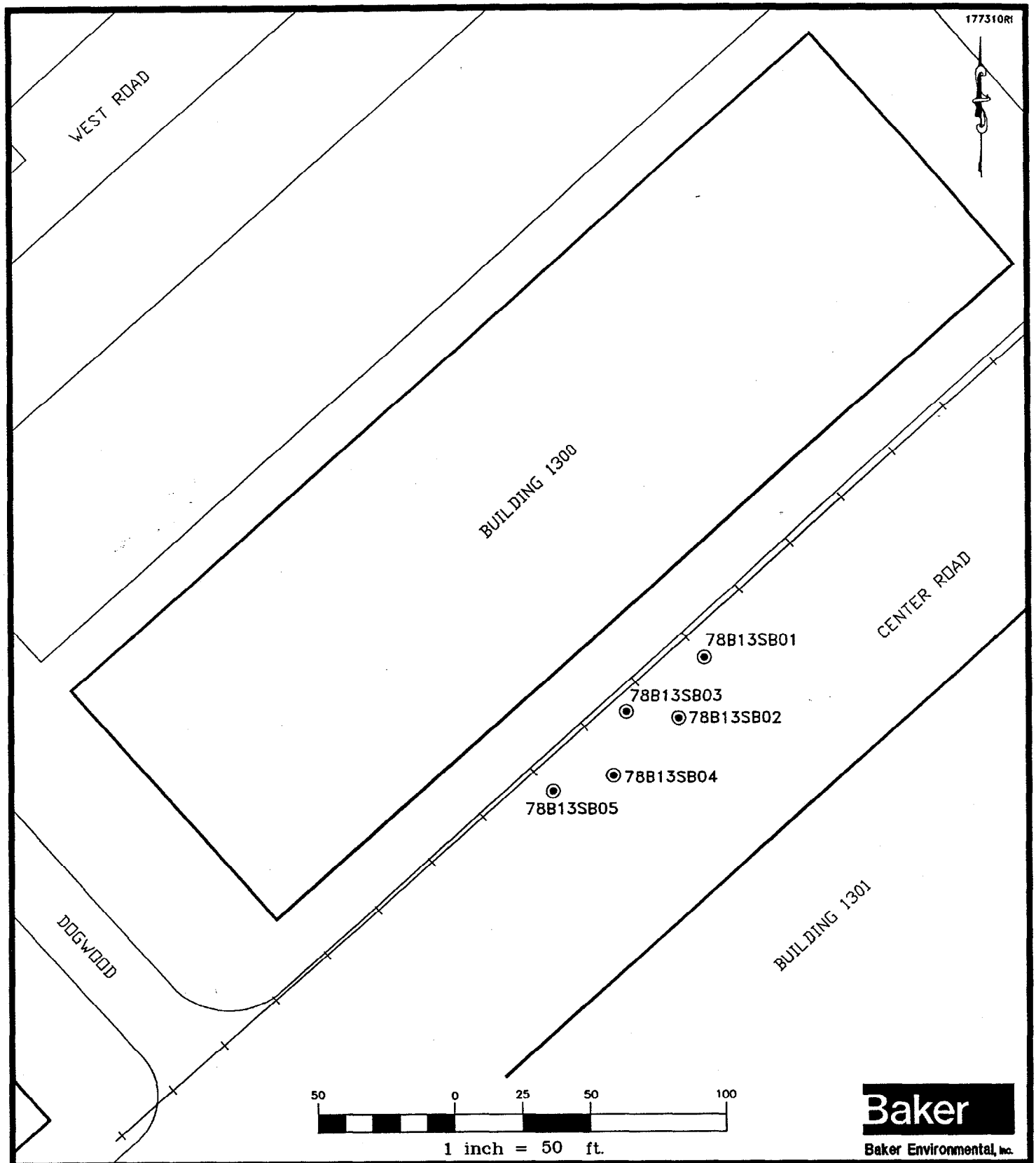


LEGEND

78B11SB01 SOIL BORING

SOURCE: LANTDIV, FEB. 1992

FIGURE 2-5C
SOIL BORING LOCATIONS
BUILDING 1103
SITE 78
REMEDIAL INVESTIGATION CTO-0177
MARINE CORPS BASE, CAMP LEJEUNE
NORTH CAROLINA



LEGEND

78B13SB01 ◉ SOIL BORING

SOURCE: LANTDIV, FEB. 1992

FIGURE 2-5D
SOIL BORING LOCATIONS
BUILDING 1300
SITE 78
REMEDIAL INVESTIGATION CTO-0177
MARINE CORPS BASE, CAMP LEJEUNE
NORTH CAROLINA

Soil Sampling Procedures

Surface and subsurface soil samples were obtained via a drill rig (i.e., split-spoon samples) or a hand auger as described in Sections 2.3.3.1 and 2.3.3.2. Typically, two samples per borehole were submitted for analysis. In some cases, a third sample from a borehole was also submitted for analysis if indications of contamination (i.e., elevated PID readings or visual contamination) were noted or if the boring was deeper than 10 feet. In general, samples retained for laboratory analysis were collected from the surface and just above the water table. A sample was also submitted from just below the water table at borings advanced for monitoring well installation (no surface sample submitted for these borings) so that groundwater results could be correlated with soil conditions. Soil samples retained for analysis were prepared and handled according to the procedures outlined on Sections 2.3.3.1 and 2.3.3.2 (same procedures as those described for Sites 21 and 24). A summary of the sample numbers, sample depths, and parameters analyzed is provided in Appendix G (G.3).

Analytical Program

The analytical program initiated for the soil investigation at Site 78 focused on the suspected contaminants of concern at each building. As mentioned previously, the contaminants of concern were identified from previous investigations. Samples from the suspected UST areas were analyzed for TCL volatiles; samples from Buildings 1103, 1601 (and 1608) were analyzed for TCL pesticides/herbicides; samples from Building 1300 were analyzed for TCL pesticides/herbicides and TCL PCBs; and samples collected during the installation of replacement monitoring well 78GW09-1 were analyzed for TCL volatiles. A summary of the boring numbers, sampling intervals, and parameters analyzed is provided in Appendix G (G.3).

In addition to analyzing for the contaminants of concern, two borings advanced at Building 903 to collect composite samples for chemical engineering parameters. These samples were analyzed for the same engineering parameters as those described in Section 2.3.3.1. The samples were collected to provide information for evaluating potential applicable treatment technologies, if required.

Quality Assurance and Quality Control Samples

Field QA/QC samples were also collected during the soil investigation at Site 78 (including: duplicate samples; equipment rinsate samples; and trip blanks). Table 2-7 summarizes field QA/QC sample types, sample frequencies, the number of QA/QC samples, and parameters analyzed. Field QA/QC samples were collected according to the procedures outlined in the USEPA Region IV SOPs (note that equipment rinsate samples were collected daily, but were analyzed every other day in accordance with 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. Air monitoring and field screening procedures implemented at Site 78 were the same as those described for in Sections 2.3.3.1 and 2.3.3.2 for Sites 21 and 24. Measurements obtained in the field (i.e., screening of split-spoon samples) 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 E and F, respectively.

2.3.4 Groundwater Investigation

The groundwater investigations implemented at OU No. 1 consisted of several activities including drilling/monitoring well installation, well development, groundwater sampling, and static water level measurements. The investigation was intended to confirm the presence or absence of shallow and deep groundwater contamination (e.g, VOCs), evaluate the horizontal extent of the potentially impacted groundwater, and evaluate the shallow groundwater flow patterns in the area. The primary objectives of these investigations are summarized on Tables 2-1 through 2-3.

The field procedures and sampling methods employed for this study were implemented in accordance with USEPA Region IV SOPs. These procedures also included sample handling and preservation, documentation, and chain-of-custody procedures. Specific sampling procedures are outlined in the FSAP for OU No. 1. The following sections describe the procedures for drilling/monitoring well installation, well development, groundwater sampling, and static water level measurements implemented at each site.

TABLE 2-7

SUMMARY OF FIELD QUALITY ASSURANCE/QUALITY CONTROL SAMPLING PROGRAM FOR THE SOIL INVESTIGATION
SITE 78
REMEDIAL INVESTIGATION CTO-0177
MCB CAMP LEJEUNE, NORTH CAROLINA

QA/QC Sample (1)	Frequency of Collection	Number of Samples	Analytical Parameters (3)
Trip Blanks (2)	One per Cooler	16	TCL Volatiles
Field Blanks (4)	One per Event	0	TCL Organics/TAL Inorganics
Equipment Rinsates (5)	One per Day	4	TCL Organics/TAL Inorganics
Field Duplicates (6)	10% of Sample Frequency	10	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 TCL volatiles only.
(3) Parameters analyzed according to CLP Protocol.
(4) Field blank collected during Site 21 investigation (see Table 2-5).
(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.
(6) Field duplicate samples collected from soil borings presented in Appendix N.

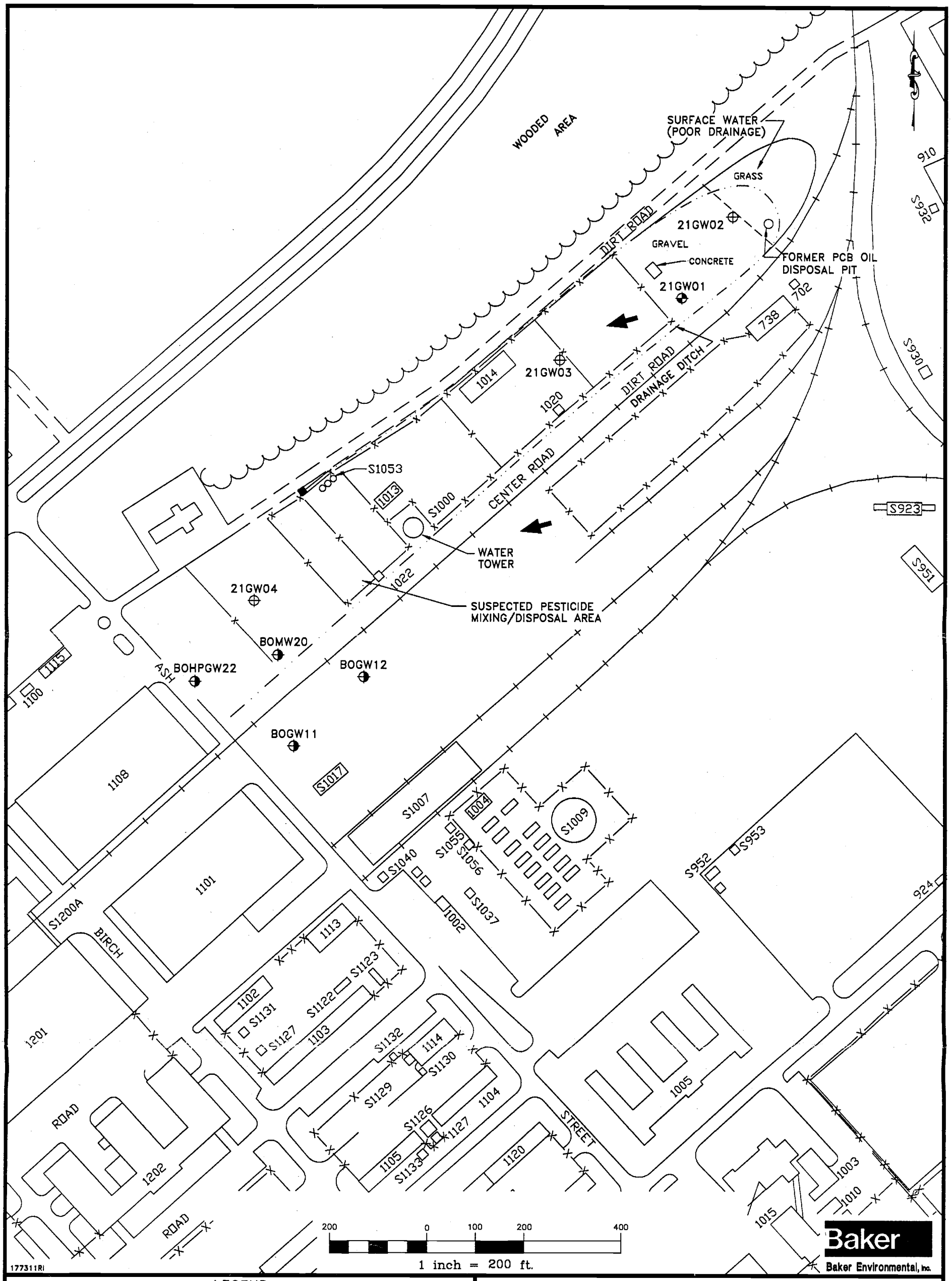
2.3.4.1 Site 21 Groundwater Investigation

Well Installation

Three shallow Type II (i.e., wells installed without outer casing to seal off a confining layer) monitoring wells (21GW02, 21GW03, and 21GW04) were installed at Site 21 between May 4, 1993, and May 6, 1993, at the locations shown on Figure 2-6. The 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. Selection for the placement of the wells was based on review of historical aerial photographs, Camp Lejeune records, and analytical data from previous investigations. These documents indicated that several areas within Site 21 may have been impacted from previous disposal practices and site activities.

The shallow monitoring wells were installed upon completion of advancing the boreholes (refer to Section 2.3.3.1 for drilling procedures). Each borehole was overdrilled with 8-1/4-inch ID hollow stem augers prior to well installation. Well depths range from 15 to 20.5 feet bgs. In general, the wells were installed approximately 10 feet below where the water table encountered during 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 2-8, and well construction diagrams are shown on the Test Boring and Well Construction Records provided in Appendix F.

The wells are constructed of 4-inch nominal diameter Schedule 40, flush-joint and threaded Poly vinyl chloride (PVC) casing with a 10-foot long No. 10 (.01 inch) slotted screen section. A medium-grained sand pack (No. 2 silica sand), extending approximately 2 feet (where conditions permitted) above the top of the screen, was placed in the annulus between the screen and the borehole wall (12-inch borehole diameter) from inside the augers. 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 water run-off from intruding onto the sand pack. The remaining annular space (approximately 1 to 2 feet in most cases) was backfilled with a mixture of Portland cement and 5 percent bentonite for construction of the pad. An above ground protective casing and PVC locking cap were fitted at the top of each well. Well tags were installed at the top of each well



LEGEND

- 21GW01 — EXISTING SHALLOW MONITORING WELL INSTALLED BY ESE, 1984
- 21GW02 — SHALLOW MONITORING WELL INSTALLED BY BAKER ENVIRONMENTAL, INC., 1993
- BOGW11 — EXISTING SHALLOW MONITORING WELL
- → APPROXIMATE DIRECTION OF GROUNDWATER FLOW

SOURCE: LANTDIV, FEBRUARY 1992

FIGURE 2-6
MONITORING WELL LOCATIONS
SITE 21
REMEDIAL INVESTIGATION CTO-0177

MARINE CORPS BASE, CAMP LEJEUNE
NORTH CAROLINA

0127IV132

TABLE 2-8

SUMMARY OF WELL CONSTRUCTION DETAILS
SITE 21
REMEDIAL INVESTIGATION CTO-0177
MCB CAMP LEJEUNE, NORTH CAROLINA

Well No.	Date Installed	Top of PVC Casing Elevation (feet, above msl)(1)	Ground Surface Elevation (feet, above msl)	Boring Depth (feet, below ground surface)	Well Depth (feet, below ground surface)	Screen Interval Depth (feet, below ground surface)	Sand Pack Interval Depth (feet, below ground surface)	Bentonite Interval Depth (feet, below ground surface)
21GW02	5/4/93	31.02	31.3	20.5	19.5	9.7 - 18.7	6.0 - 20.5	3.0 - 6.0
21GW03	5/4/93	28.94	29.1	18.0	18.0	8.3 - 17.2	7.0 - 18.0	3.0 - 7.0
21GW04	5/6/93	27.56	27.8	15.0	15.0	5.2 - 14.2	3.0 - 15.0	1.0 - 3.0

Notes: (1) msl - mean sea level

Note that all wells were installed as "flush-mounted"
Horizontal positions are referenced to N.C. State Plane Coordinate System (NAD 27) CF = 0.9999216 from USMC Monument Toney. Vertical datum NGVD 29.

which contained well construction information and the notation "Caution Not Potable Water." Typical well construction details are shown on Figure 2-7.

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 wells were developed by a combination of surging and pumping (centrifugal pump). Typically, 50 gallons (approximately 3 to 5 well volumes) of water were evacuated from the wells, followed by 10 minutes of surging, then continued pumping. Groundwater recovered during well development was temporarily stored in drums, then transferred into an on-site tanker (refer to Section 2.3.8 for IDW handling). Pumping hoses (constructed of PVC) were dedicated for each well to minimize the potential for cross-contamination.

Three to five well volumes were removed from each well (where conditions permitted) until the groundwater was essentially sediment-free. Measurements of pH, specific conductance, and temperature were recorded at each well volume to assist in determining well stabilization. Periodic flow and volume measurements were also recorded during development to evaluate flow rates of the shallow water-bearing zone. Well Development Forms summarizing this information are provided in Appendix H (H.1).

Water Level Measurements

Static water level measurements were collected after well development from top-of-casing (TOC) reference points (marked on the PVC casing) at each existing and newly-installed well (refer to Table 3-4 in Section 3.6.2 for results). Complete rounds of the measurements were collected on May 17, June 4, and August 1, 1993. 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 four hour period.

Groundwater Sampling

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

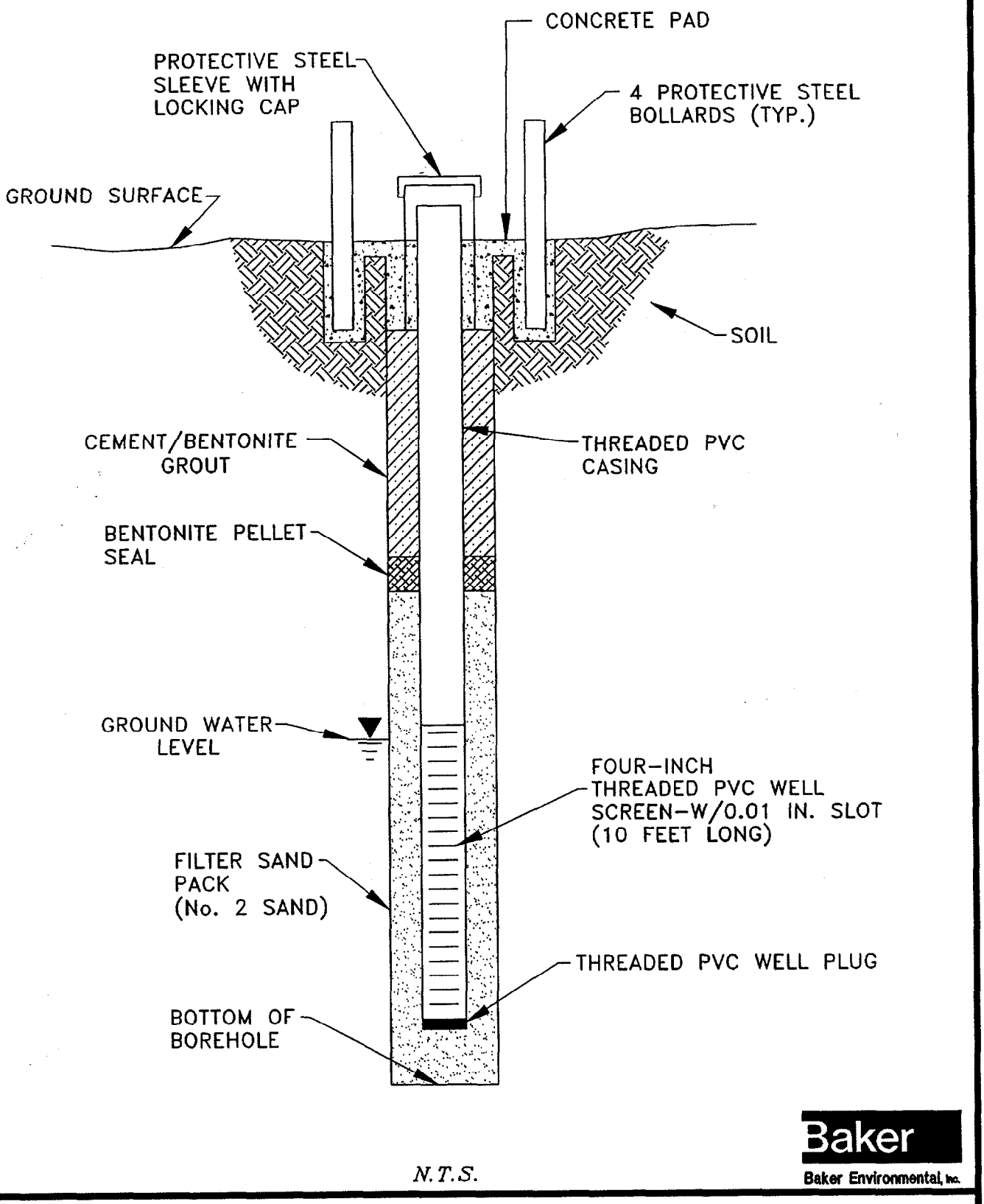


FIGURE 2-7
TYPICAL SHALLOW TYPE II GROUNDWATER
MONITORING WELL CONSTRUCTION DIAGRAM
REMEDIAL INVESTIGATION CTO-0177

MARINE CORPS BASE, CAMP LEJEUNE
NORTH CAROLINA

Groundwater Sampling Locations

Groundwater samples were collected from the four existing and the three newly-installed wells at Site 21. The locations of these wells are shown on Figure 2-6.

Groundwater Sampling Procedures

Groundwater samples were collected to confirm the presence or absence of shallow contamination which may have resulted from previous disposal practices or site activities. At Site 21, the contaminants of concern were pesticides/herbicides and PCBs based on previous investigation results. Accordingly, the sampling program initiated at Site 21 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 submersible pump (Redi-Flo®) and teflon hoses. A flow rate of 1 to 2 gallons per minute (gpm) was maintained during purging. 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 Table 4-9 in Section 4.2.1.2 for results). Purge water was contained and handled as described in Section 2.3.8.

