✓

03.05-02/21/97-01760

FINAL

SITE EVALUATION
PROJECT PLANS

OPERABLE UNIT NO. 15 (SITE 88)
MCB CAMP LEJEUNE, NORTH CAROLINA

CONTRACT TASK ORDER 0356

FEBRUARY 21, 1997

Prepared for:

DEPARTMENT OF THE NAVY
ATLANTIC DIVISION
NAVAL FACILITIES
ENGINEERING COMMAND
Norfolk, Virginia

Under:

LANTDIV CLEAN Program
Contract N62470-89-D-4814

Prepared by:

BAKER ENVIRONMENTAL, INC.
Coraopolis, Pennsylvania

FINAL

SITE EVALUATION
WORK PLAN

OPERABLE UNIT NO. 15 (SITE 88)
MCB CAMP LEJEUNE, NORTH CAROLINA

CONTRACT TASK ORDER 0356

FEBRUARY 21, 1997

Prepared for:

DEPARTMENT OF THE NAVY
ATLANTIC DIVISION
NAVAL FACILITIES
ENGINEERING COMMAND
Norfolk, Virginia

Under:

LANTDIV CLEAN Program
Contract N62470-89-D-4814

Prepared by:

BAKER ENVIRONMENTAL, INC.
Coraopolis, Pennsylvania

TABLE OF CONTENTS

Page

1.0 INTRODUCTION 1-1
- 1.1 Objective of the Site Evaluation Work Plan 1-1
- 1.2 Site Evaluation Scoping 1-1
- 1.3 Site Evaluation Work Plan Format 1-2

2.0 BACKGROUND AND SETTING 2-1
- 2.1 MCB Camp Lejeune, North Carolina 2-1
  - 2.1.1 Location and Setting 2-1
  - 2.1.2 History and Mission of Camp Lejeune 2-3
  - 2.1.3 Previous Investigations 2-3
  - 2.1.4 Topography and Surface Drainage 2-4
  - 2.1.5 Regional Geology 2-4
  - 2.1.6 Regional Hydrogeology 2-4
  - 2.1.7 Surface Water Hydrology 2-6
  - 2.1.8 Climatology 2-7
  - 2.1.9 Natural Resources and Ecological Features 2-7
  - 2.1.10 Land Use and Demographics 2-8
  - 2.1.11 Water Supply 2-8
- 2.2 Site 88 (Building 25, MWR Dry Cleaners) 2-9
  - 2.2.1 Site Location and Setting 2-9
  - 2.2.2 Site Topography and Drainage 2-9
  - 2.2.3 Site History 2-10
  - 2.2.4 Site Geology and Hydrogeology 2-10
  - 2.2.5 Initial Investigation 2-12
  - 2.2.6 Phase I Investigation Summary 2-13

3.0 DATA QUALITY AND SAMPLING OBJECTIVES 3-1
- 3.1 Data Quality Objectives 3-1
  - 3.1.1 Stage 1 - Identification of Decision Types 3-1
  - 3.1.2 Stage 2 - Identification of Data Uses/Needs 3-1
  - 3.1.3 Stage 3 - Design Data Collection Program 3-3
- 3.2 Study Objectives 3-4

4.0 SITE EVALUATION TASKS 4-1
- 4.1 Task 1 - Project Management 4-1
- 4.2 Task 2 - Subcontract Procurement 4-1
- 4.3 Task 3 - Field Investigations 4-1
  - 4.3.1 Phase I 4-1
  - 4.3.2 Phase II 4-1
  - 4.3.3 Surveying 4-3
  - 4.3.4 Investigation Derived Waste Handling 4-3
- 4.4 Task 4 - Sample Analysis and Validation 4-4
- 4.5 Task 5 - Data Evaluation 4-4

TABLE OF CONTENTS
(Continued)

Page

4.6 Task 6 - Human Health Evaluation Process 4-4
  4.6.1 Site Location and Characterization 4-4
  4.6.2 Data Summary 4-4
  4.6.3 Identifying Chemicals of Potential Concern 4-5
  4.6.4 Exposure Assessment 4-5
  4.6.5 Toxicity Assessment 4-7
  4.6.6 Risk Characterization 4-7
  4.6.7 Preliminary Remediation Goals 4-8
  4.6.8 Uncertainty Analysis 4-9
4.7 Task 7 - Site Evaluation Report 4-10
4.8 Task 8 - Meetings 4-10

5.0 PROJECT MANAGEMENT AND STAFFING 5-1

6.0 PROJECT SCHEDULE 6-1

7.0 REFERENCES 7-1

LIST OF TABLES

2-1 Geologic and Hydrogeologic Units in the Coastal Plain of North Carolina
2-2 Land Utilization: Developed Areas Land Use

3-1 Site Evaluation Objectives for Operable Unit No. 15 (Site 88)

4-1 Summary of Sampling and Analytical Requirements
4-2 Preliminary Remediation Goals

6-1 Site Evaluation Schedule

LIST OF FIGURES

2-1 Operable Units and Site Locations at Marine Base Corps Base Camp Lejeune
2-2 Location of Hydrogeologic Cross Sections
2-3 Hydrogeologic Cross Sections of MCB Camp Lejeune Area
2-4 Hadnot Point Industrial Area
2-5 Site Location Map
2-6 Cross-Section Location Map
2-7 Hydrogeologic Cross-Section A-A'
2-8 Hydrogeologic Cross-Section B-B'
2-9 Groundwater Elevations
2-10 Subsurface Soil Contamination by On-Site Analysis
2-11 Volatile Organic Compounds in Groundwater (Shallow Wells)
2-12 Volatile Organic Compounds in Groundwater (Intermediate Wells)
2-13 Total Volatile Organic Concentrations in Groundwater on Cross-Sections A-A' and B-B'

4-1 Proposed Soil Sampling Locations
4-2 Proposed Temporary and Permanent Monitoring Wells

5-1 Project Organization

APPENDIX A Phase I Investigation Photographs

LIST OF ACRONYMS AND ABBREVIATIONS

AST	above ground storage tank
ARARs	applicable or relevant and appropriate requirements
bgs	below ground surface
BRA	baseline risk assessment
CDI	chronic daily intake
CERCLA	Comprehensive Environmental Response, Compensation and Liability Act
CLP	Contract Laboratory Program
COPC	Chemicals of Potential Concern
DCE	Dichloroethene
DOD	Department of the Defense
DoN	Department of the Navy
DQO	Data Quality Objective
EE/CA	Engineering Evaluation/Cost Analysis
ESE	Environmental Science and Engineering, Inc.
°F	degrees Fahrenheit
FFA	Federal Facilities Agreement
FFSG	Force Service Support Group
FMF	Fleet Marine Force
FMFLANT	Fleet Marine Force Atlantic
FSAP	Field Sampling and Analysis Plan
ft	feet
GSRA	Greater Sandy Run Area
HEAST	Health Effects Assessment Summary Tables
HI	hazard index
HQ	hazard quotient
IAS	Initial Assessment Study
IRIS	Integrated Risk Information system
IRP	Installation Restoration Program
LANTDIV	Naval Facilities Engineering Command, Atlantic Division
µg/L	micrograms per liter
µg/kg	micrograms per kilogram
MAGTF	Marine Air Ground Task Force
MCAS	Marine Corps Air Station
MCB	Marine Corps Base
MCL	maximum contaminant level
mg/d	million of gallons per day

LIST OF ACRONYMS AND ABBREVIATIONS
(Continued)

mg/kg	milligrams per kilogram
mg/L	milligrams per liter
msl	mean sea level
NACIP	Navy Assessment and Control of Installation Pollutants
NC DEHNR	North Carolina Department of Environment, Health, and Natural Resources
NCWQS	North Carolina Water Quality Standard
NEESA	Navy Energy and Environmental Support Activity
NPL	National Priorities List
NREA	Natural Resources and Environmental Affairs
OHM	OHM Remediation Services Corporation
OU	operable unit
PA/SI	Preliminary Assessment/Site Inspection
PCB	polychlorinated biphenyl
PCE	Tetrachloroethylene
ppb	parts per billion
ppm	parts per million
PRGs	Preliminary Remediation Goals
QA/QC	quality assurance/quality control
QAPP	Quality Assurance Project Plan
RBC	Risk Based Concentration
RCRA	Resource Conservation and Recovery Act
RfD	reference dose
RI/FS	Remediation Investigation/Feasibility Study
ROD	Record of Decision
RPM	Remedial Project Management
SARA	Superfund Amendments and Reauthorization Act
SDWA	Safe Drinking Water Act
SVOC	Semivolatile Compounds
TAL	Target Analyte List
TCA	Trichloroethane
TCE	Trichloroethene
TCL	Target Compound List
TCLP	Toxicity Characteristics Leaching Procedure
TDS	total dissolved solids
TOC	total organic carbon

LIST OF ACRONYMS AND ABBREVIATIONS
(Continued)

TPH	total petroleum hydrocarbon
TSS	total suspended solids
USEPA	United States Environmental Protection Agency
USGS	United States Geological Society
UST	Underground Storage Tank
VOC	volatile organic compound
WOE	weight-of-evidence

1.0 INTRODUCTION

Marine Corps Base (MCB) Camp Lejeune was placed on the Comprehensive Environmental Response, Compensation, and Liability Act of 1980 (CERCLA) National Priorities List (NPL) effective November 4, 1989 (54 Federal Register 41015, October 4, 1989). Subsequent to this listing, the United States Environmental Protection Agency (USEPA) Region IV, the North Carolina Department of Environment, Health and Natural Resources (NC DEHNR), the United States Department of the Navy (DoN) and the Marine Corps entered into a Federal Facilities Agreement (FFA) for MCB Camp Lejeune. The primary purpose of the FFA was to ensure that environmental impacts associated with past and present activities at the MCB are thoroughly investigated, and that appropriate CERCLA response and Resource Conservation Recovery Act (RCRA) corrective action alternatives are developed and implemented as necessary to protect the public health and welfare, and the environment (MCB Camp Lejeune FFA, 1989).