Groundwater samples were collected using decontaminated teflon bailers (i.e., bottom loading bailer) equipped with a teflon-coated leader. The samples were introduced directly from the bailer into laboratory-prepared, preserved sample containers (where appropriate) and stored on ice. Sample bottles for VOC analysis were filled first, followed by SVOCs, PCBs, pesticides, TAL metals (total and dissolved), and cyanide. Volatile samples were collected by slowly pouring water from the bailer into 40 ml vials [acidified with hydrochloric (HCl)] 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 in field with

acidified to pH <2 with nitric (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.

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 Q) accompanied the samples to NUS.

Analytical Program

One round of groundwater samples were analyzed from the four existing and three newly-installed wells. Groundwater samples from the three newly-installed wells (21GW02, 21GW03, and 21GW04), and existing well 21GW01 were analyzed for full TCL organics (including herbicides) and TAL inorganics (i.e., total and dissolved metals, and cyanide). Further, groundwater samples collected from existing wells BOGW11 (samples identified as 21GW0A), BOGW12 (sample identified as 21GW0B), and BOMW20 (Sample identified as 21GW0C) were analyzed for TCL pesticides, herbicides and TAL inorganics. The samples were analyzed by Contract Laboratory Program (CLP) protocols. Note that VOCs were analyzed using USEPA Method 524.2 so that lower detection limits could be obtained.

Quality Assurance and Quality Control Samples

Field QA/QC samples were also submitted during the groundwater investigation. These samples included trip blanks, field blanks, equipment rinsates, and duplicates. Equipment rinsates were collected from the sampling bailers prior to usage. Table 2-9 summarizes the QA/QC sampling program employed for the groundwater investigation conducted at Site 21.

2.3.4.2 Site 24 Groundwater Investigation

Well Installation

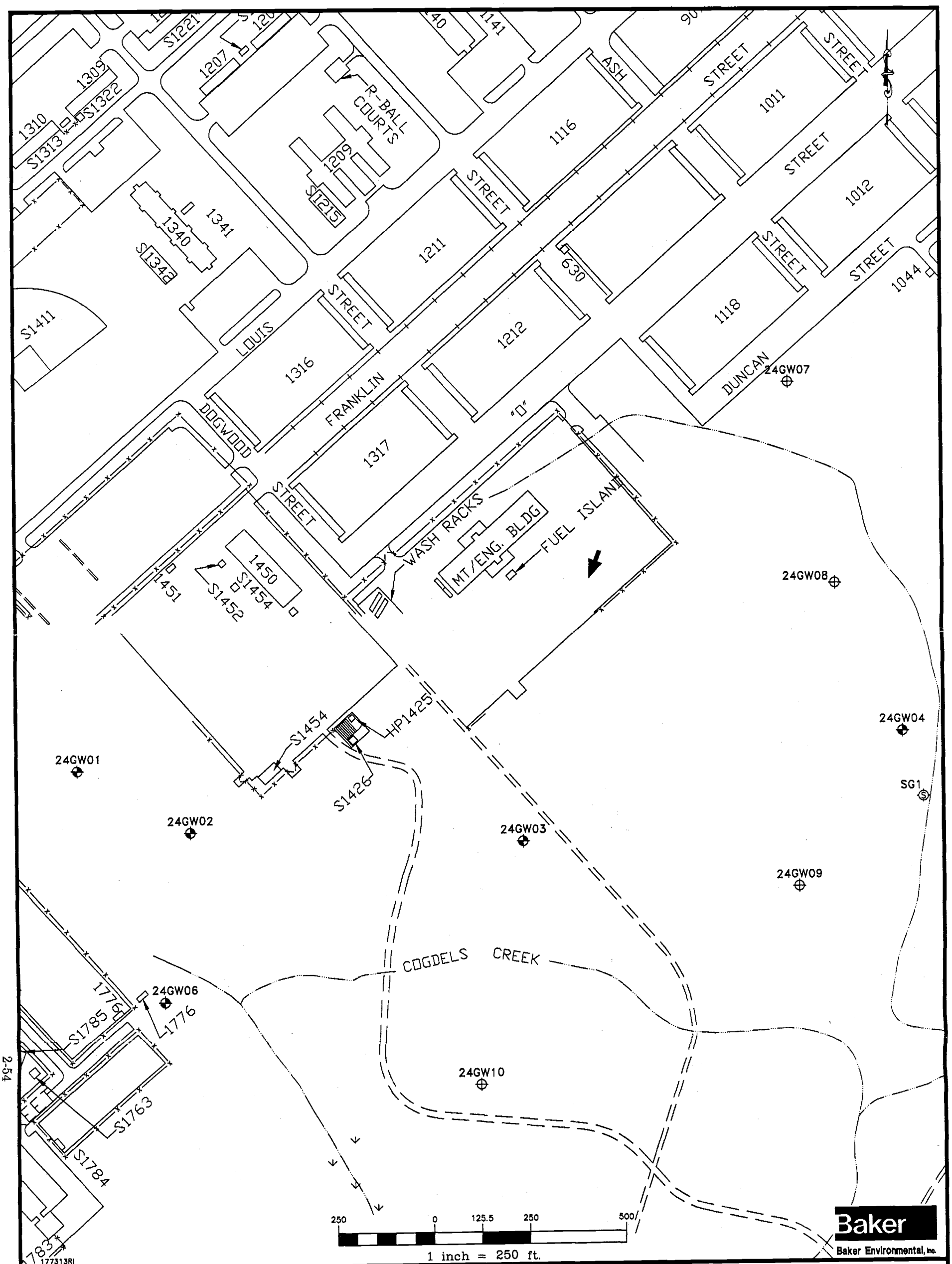
Four shallow Type II monitoring wells (24GW07, 24GW08, 24GW09, and 24GW10) were installed at Site 24 between April 25, 1993, and April 26, 1993, at the locations shown on Figure 2-8. Note that the reported existing well 24GW07 was not located and was

TABLE 2-9

SUMMARY OF FIELD QUALITY ASSURANCE/QUALITY CONTROL SAMPLING PROGRAM FOR THE GROUNDWATER INVESTIGATION SITE 21 REMEDIAL INVESTIGATION CTO-0177 MCB CAMP LEJEUNE, NORTH CAROLINA

QA/QC Sample (1)	Frequency of Collection	Number of Samples	Analytical Parameters (3)
Trip Blanks (2)	One per Cooler	2	Volatiles
Field Blanks (4)	One per Event	0	TCL Organics/TAL Inorganics
Equipment Rinsates (5)	One per Day	1	TCL Organics/TAL Inorganics
Field Duplicates (6)	10% of Sample Frequency	1	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) Field blank collected during Site 21 investigation (see Table 2-5).
(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.
(6) Field duplicate sample locations are summarized in Appendix N.



LEGEND

- 24GW01 — EXISTING SHALLOW MONITORING WELL INSTALLED BY ESE, 1984–1986
- 24GW07 — SHALLOW MONITORING WELL INSTALLED BY BAKER ENVIRONMENTAL, INC., 1993
- SG1 — STAFF GAUGE INSTALLED BY BAKER ENVIRONMENTAL, INC., 1993
- APPROXIMATE DIRECTION OF GROUNDWATER FLOW

SOURCE: LANTDIV, FEBRUARY 1992

FIGURE 2–8
MONITORING WELL AND
STAFF GAUGE LOCATIONS
SITE 24
REMEDIAL INVESTIGATION CTO–0177
MARINE CORPS BASE, CAMP LEJEUNE
NORTH CAROLINA

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subsequently replaced (refer to Figure 1-4). The monitoring wells were installed to collect surficial groundwater samples to further assess groundwater quality, and to evaluate shallow groundwater flow patterns at the site. Selection for the placement of the four wells was based on review of historical aerial photographs, Camp Lejeune records, geophysical results, and analytical data from previous investigations. Based on review of these data, it was determined that the southern and western portions of Site 24 needed further assessed. Accordingly, the newly-installed wells focused on these areas. Note that the new well 24GW07 was installed to serve as a site-specific background well.

The shallow monitoring wells were installed upon completion of advancing the boreholes (refer to Section 2.3.3.1 for drilling procedures). The procedures for drilling and installation of the wells were the same as those described for Site 21 wells (i.e., boreholes over-drilled with 8 1/4-inch augers). The depth of the wells range from 12.5 to 19 feet bgs. Further, well construction details (as shown on Figure 2-7) and construction materials are also the same as those described for Site 21 wells (i.e., medium-grained sand pack extending approximately 2 feet above the top of the screen, 1 to 2-foot sodium bentonite pellet seal). Well construction details for the Site 24 wells are summarized on Table 2-10, and well construction diagrams are shown on the Test Boring and Well Construction Records provided in Appendix F.

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. All newly-installed wells at Site 24 were developed by employing the same methods as described in Section 2.3.4.1 (i.e., a combination of surging and pumping). Well Development Forms summarizing this information are provided in Appendix H (H.2).

Water Level Measurements

Static water level measurements were collected from TOC reference points (marked on the PVC casing) at each existing and newly-installed well (refer to Table 3-5 in Section 3.6.2 for results). Complete rounds of measurements were collected on May 17, June 4, and August 1, 1993. 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 four hour period.

TABLE 2-10

SUMMARY OF WELL CONSTRUCTION DETAILS
SITE 24
REMEDIAL INVESTIGATION CTO-0177
MCB CAMP LEJEUNE, NORTH CAROLINA

Well No.	Date Installed	Top of PVC Casing Elevation (feet, above msl)(1)	Ground Surface Elevation (feet, above msl)	Boring Depth (feet, below ground surface)	Well Depth (feet, below ground surface)	Screen Interval Depth (feet, below ground surface)	Sand Pack Interval Depth (feet, below ground surface)	Bentonite Interval Depth (feet, below ground surface)	Bentonite Interval Depth (feet, below ground surface)
24GW07	4/25/93	29.82	27.4	18.0	18.0	7.7 - 17.2	6.0 - 18.0	4.0 - 6.0	2.4
24GW08	4/25/93	26.20	23.6	19.0	19.0	9.1 - 18.2	7.0 - 19.0	5.0 - 7.0	2.6
24GW09	4/26/93	16.55	13.8	12.5	12.5	2.6 - 11.7	1.5 - 12.5	0.5 - 1.5	2.7
24GW10	4/26/93	19.33	17.3	18.0	18.0	8.0 - 17.2	6.0 - 18.0	4.0 - 6.0	2.0

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

Groundwater Sampling

This section describes the sampling procedures and analytical methods for the groundwater sampling program. Note that the same sampling procedures as those described for Site 21 were employed at Site 24. Accordingly, an abbreviated discussion of the sampling procedures at Site 24 is presented.

Groundwater Sampling Locations

Groundwater samples were collected from five existing (24GW01 through 24GW04, and 24GW06) and four newly-installed (24GW07 through 24GW10) wells at Site 24. The location of these wells is shown on Figure 2-8. Note that existing well 24GW05 could not be located and is presumed to be destroyed.

Groundwater Sampling Procedures

Groundwater samples were collected to confirm the presence or absence of shallow contamination which may have resulted from previous disposal practices or site activities. At Site 24, both organic and inorganic contaminants may be present. Accordingly, the sampling program initiated at Site 24 focused on these contaminants. Sampling procedures implemented at Site 24 were the same as those described for Site 21.

Analytical Program

One round of groundwater samples were analyzed from the five existing and four newly-installed wells. Groundwater samples collected from the existing wells were analyzed for TAL inorganics (total and dissolved metals and cyanide) only. TAL inorganics were only analyzed in these wells because the July 1992 sampling episode conducted by Baker did not indicate any levels of organic contamination (VOCs, SVOCs, PCBs, or pesticides). Samples collected from the four newly-installed wells were analyzed for TCL organics (SVOCs, pesticides, and PCBs), VOCs (EPA Methods 524.2), and TAL inorganics. In addition to analyzing for the contaminants of concern, samples collected from well 24GW08 were analyzed for several general chemistry parameters including biological oxygen demand (BOD), chemical oxygen demand (COD), total suspended solids (TSS), total dissolved solids (TDS), total organic carbon

(TOC), and total volatile solids (TVS). These samples were collected to evaluate process options for treatment of groundwater, if required.

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 2-11 summarizes the QA/QC sampling program employed for the groundwater investigation.

2.3.4.3 Site 78 Groundwater Investigation

Well Installation

Between May 18, 1993, and May 19, 1993, seven shallow Type II monitoring wells (78GW33 through 78GW39) were initially installed at Site 78 in May 1993 at the locations shown on Figure 2-9. These locations were selected based on the results of the soil gas survey. Moreover, the selection of the seven well locations was based on the following factors: (1) the locations of the areas of concern; (2) the locations of existing wells at within OU No. 1; (3) the location of the existing plumes at Site 78; (4) the estimated direction of groundwater flow; and (5) results of the soil gas investigation. The monitoring wells were installed to collect shallow groundwater samples to further assess groundwater quality, and to evaluate shallow groundwater flow patterns at the site. One additional shallow monitoring well, 78GW09-1, was installed on December 9, 1993, to replace the existing well which could not be located during the initial field activities conducted in May. It is assumed that the original well was destroyed.

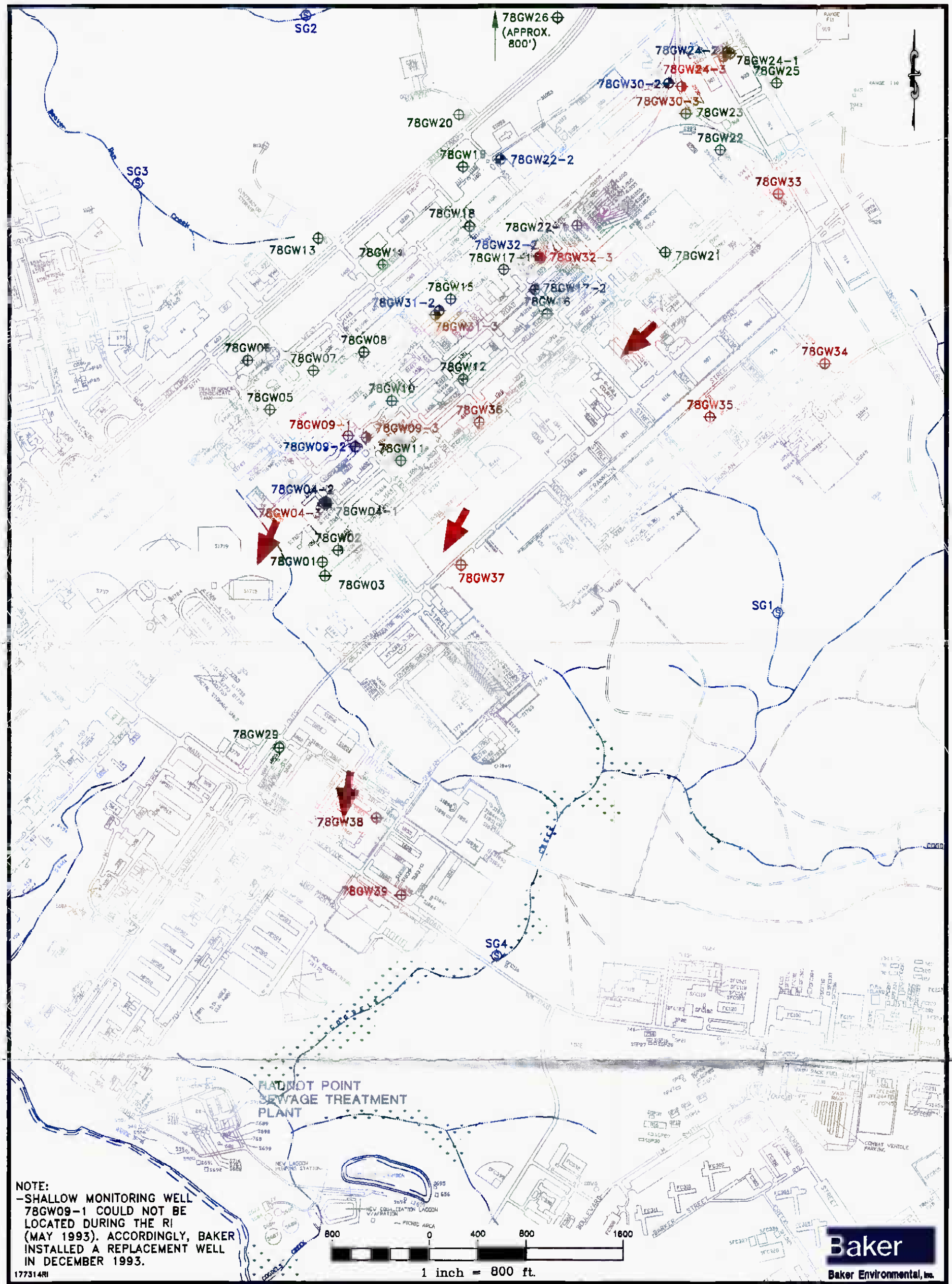
The shallow monitoring wells were installed upon completion of advancing the boreholes (refer to Section 2.3.4.1 for drilling procedures). The procedures for drilling and installing the wells were the same as those described for wells at Sites 21 and 24 (i.e., boreholes over-drilled with 8-1/4-inch augers). The depth of the wells range from 13 to 29 feet bgs. The seven wells are constructed of the same materials as those wells installed at Sites 21 and 24 (i.e., 4-inch nominal diameter Schedule 40, flush-joint and threaded PVC casing with a 10-foot long No. 10 slotted screen section). Further, well construction details (as shown on Figure 2-7) are also the same as those described for wells at Sites 21 and 24 (i.e., medium-grained sand pack extending approximately 2 feet above the top of the screen, 1 to 2-foot sodium bentonite pellet seal). Well

TABLE 2-11

SUMMARY OF FIELD QUALITY ASSURANCE/QUALITY CONTROL SAMPLING PROGRAM FOR THE GROUNDWATER INVESTIGATION SITE 24 REMEDIAL INVESTIGATION CTO-0177 MCB CAMP LEJEUNE, NORTH CAROLINA

QA/QC Sample (1)	Frequency of Collection	Number of Samples	Analytical Parameters (3)
Trip Blanks (2)	One per Cooler	6	Volatiles
Field Blanks (4)	One per Event	0	TCL Organics/TAL Inorganics
Equipment Rinsates (5)	One per Day	1	TCL Organics/TAL Inorganics
Field Duplicates (6)	10% of Sample Frequency	1	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 Methods 524.2; all other parameters analyzed according to CLP Protocol.
(4) Field blank collected during Site 21 investigation (see Table 2-5).
(5) Equipment rinsates collected from various sampling equipment (e.g., bailers, 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.
(6) Field duplicate samples collected from monitoring wells presented in Appendix N.



NOTE:
-SHALLOW MONITORING WELL 78GW09-1 COULD NOT BE LOCATED DURING THE RI (MAY 1993). ACCORDINGLY, BAKER INSTALLED A REPLACEMENT WELL IN DECEMBER 1993.

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LEGEND

- 78GW02 — EXISTING SHALLOW MONITORING WELL INSTALLED BY ESE, 1984–1991
- 78GW04-2 — EXISTING INTERMEDIATE MONITORING WELL INSTALLED BY ESE, 1991
- 78GW04-3 — EXISTING DEEP MONITORING WELL INSTALLED BY ESE, 1991
- 78GW33 — SHALLOW MONITORING WELL INSTALLED BY BAKER ENVIRONMENTAL, INC., 1993
- SG1 — STAFF GAUGE INSTALLED BY BAKER ENVIRONMENTAL, INC., 1993 (APPROXIMATE LOCATION)
- APPROXIMATE DIRECTION OF GROUNDWATER FLOW

SOURCE: LANTDIV, FEBRUARY 1992

FIGURE 2-9
MONITORING WELL AND STAFF GAUGE LOCATIONS
SITE 78
REMEDIAL INVESTIGATION CTO-0177
MARINE CORPS BASE, CAMP LEJEUNE
NORTH CAROLINA

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construction details for the Site 24 wells are summarized on Table 2-12, and well construction diagrams are shown on the Test Boring and Well Construction Records provided in Appendix F.

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 wells were developed by employing the same methods as described in Section 2.3.4.1 (i.e., a combination of surging and pumping). Well Development Forms summarizing this information are provided in Appendix H (H.3).

Water Level Measurements

Static water level measurements were collected from TOC reference points (marked on the PVC casing) at each existing (including shallow, intermediate, and deep wells) and 7 of the 8 newly-installed wells (refer to Table 3-6 in Section 3.6.2 for results). The measurements were collected on May 17-18, June 4, and August 1-2, 1993. 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 two hour period.

Groundwater Sampling

This section describes the sampling procedures and analytical requirements for the groundwater sampling program. Note that the same sampling procedures as those described for Sites 21 and 24 were employed at Site 78. Accordingly, an abbreviated discussion of the sampling procedures at Site 78 is presented.

Sampling Locations

Groundwater samples were collected from 41 existing wells and eight newly-installed wells throughout Site 78. The wells which were sampled are listed below.

TABLE 2-12

SUMMARY OF WELL CONSTRUCTION DETAILS
SITE 78
REMEDIAL INVESTIGATION CTO-0177
MCB CAMP LEJEUNE, NORTH CAROLINA

Well No.	Date Installed	Top of PVC Casing Elevation (feet, above msl)[1]	Ground Surface Elevation (feet, above msl)	Boring Depth (feet, below ground surface)	Well Depth (feet, below ground surface)	Screen Interval Depth (feet, below ground surface)	Sand Pack Interval Depth (feet, below ground surface)	Bentonite Interval Depth (feet, below ground surface)	Stick-Up (feet, below ground surface)
78GW09-1[2]	12/09/93	NA	NA [3]	24.0	22.0	6.6 - 21.6	5.0 - 24.0	4.0 - 5.0	-- [4]
78GW33	5/18/93	29.84	29.9	14.0	14.0	4.0 - 13.1	2.0 - 14.0	0 - 1.0	--
78GW34	5/18/93	32.66	29.9	13.0	13.0	2.9 - 12.0	2.0 - 13.0	0 - 0.5	2.7
78GW35	5/18/93	32.08	29.2	20.0	20.0	9.8 - 18.9	8.0 - 20.0	0 - 8.0	2.8
78GW36	5/18/93	29.68	26.9	18.0	18.0	8.1 - 17.2	6.0 - 17.2	0 - 6.0	2.7
78GW37	5/19/93	20.02	18.2	14.0	14.0	3.8 - 13.1	21.0 - 14.0	0 - 2.0	1.8
78GW38	5/19/93	25.44	25.9	29.0	29.0	18.9 - 28.0	17.0 - 29.0	0 - 17.0	--

Notes: [1] msl = mean sea level
[2] Replacement monitoring well
[3] NA = not measured.
[4] -- = flush-mounted well; not applicable
Horizontal positions are referenced to N.C. State Plane Coordinate System (NAD 27) CF = 0.9999216 from USMC Monument Toney. Vertical datum NGVD 29.

Existing Shallow Monitoring Wells		Newly Installed Monitoring Wells
78GW01	78GW17-1	78GW09-1 (replacement)
78GW02	78GW18	78GW33
78GW03	78GW19	78GW34
78GW04-1	78GW20	78GW35
78GW05	78GW21	78GW36
78GW06	78GW22	78GW37
78GW07	78GW22-1	78GW38
78GW08	78GW22-2	78GW39
78GW10	78GW23	
78GW11	78GW24-1	
78GW12	78GW25	
78GW13	78GW26	
78GW14	78GW29	
78GW15		
78GW16		

Existing Intermediate Wells	Existing Deep Wells
78GW4-2	78GW4-3
78GW9-2	78GW9-3
78GW17-2	78GW24-3
78GW24-2	78GW30-3
78GW30-2	78GW31-3
78GW31-2	78GW32-3
78GW32-2	

It is important to note that six wells which had been sampled during at least one of the previous sampling events could not be located during the initial RI field investigation conducted in May 1993. The six wells included four shallow wells (78GW01, 78GW09-1, 78GW18, and 78GW26); one intermediate well (78GW30-2); and one deep well (78GW30-3). Five of the wells were found in December 1993 and sampled. A replacement well for 78GW09-1 was installed by Baker on December 9, 1993. This well was then sampled. The location of the wells sampled during the RI are identified on Figure 2-9.

Groundwater Sampling Procedures

In general, groundwater sampling procedures implemented at Site 78 were the same as those described for Sites 21 and 24. This information is summarized in Section 2.3.4.1.

Analytical Program

One round of groundwater samples were analyzed from the existing and the nine newly-installed wells at Site 78. Groundwater samples collected from the existing shallow, intermediate, and deep wells, as well as newly-installed wells, 78GW33 through 78GW39,were analyzed for full TCL organics (VOCs analyzed by EPA Method 524.2) and TAL inorganics (total and dissolved metals and cyanide). Replacement monitoring well 78GW09-1 was sampled for VOCs only because these were the compounds of concern identified from previous investigations. In addition to analyzing for the contaminants of concern, samples collected from wells 78GW04-1 (shallow), 78GW31-3 (deep), and 78GW34 (shallow) were analyzed for engineering parameters including BOD, COD, TSS, TDS, TOC, and TVS. These samples were collected to evaluate process options for treatment of groundwater, if required.

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 2-13 summarizes the QA/QC sampling program employed for the groundwater investigation.

2.3.5 Surface Water and Sediment Investigations

This section discuses the surface water and sediment investigations conducted for the entire operable unit. Included in this section are the sampling methodologies, procedures, locations, analytical requirements, and QA/QC sample types of the surface water and sediment sampling investigation. Although the surface water and sediment investigation was conducted under Site 78, note that samples collected specifically from Beaver Dam Creek, Cogdels Creek, and the New River were obtained to assess the overall impact from the entire operable unit. Moreover, samples collected from the drainage ditch around Site 21 were obtained to assess impacts from Site 21 only. The surface water and sediment samples were collected from May 4, 1993, through May 11, 1993.

2.3.5.1 Surface Water Sampling Methodology

The following sections describe the stations where surface water samples were collected and the procedures used for collecting the samples.

TABLE 2-13

SUMMARY OF FIELD QUALITY ASSURANCE/QUALITY CONTROL SAMPLING PROGRAM FOR THE GROUNDWATER INVESTIGATION SITE 78 REMEDIAL INVESTIGATION CTO-0177 MCB CAMP LEJEUNE, NORTH CAROLINA

QA/QC Sample (1)	Frequency of Collection	Number of Samples	Analytical Parameters (3)
Trip Blanks (2)	One per Cooler	27	Volatiles
Field Blanks (4)	One per Event	1	TCL Organics/TAL Inorganics
Equipment Rinsates (5)	One per Day	6	TCL Organics/TAL Inorganics
Field Duplicates (6)	10% of Sample Frequency	5	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) Field blank collected during Site 21 investigation (see Table 2-5).
(5) Equipment rinsates collected from various sampling equipment (e.g., bailers, 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.
(6) Field duplicate samples collected from monitoring wells presented in Appendix N.

Surface Water Sampling Locations

Thirty surface water samples were collected at OU No. 1. Seven samples were collected from Beaver Dam Creek, 15 samples were collected from Cogdels Creek and three of its unnamed tributaries, five samples from the New River and one of its unnamed tributaries, and three samples from the drainage ditch encompassing Site 21. The surface water numbers were designated as 78-CC-SW"X"; the 78 indicates the samples were collected from OU No. 1, Site 78 as shown on Figure 2-10. It should be noted that the number 21 was substituted in place of 78 for surface water samples collected at Site 21 as depicted on Figure 2-11. It should be noted that all samples were collected approximately 18 inches from the bank of the surface water feature.

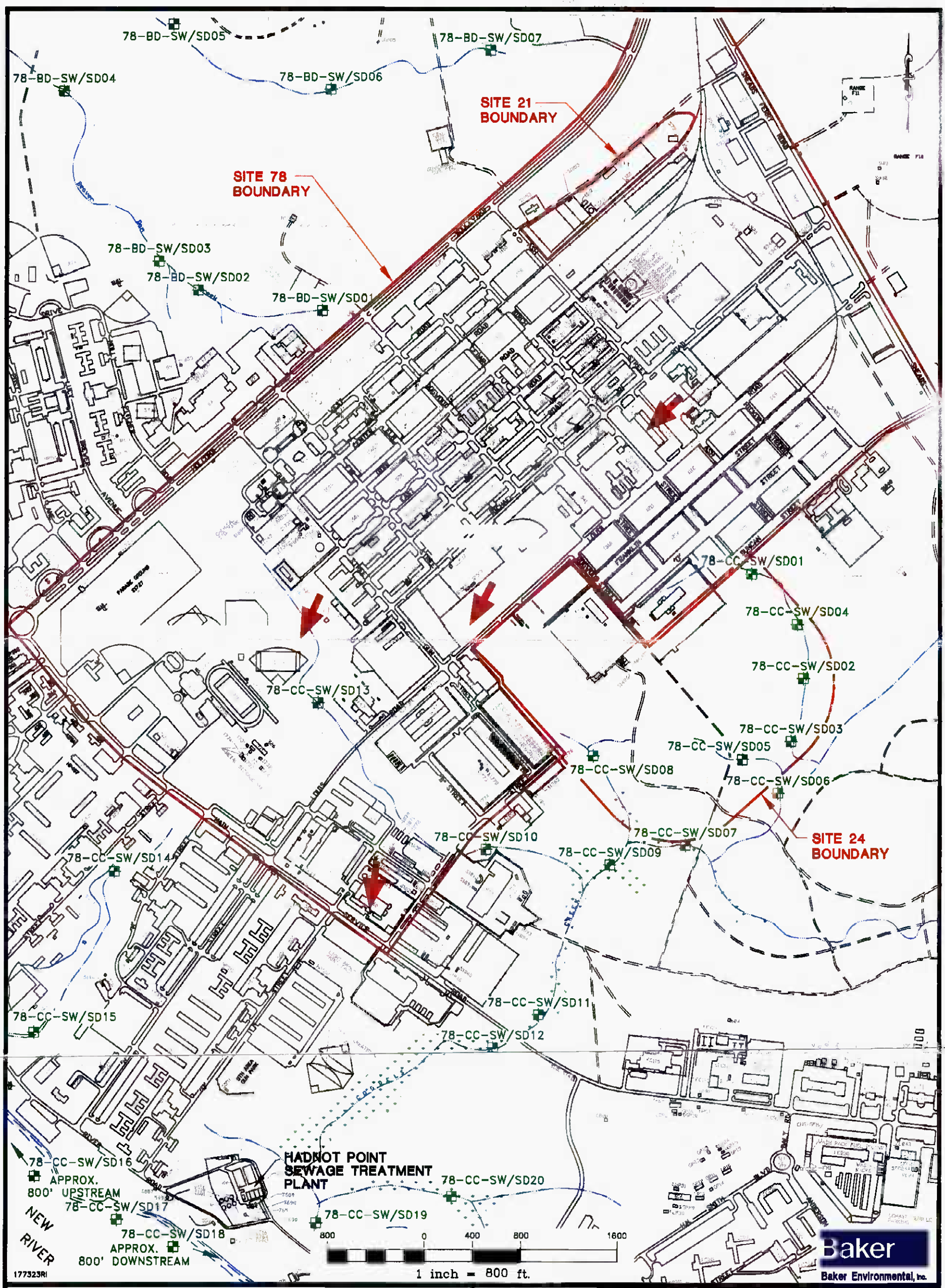
Surface Water Sampling Procedure

At all sampling stations, 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.

All samples were collected in clean containers provided by the analytical laboratory. For sample bottles containing preservative (i.e., nitric acid), a transfer bottle was utilized for sample collection. Transfer bottles were double rinsed with water from the station location prior to collection.

The downstream water samples were collected first, with subsequent samples collected while progressing upstream. It should be noted that a 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. Sediment samples were collected following collection of the surface water samples to minimize sediment resuspension that may have interfered with the water analysis.

All sampling locations were displayed by placing a wooden stake with fluorescent markings at the nearest bank or shore. The sample number was marked on the stake with indelible ink.



LEGEND

78-BD-SW/SD01 SURFACE WATER(SW)/SEDIMENT(SD) SAMPLE STATION

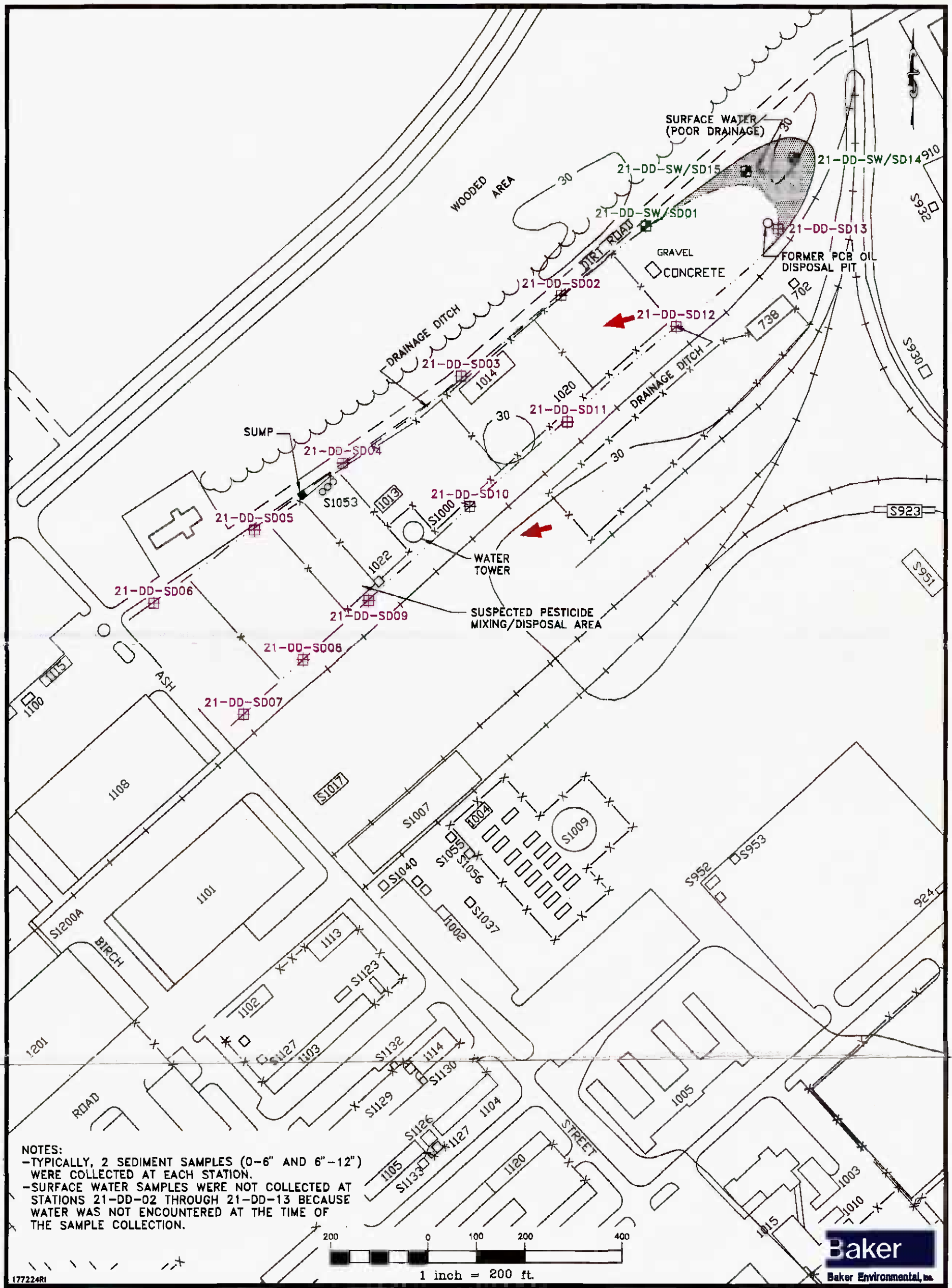
APPROXIMATE GROUNDWATER FLOW DIRECTION

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

SOURCE: LANTDIV, FEBRUARY 1992

FIGURE 2-10
SURFACE WATER AND SEDIMENT LOCATIONS
SITE 78
REMEDIAL INVESTIGATION CTO-0177

MARINE CORPS BASE, CAMP LEJEUNE
NORTH CAROLINA



NOTES:
- TYPICALLY, 2 SEDIMENT SAMPLES (0-6" AND 6"-12") WERE COLLECTED AT EACH STATION.
- SURFACE WATER SAMPLES WERE NOT COLLECTED AT STATIONS 21-DD-02 THROUGH 21-DD-13 BECAUSE WATER WAS NOT ENCOUNTERED AT THE TIME OF THE SAMPLE COLLECTION.

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LEGEND

21-DD-SW/SD01 — SURFACE WATER(SW)/SEDIMENT(SD) SAMPLE STATION

21-DD-SD02 — SEDIMENT(SD) SAMPLE STATION

APPROXIMATE GROUNDWATER FLOW DIRECTION

SOURCE: LANTDIV, FEBRUARY 1992

FIGURE 2-11
SURFACE WATER AND SEDIMENT LOCATIONS
SITE 21
REMEDIAL INVESTIGATION CTO-0177
MARINE CORPS BASE, CAMP LEJEUNE
NORTH CAROLINA

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Select photographs were taken to document the physical and biological characteristics of the sampling locations.

The following information from each station was documented:

- Project location, date and time
- Sample location number and identification number
- Flow conditions
- Visual description of water (i.e., cloudy, clear, etc.)
- Names of sampling personnel

2.3.5.2 Sediment Sampling Methodology

The following sections describe the stations where sediment samples were collected and the procedures used for collecting the samples.

Sediment Sample Locations

Eighty-two sediment samples (not including duplicate samples) were collected from 42 stations at OU No. 1 (see Figures 2-10 and 2-11 for station locations). Fourteen samples (seven stations) were collected from Beaver Dam Creek; 28 samples (14 stations) were collected from Cogdels Creek and its tributaries; 10 samples (five stations) were collected from the New River and its tributaries; and 30 samples (15 stations) were collected from the drainage ditch encompassing Site 21. Tables 2-14, 2-15 and 2-16 contain a summary of the station numbers and locations, and sample numbers collected at those stations.

Sediment Sampling Procedures

Sediment samples were collected below an aqueous layer using a hand-held device. At each station, sediment samples were collected at the surface (0 to 6 inches) and at depth (6 to 12 inches) using a stainless steel hand-held coring instrument or stainless steel sampling trowel.

Collection of surface sediment as well as sediment at depth was accomplished by inserting the instrument to the desired depth and obtaining a representative sample.

TABLE 2-14

BEAVER DAM CREEK SURFACE WATER AND SEDIMENT
STATIONS, LOCATIONS, AND SAMPLE NUMBERS
SITE 78
REMEDIAL INVESTIGATION CTO-0177
MCB CAMP LEJEUNE, NORTH CAROLINA

Station Number	Station Location	Surface Water Sample Number	Sediment Sample Number
78-BD-SW/SD01	Terminating point of Beaver Dam Creek, Southwest of Commissary.	78-BD-SW01	78-BD-SD01-06 78-BD-SD01-612
78-BD-SW/SD02	Approximately 800' upstream of Holcomb Boulevard.	78-BD-SW 02	78-BD-SD02-06 78-BD-SD02-612
78-BD-SW/SD03	Approximately 1400' upstream of Holcomb Boulevard. Also 3.0' upgradient of storm water discharge.	78-BD-SW03	78-BD-SD03-06 78-BD-SD03-612
78-BD-SW/SD04	Collected 3000' upgradient of Holcomb Boulevard and downgradient of containment basin adjacent to commissary.	78-BD-SW04	78-BD-SD04-06 78-BD-SD04-612
78-BD-SW/SD05	Approximately 2400' upgradient of electrical substation - near archery training area.	78-BD-SW05	78-BD-SD05-06 78-BD-SD05-612
78-BD-SW/SD06	Approximately 1200' upgradient of northwest terminating point of Beaver Dam Creek.	78-BD-SW06	78-BD-SD06-06 78-BD-SD06-612
78-BD-SW/SD07	Terminating point of Beaver Dam northwest of substation.	78-BD-SW07	78-BD-SD07-06 78-BD-SD07-612

Notes:
SW - Surface Water Samples
SD-06 - Sample was collected from the top six inches of the sediment
SD-612 - Sample was collected from six to twelve inches below sediment surface
All samples analyzed for full TCL Organics and TAL Inorganics

TABLE 2-15

COGDELS CREEK/NEW RIVER SURFACE WATER AND SEDIMENT STATIONS, LOCATIONS AND SAMPLE NUMBERS
SITE 78
REMEDIAL INVESTIGATION CTO-0177
MCB CAMP LEJEUNE, NORTH CAROLINA

Station Number	Station Location	Surface Water Sample Number	Sediment Sample Number
78-CC-SW/SD01	Terminating point of Cogdels Creek at Birch and Duncan Streets.	78-CC-SW01 78-CC-SW01 D	78-CC-SD01-06 78-CC-SD01-612 78-CC-SD01-06 D 78-CC-SD01-612 D
78-CC-SW/SD02	Approximately 1200' downstream of Site 78.	78-CC-SW02	78-CC-SD02-06 78-CC-SD02-612
78-CC-SW/SD03	Approximately 1600' downstream of Site 78, and downgradient of Site 24.	78-CC-SW03	78-CC-SD03-06 78-CC-SD03-612
78-CC-SW/SD04	Approximately 1000' downstream of terminating point of Cogdel's Creek at intersection of Birch and Duncan Street.	78-CC-SW04	78-CC-SD04-06 78-CC-SD04-612
78-CC-SW/SD05	Downgradient of Sites 24 and 78.	78-CC-SW05	78-CC-SD05-06 78-CC-SD05-612
78-CC-SW/SD06	Downgradient of Sites 24 and 78.	78-CC-SW06	78-CC-SD06-06 78-CC-SD06-612
78-CC-SW/SD07	Downgradient of Sites 24 and 78.	78-CC-SW07 78-CC-SW07 D	78-CC-SD07-06 78-CC-SD07-612 78-CC-SD07-06 D 78-CC-SD07-612 D
78-CC-SW/SD08	Downgradient of Sites 24 and 78.	78-CC-SW08	78-CC-SD08-06 78-CC-SD08-612
78-CC-SW/SD09	Downgradient of Sites 24 and 78.	78-CC-SW09	78-CC-SD09-06 78-CC-SD09-612
78-CC-SW/SD10	Approximately 100' downstream of Duncan Street (Site 78).	78-CC-SW10	78-CC-SD10-06 78-CC-SD10-612
78-CC-SW/SD11	Approximately 200' north of Main Service Road.	78-CC-SW11	78-CC-SD11-06 78-CC-SD11-612

Notes:
SW - Surface Water Samples
SD-06 - Sample was collected from the top six inches of the sediment
SD-612 - Sample was collected from six to twelve inches below sediment surface
SD-06D - Duplicate Sample
All samples analyzed for full TCL Organics and TAL Inorganics

TABLE 2-15 (Continued)

COGDELS CREEK/NEW RIVER SURFACE WATER AND SEDIMENT STATIONS, LOCATIONS AND SAMPLE NUMBERS
SITE 78
REMEDIAL INVESTIGATION CTO-0177
MCB CAMP LEJEUNE, NORTH CAROLINA

Station Number	Station Location	Surface Water Sample Number	Sediment Sample Number
78-CC-SW/SD12	Approximately 200' south of Main Service Road.	78-CC-SW12 78-CC-SW12D	78-CC-SD12-06 78-CC-SD12-612 78-CC-SD12-06 D 78-CC-SD12-612 D
78-CC-SW/SD13	Approximately 600' northeast of Lewis Road near Building 1747.	78-CC-SW13	78-CC-SD13-06 78-CC-SD13-612
78-CC-SW/SD14	Located between "L" and "M" Street near Building 405.	78-CC-SW14	78-CC-SD14-06 78-CC-SD14-612
78-CC-SW/SD15	Located between "L" and "N" Street near River Road - near Building S 449.	78-CC-SW15	78-CC-SD15-06 78-CC-SD15-612
78-CC-SW/SD16	Located near intersection of "L" Street and River Road - in the New River.	78-CC-SW16	78-CC-SD16-06 78-CC-SD16-612
78-CC-SW/SD17	Located near intersection of "O" Street and River Road - in the New River.	78-CC-SW17 78-CC-SW17 D	78-CC-SD17-06 78-CC-SD17-612 78-CC-SD17-06 D 78-CC-SD17-612 D
78-CC-SW/SD18	Located downstream of Pistol Range - in the New River.	78-CC-SW18	78-CC-SD18-06 78-CC-SD18-612
78-CC-SW/SD19	Located approximately 100' north of River Road near Hadnot Point Sewage Treatment Plant.	78-CC-SW19	78-CC-SD19-06 78-CC-SD19-612
78-CC-SW/SD20	Approximately 1600' west of Hadnot Point Sewage Treatment Plant and 800' north of the New River.	78-CC-SW20	78-CC-SD20-06 78-CC-SD20-612

Notes:
SW - Surface Water Samples
SD-06 - Sample was collected from the top six inches of the sediment
SD-612 - Sample was collected from six to twelve inches below sediment surface
SD-06D - Duplicate Sample
All samples analyzed for full TCL Organics and TAL Metals

TABLE 2-16

DRAINAGE DITCH SURFACE WATER AND SEDIMENT
STATIONS, LOCATIONS, AND SAMPLE NUMBERS
SITE 21
REMEDIAL INVESTIGATION CTO-0177
MCB CAMP LEJEUNE, NORTH CAROLINA

Station Number	Station Location	Surface Water Sample Number	Sediment Sample Number
21-DD-SW/SD01	Northwestern portion of drainage ditch, along dirt road.	21-DD-SW01	21-DD-SD-01-06 21-DD-SD-01-612
21-DD-SW/SD02	Northwestern portion of drainage ditch, along dirt road.	NA	21-DD-SD02-06 21-DD-SD02-612
21-DD-SW/SD03	Western portion of drainage ditch, along dirt road adjacent to Building 1014.	NA	21-DD-SD03-06 21-DD-SD03-612
21-DD-SW/SD04	Western portion of drainage ditch, along dirt road - across from water tower.	NA	21-DD-SD04-06 21-DD-SD04-612
21-DD-SW/SD05	Southwestern portion of drainage ditch, along dirt road - north of the car wash.	NA	21-DD-SD05-06 21-DD-SD05-612
21-DD-SW/SD06	Southwestern portion of drainage ditch, along dirt road - south of the car wash. Near Ash Street.	NA	21-DD-SD06-06 21-DD-SD06-612
21-DD-SW/SD07	Southeastern portion of drainage ditch, along Center Road - near Ash Street.	NA	21-DD-SD07-06 21-DD-SD07-612
21-DD-SW/SD08	Southeastern portion of drainage ditch along Center Road - across from northern boundary of car wash.	NA	21-DD-SD08-06 21-DD-SD08-612
21-DD-SW/SD09	Eastern portion of drainage ditch, along Center Road - near Building 1022.	NA	21-DD-SD09-06 21-DD-SD09-612
21-DD-SW/SD10	Eastern portion of drainage ditch, along Center Road - north of water tower.	NA	21-DD-SD10-06 21-DD-SD10-612
21-DD-SW/SD11	Eastern portion of drainage ditch, along Center Road - north of Building 1020.	NA	21-DD-SD11-06 21-DD-SD11-612

Notes: SW - Surface Water Sample
SD-06 - Sample was collected from the top six inches of the sediment.
SD-612 - Sample was collected from six to twelve inches below sediment surface.
NA - No surface water or insufficient amount to collect surface water samples.
All samples analyzed for full TCL Organics and TAL Metals

TABLE 2-16 (Continued)

DRAINAGE DITCH SURFACE WATER AND SEDIMENT
STATIONS, LOCATIONS, AND SAMPLE NUMBERS
SITE 21
REMEDIAL INVESTIGATION CTO-0177
MCB CAMP LEJEUNE, NORTH CAROLINA

Station Number	Station Location	Surface Water Sample Number	Sediment Sample Number
21-DD-SW/SD12	Northeastern portion of drainage ditch, along Center Road - in line with northern most fence line.	NA	21-DD-SD12-06 21-DD-SD12-612 21-DD-SD12-06 D 21-DD-SD12-612 D
21-DD-SW/SD13	Northeastern portion of drainage ditch near the former pit.	NA	21-DD-SD13-06 21-DD-SD13-612
21-DD-SW/SD14	Northern portion of drainage ditch, along Center Road.	21-DD-SW14	21-DD-SD14-06 21-DD-SD14-612
21-DD-SW/SD15	Northwestern portion of drainage ditch, along dirt road.	21-DD-SW15	21-DD-SD15-06 21-DD-SD15-612

Notes: SW - Surface Water Sample
SD-06 - Sample was collected from the top six inches of the sediment
SD-612 - Sample was collected from six to twelve inches below sediment surface
SD-06D - Duplicate Sample
NA - No surface water or insufficient amount to collect surface water samples
All samples analyzed for full TCL Organics and TAL Metals

2.3.5.3 Surface Water and Sediment Analytical Program

The analytical program initiated for the surface water and sediment investigation at OU No. 1 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. In general, samples were collected at surface water features adjacent to the sites as well as downgradient and upgradient to accurately assess any impacts resulting from OU No. 1. Samples were analyzed for TCL organics and TAL metals (total).

2.3.5.4 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, field blanks, and trip blanks. The QA/QC sample collection frequencies are the same as those described in Section 2.3.4.3. Table 2-17 summarizes field QA/QC samples collected for the surface water and sediment program.

2.3.6 Monitoring Well and Staff Gauge Survey Procedures

All newly-installed and existing monitoring wells, as well as newly-installed staff gauges, were surveyed to establish their vertical elevation in relationship to msl and horizontal control. Hoggard-Eure was retained for the survey. Vertical accuracy of each well or staff gauge (established to TOC at each well or top of staff gauge) was measured to the nearest 0.01 foot and horizontal accuracy within the nearest 0.1 foot. Control was established by using horizontal and vertical control points near the site which are tied into the NCSPCS. In cases where the points could not be established, temporary benchmarks were established from the closest United States Geological Survey (U.S.G.S.) benchmark.

2.3.7 Decontamination Procedures

Decontamination procedures performed in the field were initiated in accordance with USEPA Region IV SOPs. In general, sampling and drilling equipment were divided into two decontamination groups: heavy equipment and routine sample collection equipment. Heavy equipment included: the drill rig, hollow-stem augers, and drill rods. Routine sample collection equipment included: split-spoons, stainless-steel spoons and bowls, bailers, bailer wire, hand auger bucket, and sediment corer.

TABLE 2-17

SUMMARY OF FIELD QUALITY ASSURANCE/QUALITY CONTROL SAMPLING PROGRAM FOR THE SURFACE WATER AND SEDIMENT INVESTIGATIONS
SITES 21, 24 AND 78
REMEDIAL INVESTIGATION CTO-0177
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	2	TCL Organics/TAL Inorganics
Equipment Rinsates (5)	One per Day	2	TCL Organics/TAL Inorganics
Field Duplicates (6)	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 TCL Volatiles only.
(3) Parameters analyzed according to procedures outlined on Tables 2-5 and 2-6.
(4) Field blanks collected during surface water and sediment investigations in the vicinity of HPIA
(5) Equipment rinsates collected from various sampling equipment (e.g., stainless steel spoons).
(6) Field duplicate samples presented in Appendix N.

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 potable water and laboratory detergent (Alconox soap solution)
- Rinse thoroughly with potable water
- Rinse thoroughly with deionized water
- Rinse twice with 10 percent nitric acid
- Rinse thoroughly with deionized 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 2.3.8.

2.3.8 Investigative Derived Waste (IDW) Handling

CERCLA field investigation activities at Sites 21, 24, and 78 resulted in the generation of various IDW. This IDW included drilling mud, cuttings, well installation purge water, purge water and soils from sampling activities, 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 sampling activities conducted in June 1993.

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.

Non-contaminated wastewater was sent to the HPIA STP and contaminated wastewater was 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 I provides information on the management and disposal of the IDW.

3.0 PHYSICAL CHARACTERISTICS OF THE STUDY AREA

This section presents a discussion of the physical characteristics of OU No. 1 (Sites 21, 24, and 78) including: surface features, meteorology, hydrology, geology (regional and site), soils, hydrogeology (regional and site), land usage, regional ecology, and a water supply well inventory of the area. This information was obtained from available literature pertaining to MCB Camp Lejeune, interviews with Camp Lejeune personnel, review of historical aerial photographs, and from the RI field activities. Note that the discussions presented in this section pertain to the entire operable unit since the three sites are located in the immediate vicinity of each other.

3.1 Surface Features

The topography of MCB Camp Lejeune is relatively flat with ground surface elevations ranging from msl to 72 feet above msl. Most of the MCB Camp Lejeune lies between 20 and 40 feet msl. The terrain of MCB Camp Lejeune is typical of the North Carolina Coastal Plain. Drainage is generally toward the New River and the Atlantic Ocean via the Intercoastal Waterway (Harned et al., 1989).

OU No. 1 is dominantly a flat area with surface elevations between 5 and 30 feet above msl. As depicted on Figure 3-1, the highest surface elevations within OU No. 1 are encountered near the center of Site 78 (HPIA) where the elevation is approximately 30 feet above msl. Elevations drop off sharply to near 5 feet above msl at the banks of Beaver Dam Creek (north of Site 78, and north and west of Site 21), and the New River (southwest of Sites 24 and 78). The terrain in the area indicates that drainage of OU No. 1 is toward Cogdels Creek which drains into the New River southwest of Site 24.

Overall, there are not any significant land surface features (e.g., valleys, ridges, etc.) at OU No. 1. Most of the area is devoted to industrial activities and therefore is covered with numerous buildings and other structures. Surface cover within OU No. 1 is predominately asphalt and concrete with some grass and soil covered areas along the southern and northern boundaries. The south-southeastern boundary of OU No. 1 is bordered by Cogdels Creek, unnamed tributaries of Cogdels Creek, marsh areas, and woodlands (Figure 3-1).

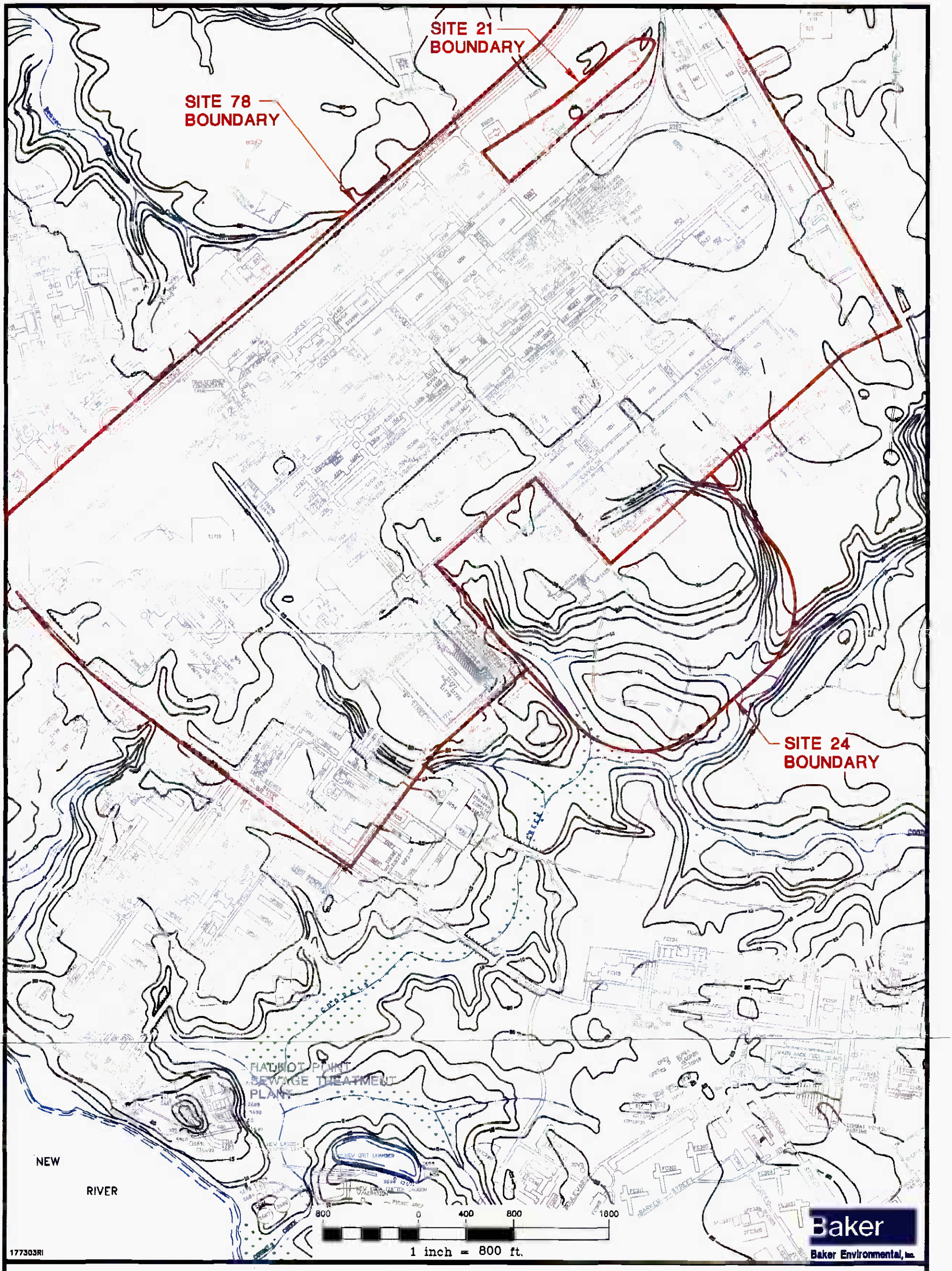

FIGURE 3-1
SITE TOPOGRAPHY AND LAND FEATURES
OPERABLE UNIT No. 1
REMEDIAL INVESTIGATION CTO-0177

MARINE CORPS BASE, CAMP LEJEUNE
NORTH CAROLINA

SOURCE: LANTDIV, FEBRUARY 1992

0127V18Y

3.2 Meteorology

MCB Camp Lejeune is located within the Coastal Plain physiographic Province of North Carolina. Coastal Plain elevations range from 200 feet above msl at the western boundary to generally 30 feet or less in areas of tidal influence to the east. The tidal portion of the Coastal Plain, where MCB Camp Lejeune is situated, is generally flat and swampy.

Although coastal North Carolina lacks distinct wet and dry seasons, there is some seasonal variation in average precipitation. July tends to receive the most precipitation and rainfall amounts during summer are generally the greatest. Daily showers during the summer are not uncommon, nor are periods of one or two weeks without rain. Convective showers and thunderstorms contribute to the variability of precipitation during the summer months. October tends to receive the least amount of precipitation, on average. Throughout the winter and spring months precipitation occurs primarily in the form of migratory low pressure storms. MCB Camp Lejeune's average yearly rainfall is approximately 52 inches. Table 3-1 presents a climatic summary of data collected during 27 years (January 1955 to December 1982) of observations at Marine Corps Air Station (MCAS) New River.

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

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

Observations of sky conditions indicate yearly averages of approximately 112 days clear, 105 partly cloudy, and 148 cloudy. Measurable amounts of rainfall occur 120 days per year, on the average. Prevailing winds are generally from the south-southwest 10 months of the year, and from the north-northwest during September and October. The average wind speed for MCAS New River is 6.9473 miles per hour.

TABLE 3-1

CLIMATIC DATA SUMMARY FOR MCAS NEW RIVER
REMEDIAL INVESTIGATION CTO-0177
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"	>=90 F	>=75 F	<=32 F
January	7.5	1.4	4.2	76	54	34	44	11	2	0	1	14
February	7.0	1.5	3.8	74	57	36	46	9	3	0	1	11
March	8.0	0.8	3.5	78	64	42	53	10	2	0	5	7
April	6.5	0.5	3.0	79	73	51	62	8	2	--(1)	14	--
May	8.4	1.7	4.3	86	80	60	70	10	3	2	25	0
June	11.8	2.4	5.8	85	85	67	76	11	4	6	29	0
July	14.3	4.5	8.0	85	88	72	80	14	5	12	31	0
August	12.6	1.7	6.1	87	87	71	80	12	4	11	31	0
September	12.2	1.4	4.7	87	83	66	75	9	3	3	27	0
October	6.5	0.7	2.8	82	74	54	64	7	2	--	16	--
November	5.7	0.6	2.6	80	66	44	55	7	1	0	6	4
December	6.1	0.4	4.0	77	58	37	48	9	2	0	2	11
Annual	14.3	0.4	52.8	81	72	53	63	117	33	34	188	47

(1) -- = Less than 0.5 days

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

3.3 Surface Water Hydrology

The majority of MCB Camp Lejeune is situated near sea level (i.e., estuarine conditions which are tidally influenced). The New River is the dominant surface water feature and receives drainage from most of OU No. 1. It flows in a southerly direction and empties into the Atlantic Ocean through the New River Inlet.

Overall, there are three main surface water bodies within OU No. 1. These include: Beaver Dam Creek, Cogdels Creek (and unnamed tributaries), and the New River. The New River borders the operable unit to the southwest, Cogdels Creek flows along the southern boundary of Site 78 (northern boundary of Site 24), and Beaver Dam Creek lies north of Site 78 across Holcomb Boulevard. All three of these surface water features are depicted on Figure 3-1. Note that Cogdels Creek has several unnamed tributaries located east and west from the main stream. According to the NC DEHNR, Cogdels Creek classifies as SC NSW and Beaver Dam Creek classifies as SB NSW.

The New River is designated as Class SC, High Quality Water (HQW) (NC DEHNR, 1992, and N.C. MFC, 1992). HQW are waters that are rated as excellent based on one or more of the following factors: biological and physical/chemical characteristics through division monitoring or special studies; native and special trout waters (and their tributaries) designated by the Wildlife Resources Commission; primary nursery areas designated by the Marine Fisheries Commission; and other functional nursery areas designated by the Wildlife Resources Commission; critical habitat designated by the Wildlife Resources Commission or the Department of Agriculture; all water supply watersheds which are classified as WS-I or WS-II or those for which a formal petition for reclassification as WS-I or WS-II have been received from the appropriate local government and accepted by the Division of Environmental Management; and all Class SA waters (NC DEHNR, 1992a). This section of the New River is classified as a primary fish nursery area, but it is not a water supply.

The 100-year flood plain elevation for this area of MCB Camp Lejeune is approximately 10 feet above msl. OU No. 1 lies between elevations five and 30 feet above msl (Figure 3-1), therefore, some portions (e.g., Site 24 near Cogdels Creek) of the OU No. 1 are within the 100-year flood plain.

3.4 Geology

3.4.1 Regional Geology

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 are layered in interfingering beds and lenses that gently dip and thicken to the southeast. Regionally, they comprise 10 aquifers and nine confining units which overlie igneous and metamorphic basement rocks of pre-Cretaceous age. These sediments were deposited in marine or near-marine environments and range in age from early Cretaceous to Quaternary time. Table 3-2 presents a generalized stratigraphic column for Jones and Onslow Counties, North Carolina (Harned et al., 1989).

U.S.G.S. studies at MCB Camp Lejeune indicate that the area is underlain by sand and limestone aquifers separated by semi-confining units (i.e., in some portions of the base) of silt and clay. These aquifers include the water table (surficial), Castle Hayne, Beaufort, Peedee, Black Creek, and upper and lower Cape Fear. The combined thickness of these sediments is approximately 1,500 feet. Less permeable clay and silt beds function as confining units or semi-confining units which separate the aquifers and impede the flow of groundwater between aquifers. A generalized hydrogeologic cross-section of this area is presented in Figure 3-2. This cross-section illustrates the relationship between the aquifers in this area (Harned et al., 1989).

3.4.2 Site Geology

Numerous borings were advanced during this RI in the shallow soils (less than 25 feet bgs) within the vicinity of OU No. 1. Subsurface soil descriptions are provided in the Test Boring Records and Test Boring and Well Construction Records in Appendices E and F, respectively. Additional information regarding the shallow, and deep (i.e., greater than 25 feet) soils was also obtained from previous investigations performed at Site 78 (ESE, 1984 through 1991). The following provides a detailed description of the shallow and deep stratigraphy underlying OU No. 1.

TABLE 3-2

GEOLOGIC AND HYDROGEOLOGIC UNITS IN
THE COASTAL PLAIN OF NORTH CAROLINA
REMEDIAL INVESTIGATION CTO-0177
MCB CAMP LEJEUNE, NORTH CAROLINA

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

Notes:
(1) Geologic and hydrologic units probably not present beneath 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

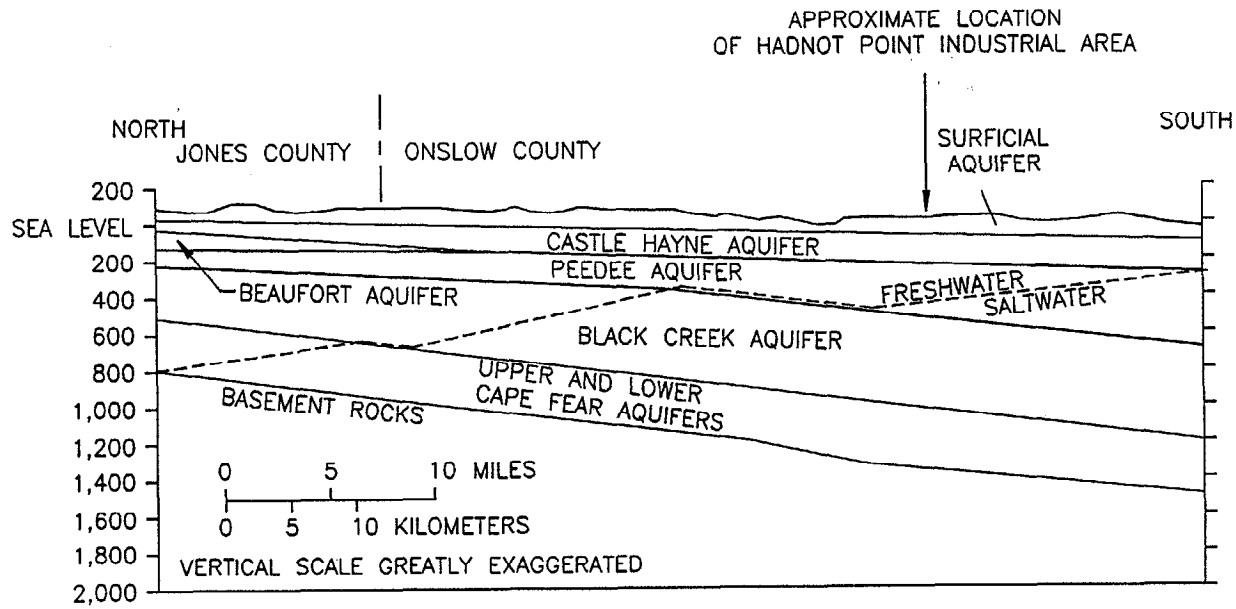

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FIGURE 3-2
GENERALIZED HYDROGEOLOGIC CROSS-SECTION
JONES AND ONSLOW COUNTIES, NORTH CAROLINA
REMEDIAL INVESTIGATION CTO-0177

MARINE CORPS BASE, CAMP LEJEUNE
NORTH CAROLINA

SOURCE: HARNED, et. al., 1989

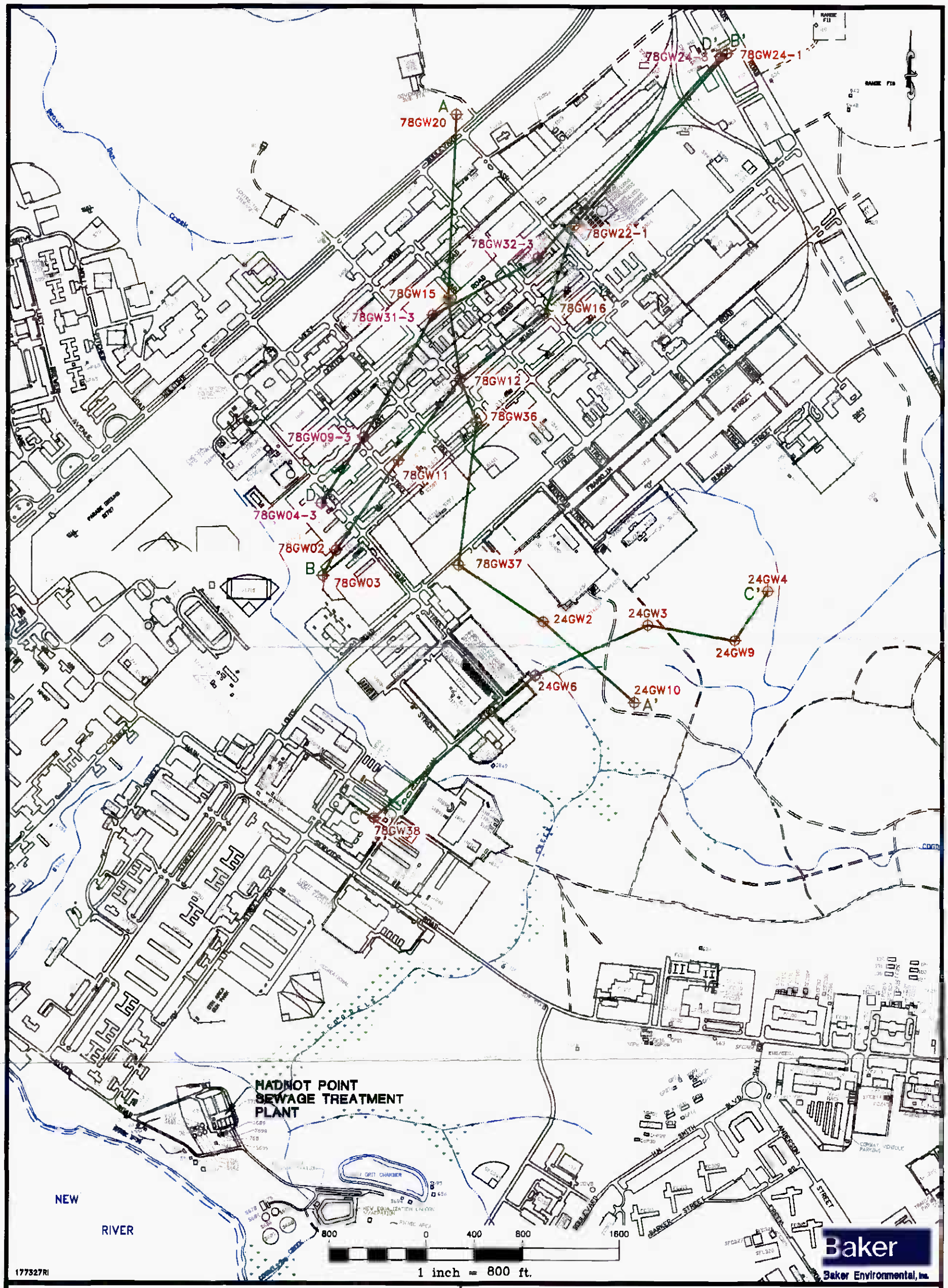
3.4.2.1 Shallow Soil Conditions

Shallow soil conditions are generally uniform throughout OU No. 1. In general, the shallow soils consist of unconsolidated deposits of silty and clayey-sand, silt, and clay. These soils represent the Quaternary age "undifferentiated" Formation which characterizes the shallow water table aquifer. Sands are fine to coarse-grained and contain varied amounts of silt (5 percent to 50 percent) and clay (5 percent to 20 percent). Results of the standard penetration tests (commonly referred to as "blow counts", ASTM 1586) indicate that the sands have a relative density of loose to dense. Based on field observations, the sands classify as SM and/or SC according to the USCS. Clays are plastic to nonplastic, contained varied amounts of silt (some of which contained organic matter) and clay (5 percent to 25 percent), and classify as CL or CH. Standard penetration results for cohesive soils (silts and clays) indicate a relative density of medium dense to stiff.

Geologic cross-sections depicting shallow soil conditions underlying OU No. 1 were developed based on information obtained during this RI and from previous investigations. As shown on Figure 3-3, several areas of OU No. 1 were traversed to provide a cross-sectional view of the soils. In general, cross-section A to A' traverses north to south (shallow soils), and cross-sections B to B' and C to C' traverse southeast to northeast (shallow soils). Cross Section D to D', which depicts the deeper subsurface soils, traverses south to north across Site 78.

Cross-section A to A' depicts shallow soil conditions from the northern boundary (78GW20) of Site 78 to the southern boundary of Site 24 (24GW10). As shown on Figure 3-4, the soils underlying the area consist of sandy-clay, clayey-sand, and silty sand. In general, clayey soils are present at the northern end of the traverse near borings 78GW20 and 78GW15. An increase in the amount sandy soils occurs toward the southern end of the traverse across Site 24. These sandy soils are encountered generally to a depth of 25 feet.

Shallow soils along the B to B' traverse consisted of sandy-peat, sandy-clay, and silty-sand as shown on Figure 3-5. Overall, the soils encountered (to a depth of 25 feet) northeastward across the site are mostly silty-sands with some stringers of clayey-sand. Sandy-peat, with a relative high organic content, was found near boring 78GW03 in the first few feet. This boring is located toward the southeastern portion of Site 78. In the vicinity of boring 78GW24-1, which is located near the northeastern-most portion of Site 78, sandy-clay and silty-peat are present below a depth of 15 feet to the termination of the boring at 25 feet.



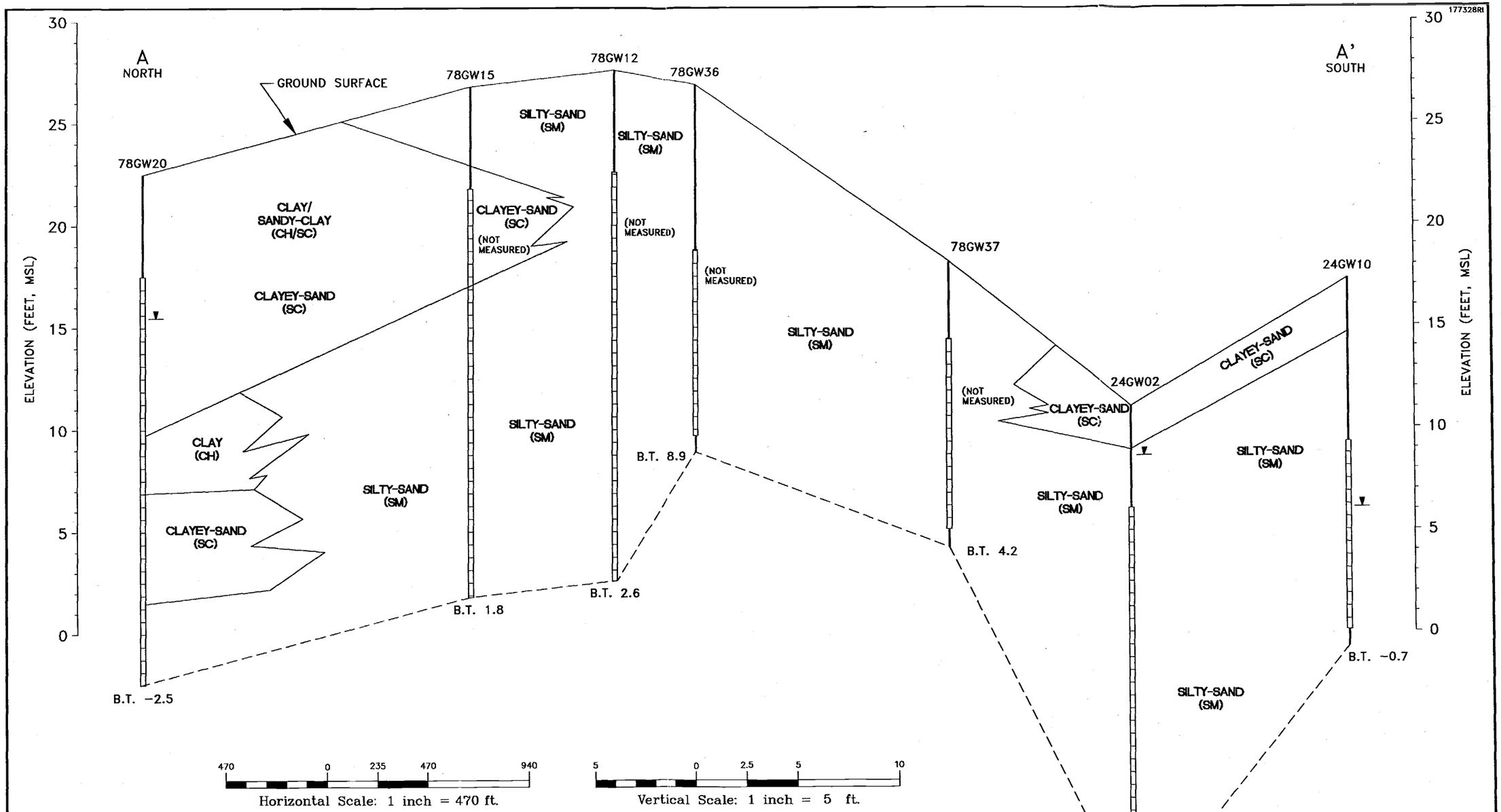
LEGEND

- 78GW02 — NEW OR EXISTING SHALLOW MONITORING WELL
- 78GW04-3 — EXISTING DEEP MONITORING WELL
- A—A' — GEOLOGIC CROSS-SECTION TRAVERSE

SOURCE: LANTDIV, FEBRUARY 1992

FIGURE 3-3
GEOLOGIC CROSS-SECTION
LOCATION MAP
OPERABLE UNIT No. 1
REMEDIAL INVESTIGATION CTO-0177
MARINE CORPS BASE, CAMP LEJEUNE
NORTH CAROLINA

01271V19Y



LEGEND

- GROUNDWATER ELEVATION, FEET ABOVE MSL (AUG. 1, 1993)
- B.T. −2.5 BORING TERMINATED, ELEVATION MSL
- WELL SCREEN INTERVAL
- ESTIMATED
- PROJECTED

NOTES:
−SOIL DESCRIPTIONS FOR BORINGS 78GW20, 78GW15, 78GW12, 78GW36, 78GW37, 24GW1, AND 24GW2 WERE OBTAINED FROM ESE, 1992.
−GROUNDWATER LEVELS WERE NOT MEASURED FOR WELLS 78GW15, 78GW12, 78GW36, AND 78GW37 ON AUGUST 1, 1993.

FIGURE 3−4
GEOLOGIC CROSS−SECTION A−A'
DEPICTING SHALLOW SOIL CONDITIONS
OPERABLE UNIT No. 1
REMEDIAL INVESTIGATION CTO−0177

MARINE CORPS BASE, CAMP LEJEUNE
NORTH CAROLINA

Baker
Baker Environmental, Inc.

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

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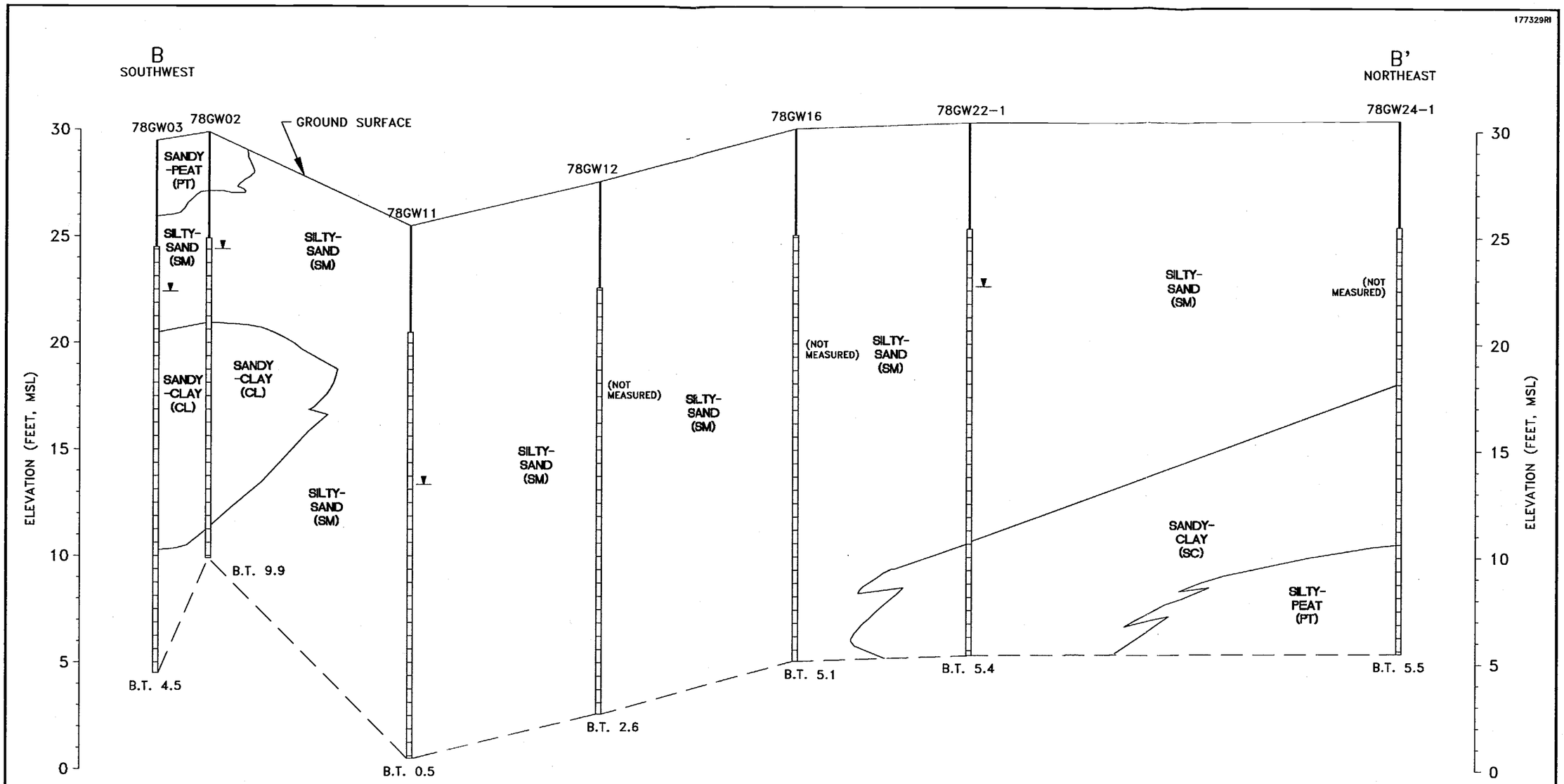

Baker
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LEGEND

- GROUNDWATER ELEVATION, FEET ABOVE MSL (AUG. 2, 1993)
- B.T. 4.5' BORING TERMINATED, ELEVATION MSL
- WELL SCREEN INTERVAL
- ESTIMATED
- PROJECTED

NOTES:
-SOIL DESCRIPTIONS FOR ALL BORINGS WERE OBTAINED FROM ESE, 1992.
-GROUNDWATER LEVELS WERE NOT MEASURED FOR WELLS 78GW12, 78GW16, AND 78GW24-1 ON AUGUST 2, 1993.

470 0 235 470 940
Horizontal Scale: 1 inch = 470 ft.

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

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

FIGURE 3-5
GEOLOGIC CROSS-SECTION B-B'
DEPICTING SHALLOW SOIL CONDITIONS
OPERABLE UNIT No. 1
REMEDIAL INVESTIGATION CTO-0177

MARINE CORPS BASE, CAMP LEJEUNE
NORTH CAROLINA

01271V21Z

Cross-section C to C' predominantly depicts soils across Site 24. Silty-sand and clayey-sand were encountered within each boring at shown on Figure 3-6. A layer of silty-sand was encountered across the site generally within the first few feet. Underlying the clayey-sand was silty-sand which was noted to a depth of 25 feet.

Overall, the shallow soils encountered at OU No. 1 are generally consistent throughout. As described above, silty-sands and clayey sands were the two dominant soil types encountered with some stringers of clayey soils. Note that within the area investigated, a laterally continuous confining layer (i.e., one which displays a low enough permeability to impede the migration of contaminants to any stratigraphically lower water-bearing zone) was absent in the shallow soils.

3.4.2.2 Deep Soil Conditions

Information pertaining to soil conditions from 25 to 150 feet bgs was obtained from boring logs from the ESE investigation conducted in 1991. As shown on Figure 3-3, a single cross-section (D to D') depicting deeper soil conditions across Site 78 was generated from this information. The soils encountered between the depths of 25 feet and 150 feet are generally uniform as shown on Figure 3-7. According to the ESE boring logs, the dominant soil type encountered is a silty-sand with shell fragments. Additionally, thin layers of shelly limestone are present near borings 78GW32-3 and 78GW31-3 at depths ranging from 30 feet to 80 feet, respectively. Within the deeper soils, a laterally continuous confining or semi-confining layer appears to be absent in the vicinity of this operable unit.

3.5 Surface Soils

Information regarding site soil conditions was obtained from the Soil Survey publication prepared by the U.S. Department of Agriculture - Soil Conservation Service (SCS) for Marine Corps Base Camp Lejeune, North Carolina (SCS, 1984). Due to past grading and surface activities at OU No. 1, however, the soils described in the SCS publication may differ from current site conditions. Table 3-3 summarizes some of the physical properties of soils encountered within OU No. 1.

According to the SCS Soil Survey the majority of OU No. 1, Sites 21 and 78, is underlain by a single distinct soil unit. The Urban soil unit typically consists of areas that are more than 85 percent covered by buildings, streets, parking lots, and associated urban areas. Due to

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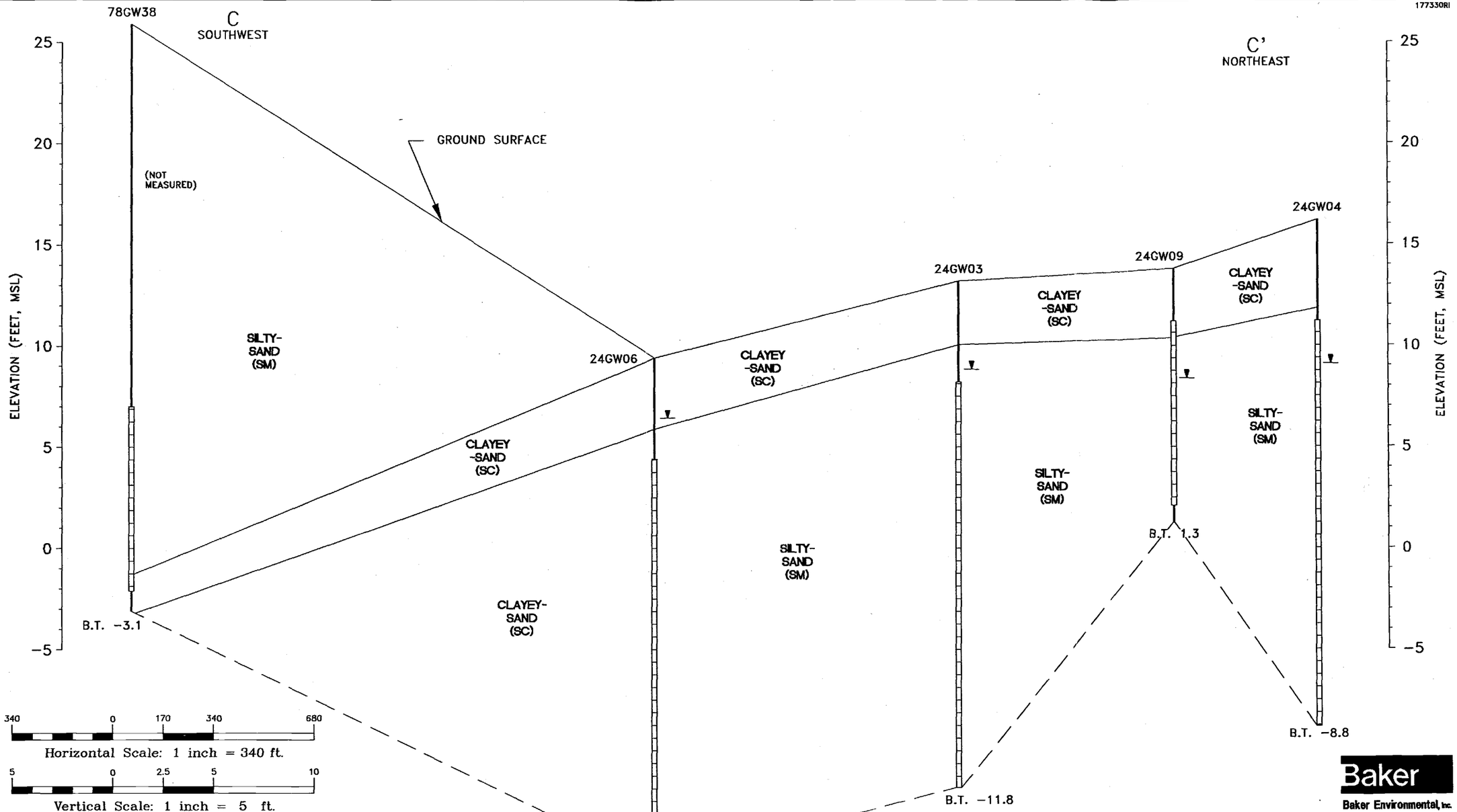


Baker
Baker Environmental, Inc.

LEGEND

- GROUNDWATER ELEVATION, FEET ABOVE MSL (AUG. 1, 1993)
- B.T. -3.1' BORING TERMINATED, ELEVATION MSL
- WELL SCREEN INTERVAL
- ESTIMATED
- PROJECTED

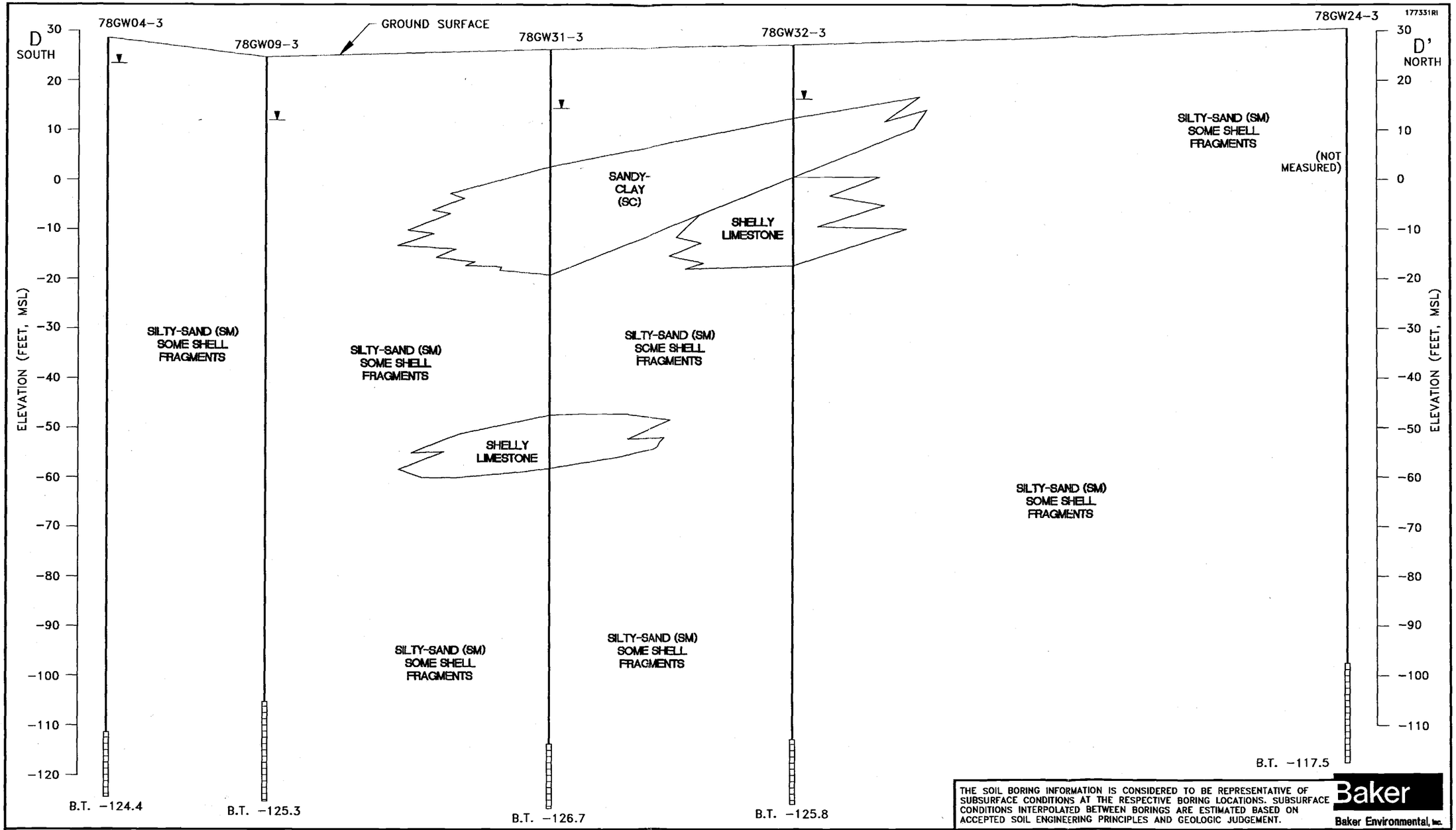
NOTES:
-SOIL DESCRIPTIONS FOR BORINGS 24GW03, 24GW04, AND 24GW06 WERE OBTAINED FROM ESE, 1992.
-GROUNDWATER LEVELS WERE NOT MEASURED FOR WELL 78GW38 ON AUGUST 1, 1993.

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

FIGURE 3-6
GEOLOGIC CROSS-SECTION C-C'
DEPICTING SHALLOW SOIL CONDITIONS
OPERABLE UNIT No. 1
REMEDIAL INVESTIGATION CTO-0177

MARINE CORPS BASE, CAMP LEJEUNE
NORTH CAROLINA

0127/V222



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

Baker

Baker Environmental, Inc.

LEGEND

- GROUNDWATER ELEVATION, FEET ABOVE MSL (AUG. 2, 1993)
- B.T. -124.4' BORING TERMINATED, ELEVATION MSL
- WELL SCREEN INTERVAL
- ESTIMATED
- PROJECTED

NOTES:
-SOIL DESCRIPTIONS FOR ALL BORINGS WERE OBTAINED FROM ESE, 1992.
-GROUNDWATER LEVELS WERE NOT MEASURED FOR WELL 78GW24-3 ON AUGUST 2, 1993.

400 0 200 400 800

Horizontal Scale: 1 inch = 400 ft.

20 0 10 20 40

Vertical Scale: 1 inch = 20 ft.

FIGURE 3-7
GEOLOGIC CROSS-SECTION D-D' DEPICTING INTERMEDIATE AND DEEP SOIL CONDITIONS
OPERABLE UNIT No. 1
REMEDIAL INVESTIGATION CTO-0177
MARINE CORPS BASE, CAMP LEJEUNE
NORTH CAROLINA

0127/V232

TABLE 3-3

SUMMARY OF SOIL PHYSICAL PROPERTIES
OPERABLE UNIT NO. 1
REMEDIAL INVESTIGATION CTO-0177
MCB CAMP LEJEUNE, NORTH CAROLINA

Soil Name	Soil Symbol	USCS Classification	Depth (inches)	Moist Bulk Density (g/cc)	Permeability (cm/s)	Soil Reaction (pH)	Shrink-Swell Potential	Organic Matter (percent)
Baymeade - Urban	BaB	SM, SP-SM	0 - 30	1.60 - 1.75	4.2×10^{-3} - 1.37×10^{-2}	4.5 - 6.5	Low	0.5 - 1.0
Baymeade	BmB	SM, SP-SM	0 - 30	1.60 - 1.75	4.2×10^{-3} - 1.37×10^{-2}	4.5 - 6.5	Low	0.5 - 1.0
Onslow	On	SM, SP-SM	0 - 21	1.60 - 1.75	$>4.2 \times 10^{-3}$	3.6 - 5.5	Low	0.5 - 2.0
Woodington	Wo	SM	0.12	1.50 - 1.70	4.2×10^{-3} - 1.37×10^{-2}	3.6 - 5.5	Low	2 - 4

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

Notes: SM - Loamy Fine Sand
SP - Fine Sand

extensive urbanization, the natural soil properties and topographic relief of the Urban complex have been altered. The infiltration rate of the Urban complex is low and, as a result, nearly all precipitation runs off.

The Baymeade (BmB) fine sand unit borders Site 78 to the south and comprises the majority of soils within the boundary of Site 24. The Baymeade fine sand unit is extensive throughout Camp Lejeune and occurs in areas with moderately convex slopes, 0 to 6 percent, near major drainageways. Commonly found in wooded areas, Baymeade fine sands exhibit rapid infiltration and slow surface water runoff. Typically, available water capacity is low and the seasonal high water table ranges from 4 to 5 feet below ground surface. The Baymeade unit is well suited for unsurfaced roads and light-duty traffic areas.

The Woodington (Wo) loamy fine sand unit borders Site 78 at its eastern corner. This nearly level, poorly-drained soil is commonly found on broad interdrainage uplands. Infiltration of this soil unit tends to be moderate and surface water runoff slow. Woodington soils typically have a seasonal high water table that approaches 0.5 feet bgs and is subjected to occasional surface water ponding. Compaction of its loamy surface layer and relatively high moisture content limits the use of Woodington soils to that of light-duty vehicle and foot traffic.

Sites 21 and 78 are bordered to the north and east by the Onslow (On) loamy fine sand unit. Being nearly level, Onslow soils exhibit moderate drainage and infiltration rates with slow surface water runoff. Onslow soil areas range from 20 to 300 acres in size and tend to be densely wooded. Seasonal high water table levels are generally between 1.5 and 3.0 feet bgs.

Sites 24 and 78 are bordered to the south and west by the Baymeade-Urban (BaB) land complex. Unlike the Urban complex, Baymeade-Urban soils exhibit 0 to 6 percent slopes and only about 30 percent of their surface area has been altered through urbanization. Infiltration is rapid and surface water runoff slow in the remaining undisturbed areas. The seasonal high water table ranges from 4 to 5 feet bgs for Baymeade-Urban soils.

3.6 Hydrogeology

The following sections discuss the regional and site-specific hydrogeologic conditions. The information presented on the regional hydrogeology is from literature (Harned, et al., 1989); site-specific hydrogeologic information presented is from data collected during the field investigation.

3.6.1 Regional Hydrogeology

The surficial water table aquifer lies in a series of undifferentiated sediments, primarily sand and clay, which commonly extend to depths of 50 to 100 feet. This aquifer is not used for water supply at MCB Camp Lejeune because of its low yielding production rates. A confining unit is present underlying the surficial aquifer within the eastern portion of MCB Camp Lejeune (Harned, et al., 1989).

The principal water supply aquifer for the Base lies in a series of sand and limestone beds between 50 and 300 feet below land surface. This series of sediments generally is known as the Castle Hayne formation. The Castle Hayne Formation is about 150 to 350 feet thick in the area and contains the most productive aquifer in North Carolina. Estimated transmissivity (T) and hydraulic conductivity (K) values for the Castle Hayne aquifer range from 4,300 to 24,500 $feet^2$/day (32,200 to 183,300 gallons/foot/day) and 14 to 82 feet/day, respectively (Harned et al., 1989).

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 from the aquifer. Overpumping of the deeper parts of the aquifer could cause intrusion of saltwater. The aquifer contains water having less than 250 milligrams per liter (mg/l) chloride throughout the area of the Base (Harned et al., 1989).

The aquifers that lie below the Castle Hayne consist of thick sequences 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 (Harned et al., 1989).

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 (Harned et al., 1989).

Water levels in wells tapping the surficial aquifer vary seasonally. The surficial aquifer receives more recharge in the winter than in the summer when much of the water evaporates or is transpired by plants before it can reach the water table. Therefore, the water table generally is highest in the winter months and lowest in summer or early fall (Harned et al., 1989).

In semi-confined aquifers, water is under excess head and the level to which it rises in a tightly cased well is called the potentiometric surface. The hydraulic head in the semi-confined Castle Hayne aquifer, shows a different pattern of variation over time. Some seasonal variation also is common in the potentiometric surface of the Castle Hayne aquifer, but the changes tend to be slower and over a smaller range than for water table wells (Harned et al., 1989).

3.6.2 Site Hydrogeology

The following sections describe the site hydrogeologic conditions for the shallow (surficial aquifer) and deeper (Castle Hayne aquifer) water-bearing zones at OU No. 1. Hydrogeologic characteristics in the vicinity of OU No. 1 were evaluated by reviewing existing information (e.g., USGS publications) and installing a network of shallow and deep monitoring wells [existing and newly installed (shallow only)] and staff gauges. The monitoring well network at OU No. 1 covers most of the HPIA which also includes Sites 21 and 24. Staff gauges were installed in Beaver Dam Creek (SG2 and SG3) and in Cogdels Creek (SG1 and SG4) to also assist in evaluating the shallow groundwater flow patterns in the area and to determine if the streams are either "gaining" (i.e., receiving groundwater discharge) or "losing" (i.e., stream discharging into groundwater) surface water bodies. Two of the staff gauges (SG1 and SG2), however, were destroyed prior to obtaining surface water measurements. Monitoring well and staff gauge locations for all three sites are shown on Figures 2-6, 2-8, and 2-9.

Groundwater was encountered during the drilling program at varying depths throughout OU No. 1. This variation in groundwater depth is attributed to topographic (i.e., land surface elevations) changes. In general, groundwater was encountered between 4 and 14 feet bgs. A higher water table was typically encountered near the southwestern portion of OU No. 1 near

Cogdels Creek, while a deeper water table was encountered near the northeastern boundary of HPIA.

Three rounds of groundwater level measurements were obtained from the shallow, intermediate (Site 78 only), and deep (Site 78 only) monitoring wells at OU No. 1. Water level measurements were obtained on May 17, June 4, and August 1 and 2, 1993 (within a 24-hour period) from the three sites. Furthermore, surface water elevations were measured from the two staff gauges installed in Cogdels Creek and Beaver Dam Creek on August 1 and 2, 1993. Groundwater and surface water elevations for the three sites are summarized on Tables 3-4 through 3-9.

Groundwater elevations exhibited some fluctuations over the three month period of monitoring at OU No. 1. The shallow wells indicated a 0.5 to 2 foot decline in the water table, whereas the intermediate and deep wells indicated a 0.5 to 1.5 foot decline. The decline in the water table depth appears to be the result of normal seasonal fluctuations. Typically at MCB Camp Lejeune, a higher water table is noted in the spring and a lower water table is noted in the late fall. Groundwater levels within the shallow water table aquifer can fluctuate as much as 5 feet throughout the year in the area.

Shallow groundwater flow patterns in the vicinity of OU No. 1 on May 18, 1993 and August 2, 1993 are depicted on Figures 3-8 and 3-9, respectively. Water level data collected from Site 78 wells were used for generating the maps since they cover a greater area within the operable unit. The groundwater contour map presented on Figure 3-8 depicts groundwater elevation distribution at the operable unit during the initial stages of the investigation prior to monitoring well installation by Baker in the southern portion of the site. Accordingly, groundwater elevation data gaps exist for the May 18, 1993 measurements. These data gaps, however, were resolved for the August 2, 1993 measurements because groundwater elevations were obtained from the southern portion of the operable unit from the newly installed Baker wells.

The data indicates that the regional groundwater flow across OU No. 1 is toward the west-southwest, in the general direction of Cogdels Creek and the New River. Localized groundwater flow toward Cogdels Creek is not depicted on the contour maps due to the complexity of the stream flow. Accordingly, the groundwater contour lines are dashed where they cross the stream to represent an estimated elevation.

TABLE 3-4

SUMMARY OF WATER LEVEL MEASUREMENTS FROM SHALLOW MONITORING WELLS ON
MAY 17, 1993, JUNE 4, 1993, AND AUGUST 1, 1993
SITE 21
REMEDIAL INVESTIGATION CTO-0177
MCB CAMP LEJEUNE, NORTH CAROLINA

Well No.	Top of PVC Casing Elevation (feet, above msl)(1)	Depth to Groundwater (feet, below top of casing) (5/17/93)	Depth to Groundwater (feet, below top of casing) (6/4/93)	Depth to Groundwater (feet, below top of casing) (8/1/93)	Groundwater Elevation (feet, above msl) (5/17/93)	Groundwater Elevation (feet, above msl) (6/14/93)	Groundwater Elevation (feet, above msl) (8/1/93)
21GW01	31.73	8.70	9.36	10.59	23.03	22.37	21.14
21GW02	31.02	9.00	9.69	11.18	22.02	21.33	19.84
21GW03	28.94	5.46	7.10	8.40	23.48	21.84	20.54
21GW04	27.56	6.05	6.63	7.41	21.51	20.93	20.15

Notes: (1) msl = mean sea level

TABLE 3-5

SUMMARY OF WATER LEVEL MEASUREMENTS FROM SHALLOW MONITORING WELLS ON MAY 17, 1993, JUNE 4, 1993, AND AUGUST 1, 1993
SITE 24
REMEDIAL INVESTIGATION CTO-0177
MCB CAMP LEJEUNE, NORTH CAROLINA

Well No.	Top of PVC Casing Elevation (feet, above msl)(1)	Depth to Groundwater (feet, below top of casing) (5/17/93)	Depth to Groundwater (feet, below top of casing) (6/4/93)	Depth to Groundwater (feet, below top of casing) (8/1/93)	Groundwater Elevation (feet, above msl) (5/17/93)	Groundwater Elevation (feet, above msl) (6/14/93)	Groundwater Elevation (feet, above msl) (8/1/93)
24GW1	18.02	--(2)	8.98	9.56	--	9.04	8.46
24GW2	13.66	--	4.40	5.00	--	9.26	8.66
24GW3	15.88	--	6.16	7.04	--	9.72	8.84
24GW4	19.17	8.92	9.40	10.08	10.25	9.77	9.09
24GW6	12.70	--	5.77	6.27	--	6.93	6.43
24GW7	29.82	14.51	15.91	15.80	15.31	13.91	14.02
24GW8	26.20	15.16	15.54	16.32	11.04	10.66	9.88
24GW9	16.55	6.86	7.46	8.16	9.69	9.09	8.39
24GW10	19.93	12.16	12.80	13.83	7.77	7.13	6.10

Notes: (1) msl = mean sea level
(2) -- = Data not collected.
Note that there is no well 24GW5 on site.

TABLE 3-6

SUMMARY OF WATER LEVEL MEASUREMENTS FROM SHALLOW MONITORING WELLS ON
MAY 17 AND 18, 1993, JUNE 4, 1993, AND AUGUST 1 AND 2, 1993
SITE 78
REMEDIAL INVESTIGATION CTO-0177
MCB CAMP LEJEUNE, NORTH CAROLINA

Well No.	Top of PVC Casing Elevation (feet, above msl)(1)	Depth to Groundwater (feet, below top of casing) (5/17/93)	Depth to Groundwater (feet, below top of casing) (5/18/93)	Depth to Groundwater (feet, below top of casing) (6/4/93)	Depth to Groundwater (feet, below top of casing) (8/1/93)	Depth to Groundwater (feet, below top of casing) (8/2/93)	Groundwater Elevation (feet, above msl) (5/17/93)	Groundwater Elevation (feet, above msl) (5/18/93)	Groundwater Elevation (feet, above msl) (6/4/93)	Groundwater Elevation (feet, above msl) (8/1/93)	Groundwater Elevation (feet, above msl) (8/2/93)
78GW02	32.15	--(2)	7.58	8.10	--	8.74	--	24.57	24.05	--	23.41
78GW03	31.85	--	7.80	8.32	--	9.44	--	24.05	23.53	--	22.41
78GW04-1	31.63	--	19.98	21.17	--	21.57	--	11.65	10.36	--	10.06
78GW05	28.51	--	10.85	11.67	--	12.65	--	17.66	16.84	--	15.86
78GW06	27.94	--	--	16.32	--	16.56	--	--	11.62	--	11.38
78GW07	27.83	--	13.72	14.75	--	15.39	--	14.11	13.08	--	12.44
78GW08	28.72	--	13.21	13.71	--	14.59	--	15.51	15.01	--	14.13
78GW10	28.13	--	12.36	12.80	--	13.72	--	15.77	15.33	--	14.41
78GW11	28.22	--	13.40	13.86	--	14.86	--	14.82	14.36	--	13.36
78GW12	30.08	--	11.30	11.63	--	12.36	--	18.78	18.45	--	17.72
78GW13	26.20	--	11.54	12.77	13.21	--	--	14.66	13.43	12.99	--
78GW14	27.32	--	10.70	11.38	12.14	--	--	16.62	15.94	15.18	--
78GW15	27.03	--	7.98	9.27	--	--	--	19.05	17.76	--	--
78GW16	32.40	--	11.74	12.05	12.86	--	--	20.66	20.35	19.54	--
78GW17-1	30.00	--	--	11.19	11.72	--	--	--	18.81	18.28	--

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

Note: Monitoring well 78GW09-1 could not be found during the RI. A replacement well was installed in December 1993 by Baker.

TABLE 3-6 (Continued)

SUMMARY OF WATER LEVEL MEASUREMENTS FROM SHALLOW MONITORING WELLS ON MAY 17 AND 18, 1993, JUNE 4, 1993, AND AUGUST 1 AND 2, 1993
SITE 78
REMEDIAL INVESTIGATION CTO-0177
MCB CAMP LEJEUNE, NORTH CAROLINA

Well No.	Top of PVC Casing Elevation[1] (feet, above msl)	Depth to Groundwater (feet, below top of casing) (5/17/93)	Depth to Groundwater (feet, below top of casing) (5/18/93)	Depth to Groundwater (feet, below top of casing) (6/4/93)	Depth to Groundwater (feet, below top of casing) (8/1/93)	Depth to Groundwater (feet, below top of casing) (8/2/93)	Groundwater Elevation (feet, above msl) (5/17/93)	Groundwater Elevation (feet, above msl) (5/18/93)	Groundwater Elevation (feet, above msl) (6/4/93)	Groundwater Elevation (feet, above msl) (8/1/93)	Groundwater Elevation (feet, above msl) (8/2/93)
78GW19	29.07	--	8.78	9.63	10.91	--	--	20.90	19.44	18.16	--
78GW20	25.33	--	7.46	8.55	9.86	--	--	17.87	16.78	15.47	--
78GW21	33.51	--	--	10.44	--	10.98	--	--	23.07	--	22.53
78GW22	32.36	--	7.12	8.74	--	9.65	--	25.24	23.62	--	22.71
78GW23	32.08	9.30	--	10.36	11.84	--	22.78	--	21.72	20.24	--
78GW24-1	32.84	--	6.77	7.40	8.54	--	--	26.07	25.44	24.30	--
78GW25	32.58	7.65	--	8.57	10.38	--	24.93	--	24.01	22.20	--
78GW33	29.84	--	--	6.17	--	7.60	--	--	23.67	--	22.24
78GW34	32.66	--	--	6.67	--	8.71	--	--	25.99	--	23.95
78GW35	32.08	--	--	13.57	--	14.06	--	--	18.51	--	18.02
78GW36	29.68	--	--	12.73	--	13.56	--	--	16.95	--	16.12
78GW37	20.02	--	--	9.46	--	10.28	--	--	10.56	--	9.74
78GW38	25.44	--	--	20.09	--	20.66	--	--	5.35	--	4.78
78GW39	19.44	--	--	15.51	--	15.96	--	--	3.93	--	3.48

Notes: [1] msl = mean sea level
[2] -- = Data not collected.

TABLE 3-7

SUMMARY OF WATER LEVEL MEASUREMENTS FROM INTERMEDIATE MONITORING WELLS ON
MAY 17 AND 18, 1993, JUNE 4, 1993, AND AUGUST 1 AND 2, 1993
SITE 78
REMEDIAL INVESTIGATION CTO-0177
MCB CAMP LEJEUNE, NORTH CAROLINA

Well No.	Top of PVC Casing Elevation (feet, above msl)(1)	Depth to Groundwater (feet, below top of casing) (5/17/93)	Depth to Groundwater (feet, below top of casing) (5/18/93)	Depth to Groundwater (feet, below top of casing) (6/4/93)	Depth to Groundwater (feet, below top of casing) (8/1/93)	Depth to Groundwater (feet, below top of casing) (8/2/93)	Groundwater Elevation (feet, above msl) (5/17/93)	Groundwater Elevation (feet, above msl) (5/18/93)	Groundwater Elevation (feet, above msl) (6/4/93)	Groundwater Elevation (feet, above msl) (8/1/93)	Groundwater Elevation (feet, above msl) (8/2/93)
78GW04-2	31.01	--(2)	19.24	20.48	--	20.74	--	11.77	10.53	--	10.27
78GW09-2	27.60	--	14.30	15.48	--	15.79	--	13.30	12.12	--	11.81
78GW17-2	32.14	--	13.38	14.18	15.02	--	--	18.76	17.96	17.12	--
78GW24-2	33.73	12.56	--	13.67	15.41	--	21.17	--	20.06	18.32	--
78GW31-2	26.24	--	10.20	11.11	--	11.68	--	16.04	15.13	--	14.56

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

TABLE 3-8

SUMMARY OF WATER LEVEL MEASUREMENTS FROM DEEP MONITORING WELLS ON
MAY 17 AND 18, 1993, JUNE 4, 1993, AND AUGUST 1 AND 2, 1993
SITE 78
REMEDIAL INVESTIGATION CTO-0177
MCB CAMP LEJEUNE, NORTH CAROLINA

Well No.	Top of PVC Casing Elevation (feet, above msl)(1)	Depth to Groundwater (feet, below top of casing) (5/17/93)	Depth to Groundwater (feet, below top of casing) (5/18/93)	Depth to Groundwater (feet, below top of casing) (6/4/93)	Depth to Groundwater (feet, below top of casing) (8/1/93)	Depth to Groundwater (feet, below top of casing) (8/2/93)	Groundwater Elevation (feet, above msl) (5/17/93)	Groundwater Elevation (feet, above msl) (5/18/93)	Groundwater Elevation (feet, above msl) (6/4/93)	Groundwater Elevation (feet, above msl) (8/1/93)	Groundwater Elevation (feet, above msl) (8/2/93)
78GW-04-3	28.40	--(2)	16.48	17.78	--	18.00	--	11.92	10.62	--	10.40
78GW-09-3	26.97	--	13.53	14.65	--	14.99	--	13.44	12.32	--	11.98
78GW24-3	32.32	11.38	--	12.58	14.27	--	20.94	--	19.74	18.05	--
78GW31-3	25.99	--	10.10	10.97	--	11.57	--	15.89	15.02	--	14.42
78GW32-3	27.09	--	9.48	9.66	--	10.84	--	17.61	17.43	--	16.25

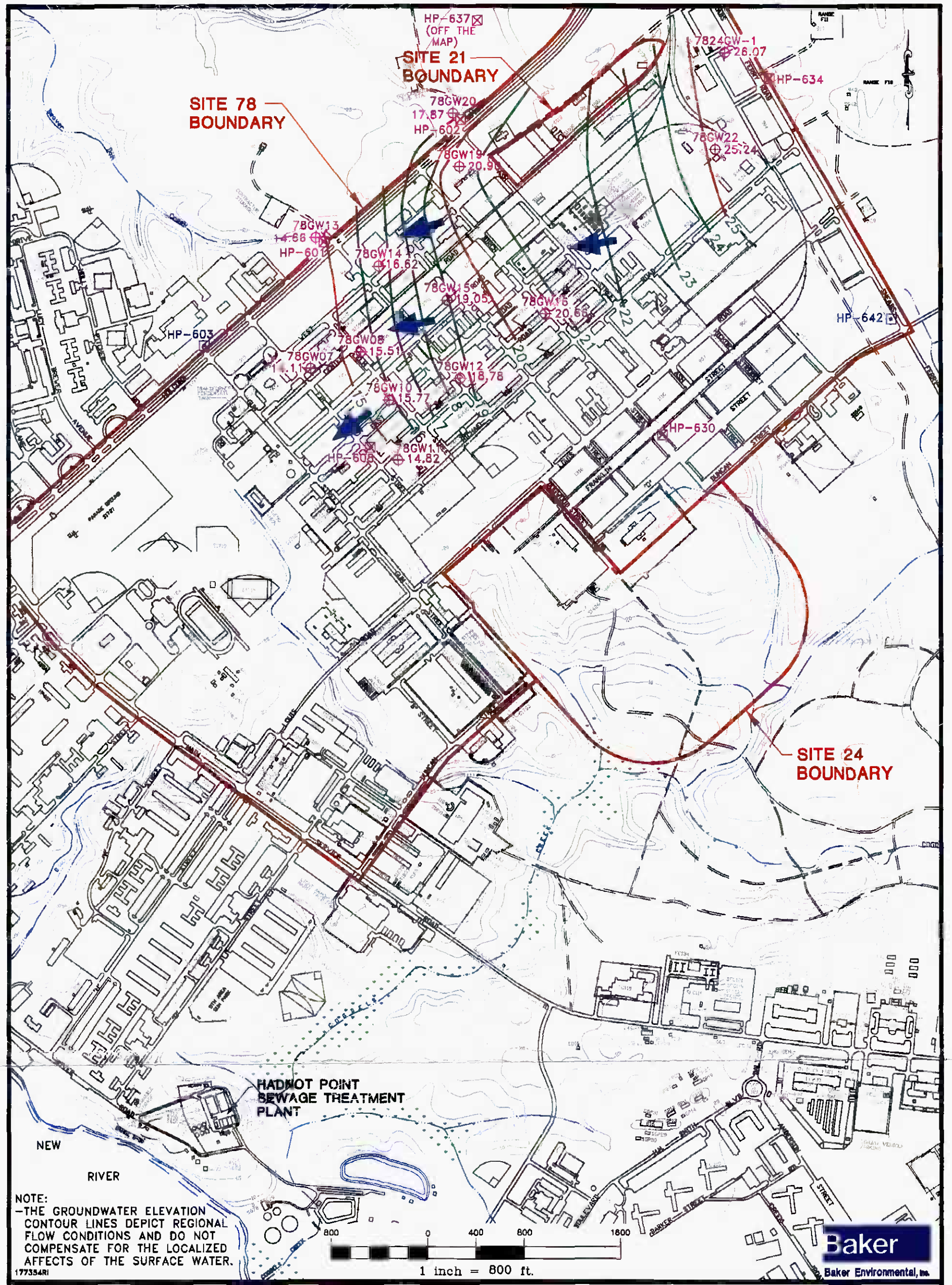
Notes: (1) msl = mean sea level
(2) -- = Data not collected.

TABLE 3-9

SUMMARY OF STAFF GAUGE READINGS ON
AUGUST 1 AND 2, 1993
OPERABLE UNIT NO. 1
REMEDIAL INVESTIGATION CTO-0177
MCB CAMP LEJEUNE, NORTH CAROLINA

Staff Gauge No.	Top of Staff Gauge Elevation (feet, above msl)[1]	Location	Staff Gauge Reading (feet) 08/01/93	Staff Gauge Reading (feet) (08/02/93)	Top of Water Elevation (feet, above msl) (08/01/93)	Top of Water Elevation (feet, above msl) (08/02/93)
SG3	10.68	Beaver Dam Creek	2.6	--[2]	8.08	--
SG4	3.48	Cogdels Creek	--	2.5	--	0.98

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



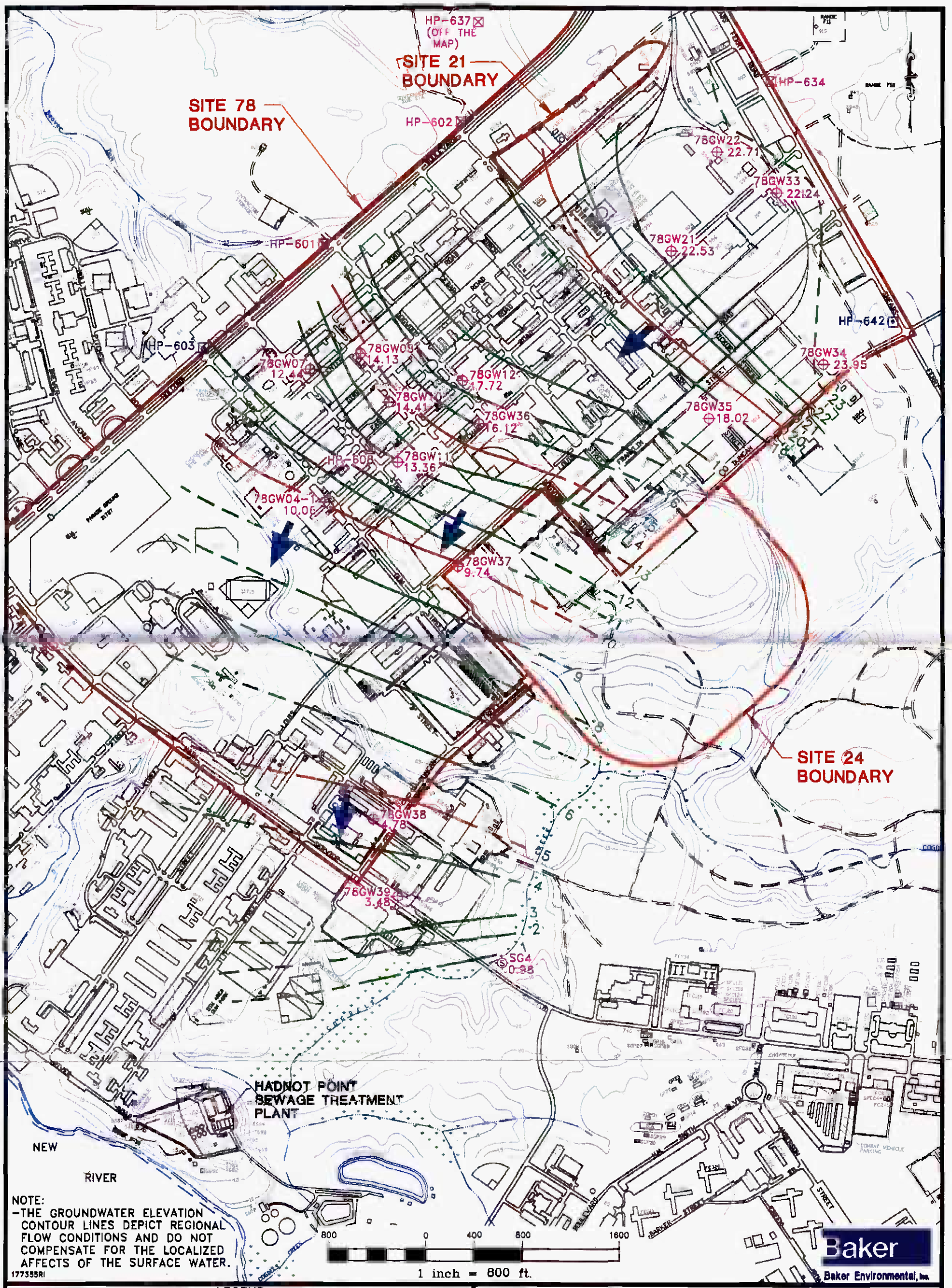
LEGEND

- 78GW07 — EXISTING SHALLOW MONITORING WELL
- 14.11 — GROUNDWATER ELEVATION, FEET ABOVE MSL (WELL SPECIFIC)
- —15— GROUNDWATER ELEVATION CONTOUR LINE, FEET ABOVE MSL
- APPROXIMATE GROUNDWATER FLOW DIRECTION
- HP-603 — WATER SUPPLY WELL (ACTIVE)
- HP-601 — WATER SUPPLY WELL (INACTIVE)

SOURCE: LANTDIV, FEBRUARY 1992

FIGURE 3-8
SHALLOW GROUNDWATER CONTOUR MAP
MAY 18, 1993
OPERABLE UNIT No. 1
REMEDIAL INVESTIGATION CTO-0177
MARINE CORPS BASE, CAMP LEJEUNE
NORTH CAROLINA

0127V24Y



NOTE:
-THE GROUNDWATER ELEVATION CONTOUR LINES DEPICT REGIONAL FLOW CONDITIONS AND DO NOT COMPENSATE FOR THE LOCALIZED AFFECTS OF THE SURFACE WATER.

177355RI

Baker Environmental, Inc.

LEGEND

78GW05 ⊕	EXISTING SHALLOW MONITORING WELL
13.08	GROUNDWATER ELEVATION, FEET ABOVE MSL (WELL/STAFF GAUGE SPECIFIC)
—1—	GROUNDWATER ELEVATION CONTOUR LINE, FEET ABOVE MSL
- -1- -	ESTIMATED GROUNDWATER ELEVATION CONTOUR LINE, FEET ABOVE MSL
HP-603 ⊡	WATER SUPPLY WELL (ACTIVE)
HP-601 ⊠	WATER SUPPLY WELL (INACTIVE)
SG4 Ⓢ	STAFF GAUGE
→	APPROXIMATE GROUNDWATER FLOW DIRECTION

SOURCE: LANTDIV, FEBRUARY 1992

FIGURE 3-9
SHALLOW GROUNDWATER CONTOUR MAP
AUGUST 2, 1993
OPERABLE UNIT No. 1
REMEDIAL INVESTIGATION CTO-0177
MARINE CORPS BASE, CAMP LEJEUNE
NORTH CAROLINA

0177X25Y

Measurements obtained from staff gauges SG3 and SG4, indicated that both Cogdel Creek and Beaver Dam Creek (i.e., the lower portions of each stream) are receiving regional groundwater discharge (i.e., base flow) and, therefore, are considered as "gaining streams." This conclusion is based on the fact that these two streams have a lower head of water compared to the surface of the water table in the area. Groundwater, under water table aquifer conditions, will flow from higher to lower heads. Groundwater discharge into the upper portions of each stream could not be determined since stream surface elevations are unknown in these areas. It does appear, however, that the upper portions of each stream would receive groundwater discharge based on the overall flow direction in the region and surface topography.

An estimate of the average groundwater gradients across OU No. 1 was calculated from the May 18, 1993 and August 2, 1993 groundwater data. The May 18, 1993 and August 2, 1993 gradients were calculated at 3.3×10^{-3} and 2.5×10^{-3}, respectively. These gradient values indicate a relatively flat water table surface. Furthermore, the data indicates a slight gradient toward the west-southwest in the general direction of Cogdels Creek and the New River.

Deeper groundwater flow patterns could not be fully evaluated because of the linear distribution of deep wells at the operable unit. Groundwater data collected from the deep wells, however, suggests that the general groundwater flow direction and gradient are also toward the west-southwest. The similar groundwater flow pattern observed between the shallow and deep water-bearing zones may further support the conclusion that the two water-bearing zones are hydraulically interconnected. Moreover, this conclusion is further supported by the fact that a laterally continuous confining layer between the two aquifers is not present in the vicinity of OU No. 1.

Groundwater elevation differentials (top of casing reference points were used as the datum reference) between the shallow and deeper water-bearing zones were evaluated from the May 18, August 1 and 2, 1993 groundwater elevation data. These differentials are presented on Table 3-10. Negative values (deep well elevations subtracted from shallow well elevations) represent upward heads and positive values represent downward heads. Well cluster 78GW24-1/24-3, which is located near the northeastern most portion of the site, exhibited a relatively high downward heads of 5.13 and 6.25 feet for May and August, respectively. A high downward head is indicative of a groundwater recharge area. At well cluster 78GW4-1/4-3, a negative or upward head of -0.27 and -0.34 feet was measured for May

TABLE 3-10

SUMMARY OF GROUNDWATER HEAD DIFFERENTIALS BETWEEN SHALLOW AND DEEP WELL CLUSTERS
SITE 78
REMEDIAL INVESTIGATION CTO-0177
MCB CAMP LEJEUNE, NORTH CAROLINA

Well No.	Groundwater Elevation (feet, above msl)[1] (5/18/93)	Groundwater Elevation (feet, above msl) (8/1/93)	Groundwater Elevation (feet, above msl) (8/2/93)	Groundwater Elevation Differential (5/1/93)	Groundwater Elevation Differential (5/1/93)	Groundwater Elevation Differential (8/2/93)
78GW4-1	11.65	--[2]	10.06	-0.27	--	-0.34
78GW4-3	11.92	--	10.40			
78GW24-1	26.07	24.30	--	5.13	6.25	--
78GW24-3	20.94	18.05	--			
78GW15	19.05	--	--	3.16	--	--
78GW31-3	15.89	--	--			

Notes: [1] msl = mean sea level
[2] -- = Data not collected.

and August, respectively. An upward head suggests a groundwater discharge area which is expected in this area because of the influence of the New River and Cogdels Creek.

The groundwater elevation data suggests that: (1) groundwater is recharging near the northeastern portion of OU No. 1; (2) the regional groundwater flow across the operable unit is toward the west-southwest; and (3) groundwater is discharging near the southwestern portion of OU No. 1 in the general direction of the New River and Cogdels Creek. Note that during periods of high evapotranspiration, which typically occur in the summer months, the shallow water-bearing zone may be more affected (i.e., water table may be lower due to a loss of recharge through evapotranspiration) compared to the deeper water-bearing zone.

Aquifer hydraulic parameters including hydraulic conductivity (K), transmissivity (T), and storativity (S) were not evaluated for either the shallow or deep water bearing-zones during this RI. Values for these parameters, however, are available from previous investigations performed at or in the immediate vicinity of the operable unit. A recent hydrogeologic investigation conducted by Baker (Baker, 1993) in the vicinity of well 78GW24-1 calculated values of T, S, and K within the shallow water-bearing zone (approximately 25 feet). Moreover, well performance tests conducted at the potable water supply wells within Hadnot Point provided estimates of T and production rates within the deeper Castle Hayne aquifer.

The Baker aquifer pump test results indicated an average T of 561 gallons/foot/day (75 $feet^2$/day), an average K of 2.8 feet/day (8.0×10^{-4} cm/sec), and an average S of 0.015 for shallow silty-sands (10 to 25 feet bgs). Very low production rates of less then 2.0 gpm within the shallow soils were noted. Additionally, in situ slug tests performed by Dewberry and Davis (1992) within the shallow soils near the Hadnot Point area indicated hydraulic conductivity values ranging from 1.1×10^{-3} to 4.0×10^{-4} cm/sec.

Estimates of specific capacity, T, and production flow rates for the Castle Hayne aquifer (typically encountered below 100 feet) are available from the well performance tests conducted in potable water supply wells in the vicinity of Hadnot Point. Specific capacity values were found to range from 3.8 to 6.8 gallons/minute/foot of available drawdown. Transmissivity values typically range between 4,300 and 7,300 $feet^2$/day (32,00 to 54,600 gallons/day/feet). Production rates from wells screened between 140 and 194 feet have produced flows of 50 to 150 gpm, although many base wells report flows of up to 300 gpm.

3.7 Land Use and Demography

MCB Camp Lejeune encompasses an area of approximately 234 square miles (approximately 149,760 acres), and comprises several distinct areas of development including Hadnot Point, MCAS/Camp Geiger, French Creek, and Courthouse Bay. The installation border is approximately 70 miles in length, which includes 14 miles of ocean front and Intracoastal Waterway. Recently, MCB Camp Lejeune acquired approximately 41,000 in the Greater Sandy Run Area.

The New River, which bisects the installation, provides both a commercial and recreational source of fish and shellfish for human consumption. The NC DEHNR reports that during the years 1989 and 1990 over 2.7 million pounds of fish and shellfish were caught commercially in the New River.

Land use within MCB Camp Lejeune is influenced by the topography of the land itself, by established environmental policy, and by base operational requirements. Soil drainage is the most critical factor which determines the suitability of a site for development. Much of the land area found within the facility consists of freshwater swamps that are wooded and largely unsuitable for development. In addition, approximately 3,000 acres of sensitive estuary and other areas set aside for the protection of threatened and endangered species are to remain undeveloped. Operational restrictions and regulations, such as explosive quantity safety distances, impact-weighted noise thresholds, and aircraft landing and clearance zones, may also greatly constrain and influence development (Master Plan, Camp Lejeune Complex, North Carolina, 1988).

The vast majority of MCB Camp Lejeune is used as training ranges and maneuver areas. Although interspersed throughout the installation, these areas are generally concentrated between Sneads Ferry Road and the eastern border of the base.

The combined military and civilian population of the Camp Lejeune/Jacksonville area is approximately 60,000. At the present time nearly 90 percent of the surrounding population resides within urbanized areas. As evidenced by the rapid population growth of Jacksonville and adjacent communities, particularly during the period from 1940 to 1960, Camp Lejeune continues to have a direct effect on regional population growth and development.

The development which typifies the HPIA evolved over a 40-year period and includes approximately 1,080 acres of land. The land uses tend to be integrated with one another, creating an environment which is pedestrian in scale. Community and recreational land uses are scattered throughout the regimental area which covers about 18 percent (196 acres) of all the developed land in the HPIA.

Administrative uses are situated in prominent central locations along the main entrance route, making them easily accessible to visitors and regimental personnel alike.

Segregated from the administrative personnel support and troop housing uses are supply/storage and maintenance uses which are consolidated in the eastern portion of Hadnot Point. Altogether, about 29 percent (310 acres) of all developed land falls into these two land use categories. Located in the center of this work area are troop housing and associated community uses which are segregated from other similar uses.

Commercial uses (36 acres) are located at three major locations at Hadnot Point. The Main Commissary Exchange is situated on Holcomb Boulevard. Two smaller commercial areas are located within the 2nd Division Regimental areas west of Main Street.

Recreational/open space uses comprise about 17 percent (182 acres) of the developed land in the HPIA. These areas are distributed mostly on the periphery of each of the troop housing area.

3.8 Regional Ecology

MCB Camp Lejeune is located on 17 miles of Atlantic coastline containing tidal marshes and alluvial deposits that are protected by a barrier of sand dunes along the coast. The New River inlet divides MCB Camp Lejeune and provides an environment for a variety of species. Onslow County maintains two forest preserves near MCB Camp Lejeune. These forest preserves, as well as other large areas of undeveloped land near the base, contribute to maintaining an environment favorable to the species that inhabit this area.

MCB Camp Lejeune is approximately 110,000 acres (not including the recent acquisition of approximately 41,000 acres), with 84 percent of the area covered by forests. Vegetation at MCB Camp Lejeune includes pure pine stands consisting of loblolly and longleaf pine (found on the drier upland soils), pure pond pine stands in high organic wet soils, pine-hardwood and

pure hardwood stands in streamside zones and in more productive soils, and bottomland hardwoods found on the floodplains of the major creeks (USMC, 1987). Wildlife on the base includes white-tailed deer, wild turkey, black bear, along with numerous small game species (e.g., bobwhite quail, morning dove, rabbit) (USMC, 1987).

3.8.1 Sensitive Environments

The NC DEHNR, Division of Environmental Management (DEM) has developed guidance pertaining to activities that may impact wetlands (NC DEHNR, 1992b). In addition, certain activities impacting wetlands also are regulated by the U.S. Corps of Engineers (COE).

The U.S. Fish and Wildlife Service (FWS) prepares National Wetland Inventory (NWI) maps. The NWI map for the Camp Lejeune, North Carolina quadrangle was prepared primarily by stereoscopic analysis of high altitude aerial photographs. 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 (An Operational Draft), Cowardin, et al., 1977 (USDI, 1982). NWI maps are intended for a cursory identification of wetland areas. They cannot be substituted for an actual wetland delineation that may be required by Federal, State and Local regulatory agencies. No wetlands have been identified within OU No. 1 from the NWI map with the exception of a limited area within the southern portion of Site 24. The NWI map does identify several forested wetland areas just south of OU No. 1 along Cogdels Creek.

Certain species have been granted protection by the U.S. FWS under the Federal Endangered Species Act (16 U.S.C. 1531-1543), and/or the North Carolina Wildlife Resources Commission, under the 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 rate, or state watch list. While only the Federal or state threatened or endangered, or state special concern species are protected from certain actions, the other classified species have the potential for protection in the future.

Many protected species have been sited near and on MCB Camp Lejeune. Table 3-11 contains a list of these protected species (either endangered, threatened, or special concern) that have been identified within the boundaries of MCB Camp Lejeune. (MCB Camp Lejeune, 1991), (LeBlond, 1991), (Fussell, 1991), and (Walters, 1991).

TABLE 3-11

PROTECTED SPECIES WITHIN MCB CAMP LEJEUNE
OPERABLE UNIT NO. 1
REMEDIAL INVESTIGATION CTO - 0177
MCB CAMP LEJEUNE, NORTH CAROLINA

Species	Protected Classification
American alligator (Alligator mississippienis)	T(f), T(s)
Bachmans sparrow (Aimophilia aestivalis)	SC
Black Skimmer (Rhynochops niger)	SC
Green (Atlantic) turtle (Chelonia m. mydas)	T(f), T(s)
Loggerhead turtle Caretta caretta)	T(f), T(s)
Piping plover (Charadrius melodus)	T(f), T(s)
Red-cockaded woodpecker (Picoides borealis)	E(f), E(s)
Rough-leaf loosestrife (Lysimachia)	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

A Peregrine falcon was spotted approximately three miles east of OU No. 1 (Fussell, 1991). These birds potentially may inhabit or feed in areas surrounding OU No. 1 because of their large foraging range. Black skimmers and piping plovers were observed near the New River Inlet (Fussell, 1991). However, these birds primarily inhabit shore line areas and, therefore, are not expected to be found at OU No. 1. Bachmans sparrows and red-cockaded woodpeckers were observed at numerous locations throughout southern MCB Camp Lejeune. The American Alligator has been reported in Cogdels Creek (Peterson, 1993) but is not likely to inhabit the narrower, upper reaches of the Creek. None of these species were observed at OU No. 1 during intensive investigations previously conducted for MCB Camp Lejeune, therefore, there is a low potential for them to exist at OU No. 1 (Fussell, 1991; Walters, 1991).

3.8.2 Other Sensitive Environments

In addition to wetlands and protected species, the presence of other sensitive environments, including those listed in 40 CFR Part 300, were evaluated. These sensitive environments are evaluated when assessing potential hazardous waste sites using the Hazard Ranking System. These sensitive environments and their presence or absence at OU No. 1 are discussed below.

- Marine Sanctuary - OU No. 1 is not located within a Marine Sanctuary (NCMFC, 1992).

- National Park - OU No. 1 is not located within a National Park (NPS, 1991).

- Designated Federal Wilderness Area - OU No. 1 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). Cogdels Creek or Beaver Dam Creek are not located within any areas identified under CAMA (NC DEHNR, 1993a).

- Sensitive Areas Identified under the National Estuary Program (NEP) or Near Coastal Waters Program (NCWP) - OU No. 1 is not located within a Sensitive Area identified under the NEP or NCWP (USEPA, 1993).

- Critical Areas Identified under the Clean Lakes Program - OU No. 1 is not located within a Critical Area identified under the Clean Lakes Program (NPS, 1991).

- National Monument - OU No. 1 is not located within a National Monument (NPS, 1991).

- National Seashore Recreational Area - OU No. 1 is not located within a National Seashore Recreational Area (NPS, 1991).

- National Lakeshore Recreational Area - OU No. 1 is not located within a National Lakeshore Recreational Area (NPS, 1991).

- National Preserve - OU No. 1 is not located within a National Preserve (NPS, 1991).

- National or State Wildlife Refuge - OU No. 1 is not located within a National or State Wildlife Refuge (NCWRC, 1992).

- Unit of the Coastal Barrier Resource Program - OU No. 1 is not located within a unit of the Coastal Barrier Resource Program (USDI, 1993).

- Administratively Proposed Federal Wilderness Area - OU No. 1 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 spawning areas have been identified within Cogdels Creek or Beaver Dam Creek (Peterson, 1993). No specific spawning areas critical for the maintenance of fish/shellfish species in Cogdels Creek or Beaver Dam Creek have been designated as such by state agencies (NCDEHNR, 1993b).

- 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 OU No. 1 are not migratory pathways or feeding area critical for the maintenance of anadromous fish species because there is not a significant population of anadromous fish in Cogdels Creek, or Beaver Dam Creek (NC DEHNR, 1993b).

- Terrestrial areas utilized for breeding by large or dense aggregations of animals - As discussed in the Regional Ecology section of this report, several large and dense aggregations of terrestrial species inhabit MCB Camp Lejeune. Therefore, there is the potential for breeding of these animals on, or adjacent to OU No. 1. However, the majority of OU No. 1 is highly developed, greatly reducing the potential for breeding within OU No. 1.

- National river reach designated as Recreational - Cogdels Creek or Beaver Dam Creek are not designated as National Recreational Rivers (NPS, 1990, 1993).

- Federal designated Scenic or Wild River - Cogdels Creek or Beaver Dam Creek are not Federally designated Scenic or Wild Rivers (NPS, 1990, 1993).

- State land designated for wildlife or game management - OU No. 1 is not located within a State game land (NCWRC, 1992).

- State designated Scenic or Wild River - Cogdels Creek or Beaver Dam Creek are not State designated Scenic or Wild Rivers (NCMFC, 1992).

- State designated Natural Area - OU No. 1 is not located within a State designated Natural Area or Area of Significant Value (LeBlond, 1991).

- State designated areas for protection or maintenance of aquatic life - No areas within the boundaries of OU No. 1 are designated as primary nursery areas or are unique or special waters of exceptional state or national recreational or ecological significance which require special protection to maintain existing uses (NC DEHNR, 1993b).

- Areas of Significant Value - OU No. 1 is not located within a State Area of Significant Value (LeBlond, 1991).

- State Registered Natural Resource Area - OU No. 1 is not located within a State Registered Natural Resource Area (LeBlond, 1991).

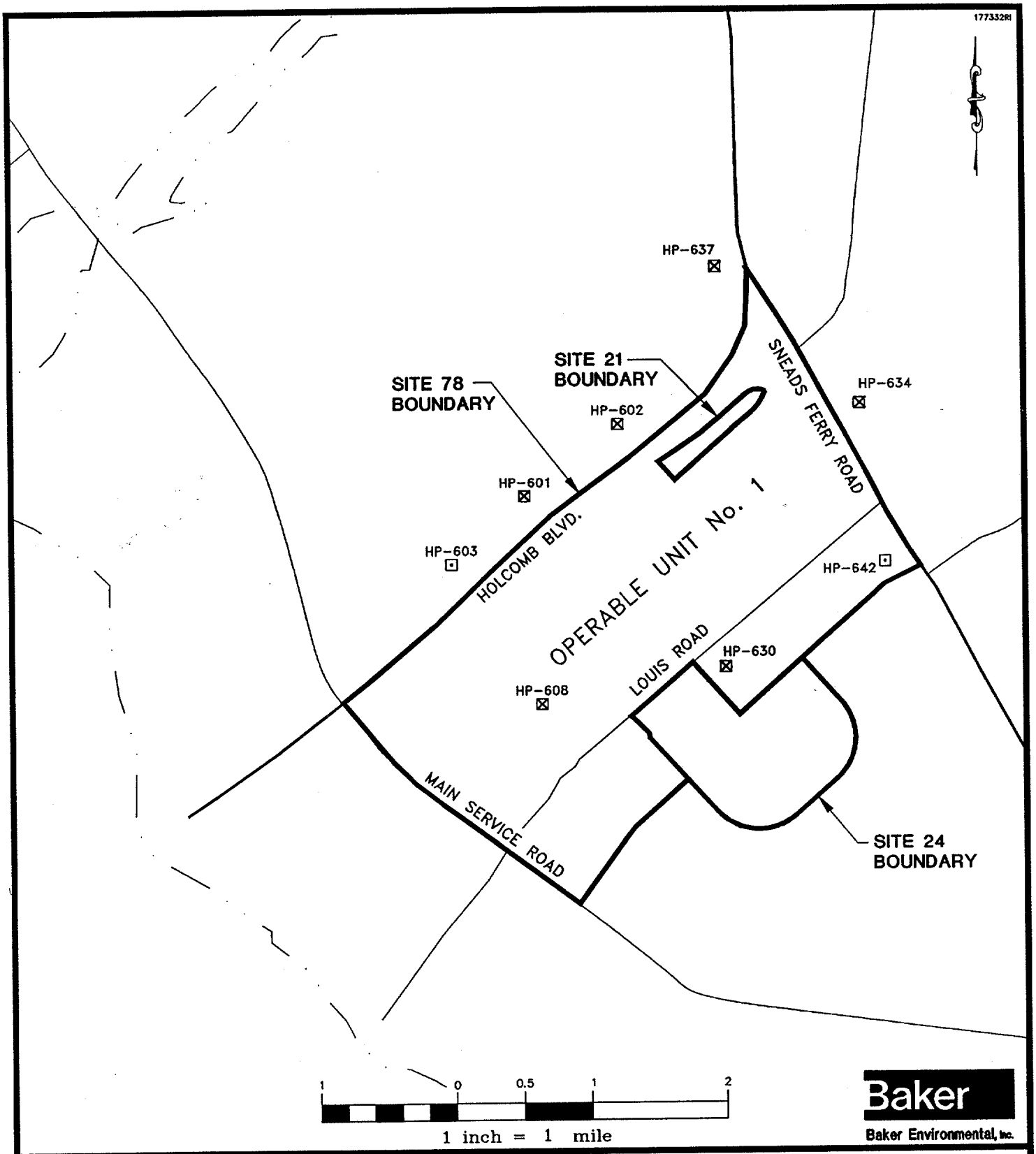
3.9 Identification of Water Supply Wells

Potable water supply wells within a one-mile radius of OU No. 1 were identified as shown on Figure 3-10. Information regarding well depths, screen intervals, aquifer characteristics (specific capacity and T), and well distance and direction to the sites is provided on Table 3-12. Supply well information was obtained from Camp Lejeune personnel, and from a U.S.G.S. professional paper 89-4096 entitled, "Assessment of Hydrologic and Hydrogeologic Data at Camp Lejeune Marine Corps Base, North Carolina" (Harned, et al., 1989).

As shown on Table 3-12, eight potable water supply wells were identified in the vicinity of OU No. 1. Six of the wells including HP-601, HP-602, HP-608, HP-630, HP-634, and HP-637 are no longer in service according to Camp Lejeune personnel. The depths of these wells range from 160 to 225 feet and their screened intervals range from 45 to 225 feet. According to information in the U.S.G.S. publication, all of the supply wells utilize the Castle Hayne aquifer which serves as the principal water-supply aquifer for Camp Lejeune. An average yield 174 gpm is reported for these supply wells (Harned et al, 1989).

The locations of the supply wells [both in service (HP-603 and HP-642) and out-of-service (HP-601, HP-602, HP-608, HP-630, HP-634, and HP-637) wells] identified near OU No. 1 are shown on Figure 3-10. Well HP-603 is located approximately 180 feet north [or in the downgradient groundwater flow direction (refer to Figure 3-9)] of Site 78, and well HP-642 is located approximately 900 feet south (or in the downgradient groundwater flow direction) of Site 78.

Analytical data of groundwater samples collected in 1984, 1985, and 1992 from the supply wells are summarized on Table 3-13 (Geophex, Ltd., 1991). Note that the out-of-service wells were not sampled in 1992. Six of the wells exhibited VOC contamination (HP-601, HP-602, HP-603, HP-608, HP-634, and HP-637) and one well (HP-642) exhibited SVOCs contamination. The VOCs detected were predominately halogenated compounds (e.g., DCE, TCE, PCE) with some non-halogenated compounds (e.g., benzene, ethylbenzene, toluene). The overall highest total VOC concentrations were detected in wells HP-602 (2,254 µg/l in 1984), HP-634 (2,010 µg/l in 1985), and HP-601 (333.4 µg/l in 1984). Moreover note that well HP-603, which is currently in service, exhibited a TCE concentration of 2.0 µg/l in 1992.



LEGEND

HP-603 ⊡ POTABLE WATER SUPPLY WELL (ACTIVE)

HP-601 ⊠ POTABLE WATER SUPPLY WELL (INACTIVE)

NOTE:
-REFER TO FIGURE 1-5 FOR SPECIFIC DETAILS REGARDING STRUCTURES, ROADS, AND BUILDINGS WITHIN OPERABLE UNIT No. 1.

FIGURE 3-10
LOCATION OF NEARBY POTABLE WATER SUPPLY WELLS
OPERABLE UNIT No. 1
REMEDIAL INVESTIGATION CTO-0177
MARINE CORPS BASE, CAMP LEJEUNE
NORTH CAROLINA

TABLE 3-12

SUMMARY OF POTABLE WATER SUPPLY WELLS
WITHIN THE VICINITY OF OPERABLE UNIT NO. 1[1]
REMEDIAL INVESTIGATION CTO-0177
MCB CAMP LEJEUNE, NORTH CAROLINA

Supply Well Number	Well Depth (feet)	Screened Intervals (feet)	Well Diameter (inches)	Specific Capacity (gal/min/ft)	Estimated Transmissivities (ft^2/day	Approximate Distance/ Direction to Closest Site [3] (feet)
HP-601/660	195	45-60 95-100 115-130 175-195	8	--[2]	--	180/North (Site 78)
HP-602	160	70-80 100-105 120-125 145-150 155-160	8	--	--	180/North (Site 78)
HP-603	195	70-80 100-110 130-140 160-170 190-195	8	--	--	180/North (Site 78)
HP-608	161.5	61.5-81.5 91.5-101.5 121.5-131.5 151.5-161.5	8	--	--	Within southwestern portion of Site 78
HP-630	176	62-67 87-92 107-117 127-142 152-162	8	--	--	Within southern portion of Site 78
HP-634	225	65-70 73-78 83-88 93-98 107-117 124-129 135-140 153-163 170-175 195-200 215-225	8	4.5	4,300	100/East (Site 78)

Notes: (1) Information obtained from "U.S.G.S. Water Resources Investigation Report 89-4096" (Harned et. al., 1989).
(2) Information not available
(3) Distance measured from site boundary

TABLE 3-12 (Continued)

SUMMARY OF POTABLE WATER SUPPLY WELLS
WITHIN A ONE-MILE RADIUS OF OPERABLE UNIT NO. 1(1)
REMEDIAL INVESTIGATION CTO-0177
MCB CAMP LEJEUNE, NORTH CAROLINA

Supply Well Number	Well Depth (feet)	Screened Intervals (feet)	Well Diameter (inches)	Specific Capacity (gal/min/ft)	Estimated Transmissivities (ft^2/day	Approximate Distance/ Direction to Site (feet)
HP-637	172	90-98 102-114 120-128 140-148 156-172	8	--	--	1000/North (Site 78)
HP-642	210	112-124 136-144 157-163 174-178 188-196	8	--	--	900/South (Site 78)

Notes: (1) Information obtained from "U.S.G.S. Water Resources Investigation Report 89-4096" (Harned et. al., 1989).
(2) Information not available
(3) Distance measured from site boundary

TABLE 3-13

SUMMARY OF POTABLE WATER SUPPLY WELL STATUS AND CONTAMINATION LEVELS (1) REMEDIAL INVESTIGATION CTO-0177 MCB CAMP LEJEUNE, NORTH CAROLINA

Supply Well Number	Well Status	Date Shut-off	Contaminant Levels (µg/l)		
			1984	1985	1992
HP-601/660	Off	12/6/84	DCE 99 TCE 230 PCE 4.4	DCE 74 TCE 38 PCE 1.5	Not Sampled
HP-602	Off	11/30/84	DCE 630 TCE 1,600 PCE 24	Not Sampled	Not Sampled
HP-603	On	Not Applicable	Not Sampled	Not Sampled	TCE 2.0
HP608	Off	-- (2)	DCE 5.4 TCE 110 Benzene 3.7	TCE 9.0 Benzene 1.6	Not Sampled
HP-630	Off	--	--	--	--
HP-634	Off	12/14/84	DCE 2.3 Vinyl chloride 130	DCE 700 TCE 10 Vinyl Chloride 1,300	Not Sampled
HP-637	Off	12/14/84	Methylene Chloride 270	Not Sampled	Not Sampled
HP-642	On	Not Applicable	Not Sampled	Not Sampled	Naphthalene 1.0

Notes: (1) Information obtained from "Wellhead Management Program Engineering Study 91-36" by Geophex, Ltd., 1991.
(2) -- = Information Unknown

The source of the contaminants which have impacted the supply wells appears to have originated from the Hadnot Point area. Contaminants released on the ground surface within the Hadnot Point area appear to have migrated vertically into the deeper Castle Hayne aquifer system in which the supply wells are installed. Vertical and horizontal migration of the contaminants may have been assisted by the pumping of the supply wells over a period of time. The area for the zone of capture created by the pumping of the supply wells within Hadnot Point is estimated to be approximately 65 acres based on a model employed by Geophex, Ltd., 1991. Based on his model, therefore, contaminants which have migrated into the deeper aquifer would most likely impact the supply wells at Hadnot Point over time.