The scope of the FFA includes 18 Operable Units (OUs) and 42 sites throughout MCB Camp Lejeune. This Site Evaluation Work Plan addresses one of the OUs: OU No. 15 (Site 88). The evaluation at OU No. 15 (Site 88) will be considered the site evaluation step in the Engineering Evaluation/Cost Analysis (EE/CA) process. The project plans for this site evaluation also include a Field Sampling and Analysis Plan, a Quality Assurance Project Plan, and a Health and Safety Plan.

The Site Evaluation field activities are being completed in two separate phases. Phase I was performed in August 1996 and included the installation of temporary monitoring wells and sampling of soil and groundwater to define the horizontal and vertical extent of contamination. The project plans contained herein provide a brief summary of the Phase I work and then describe the procedures and methods to be applied during the second phase of the investigation.

1.1 Objective of the Site Evaluation Work Plan

The objective of this Site Evaluation Work Plan is to identify the tasks required to complete the second phase of the Site Evaluation for Site 88. The various studies or investigations required to collect appropriate data are described in this Work Plan. In addition, the Work Plan documents the scope and objectives of the individual Site Evaluation activities. It serves as a tool for assigning responsibilities and establishing the project schedule and cost. The preparation and contents of the Site Evaluation Work Plan are based on the scoping process, which is described below.

1.2 Site Evaluation Scoping

Scoping is the initial planning stage of the site evaluation. The results or outcome of the scoping process are documented in the Site Evaluation Work Plan. Scoping begins once the background information is reviewed and evaluated. The background information available to this process included a number of existing environmental assessment reports, which are identified in Section 7.0 (References), and information collected during site visits. The scoping and Phase I program consisted of the following activities:

- Preliminary assessment, based on readily available information, to identify the source and nature of the release or threatened release and to assess the threat to public health, the magnitude of the threat, and the factors necessary to determine the need for a removal action.

- Identifying any potential interim action which may need to be undertaken early in the program to mitigate potential threats to the public health and environment.
- Identifying potential contaminant migration pathways.
- Identifying contaminants of potential concern.
- Identifying potential Federal and State Applicable or Relevant and Appropriate Requirements (ARARs).
- Define the optimum sequence of investigation activities.
- Identifying the sampling strategies for the collection of data.
- Determining the type, amount, and data quality objectives (DQOs) to assess human health and environmental risks.
- Identifying potential technologies/alternatives for mitigating site problems.
- Identifying the remedial alternatives suitable to site conditions.

These tasks, completed during the Phase I investigation, produced site specific results. These results were discussed during a partnering meeting in January 1997 which included representatives of Naval Facilities Engineering Command (LANTDIV), USEPA Region IV, NC DEHNR, MCB Camp Lejeune and Baker Environmental (Baker). The meeting participants reviewed the Phase I results and developed a Scope of Work for the Phase II Investigation. Phase II will address remaining site concerns including:

- Establish the volume of impacted soil beneath Building 25 and nearby areas.
- Collect soil engineering parameters to aid in the specific design of remedial alternatives.
- Define the local geology and its relationship to contaminant migration.
- Define the horizontal and vertical extent of groundwater contamination.
- Establish groundwater flow patterns in the shallow, intermediate and deep aquifer zones.
- Collect necessary data for evaluating specific remedial alternatives applicable to remediation of groundwater at the site.

1.3 Site Evaluation Work Plan Format

This Site Evaluation Work Plan is comprised of seven sections listed below.

- Section 1.0 - Introduction
- Section 2.0 - Background and Setting

- Section 3.0 - Data Quality and Sampling Objectives
- Section 4.0 - Site Evaluation Tasks
- Section 5.0 - Project Management and Staffing
- Section 6.0 - Project Schedule
- Section 7.0 - References

Section 1.0 is the introduction which provides the objectives of the Site Evaluation Workplan, details scoping, and a provides general explanation of the format of the document.

Section 2.0 documents background information, along with the location and setting of the site. The purpose of this section is to provide the general background and setting of MCB Camp Lejeune and define the physical and known environmental characteristics of the site. This section focuses on identifying potential and/or confirmed contaminant migration pathways, identifying potential (or known) impacts to public health and environment, and listing Federal or State standards and criteria.

Section 3.0 defines site-specific data quality and sampling objectives. Data or information deemed necessary to identify migration pathways, assess environmental and human health risks, or evaluate and select alternative technologies are presented in this section. This data may consist of chemical analyses, hydrogeologic information, or engineering analyses. The collection methods for obtaining this information also are identified and described in general terms [more detailed descriptions of the field investigation activities are documented in the Field Sampling and Analysis Plan (FSAP)].

Section 4.0 identifies and describes the tasks and field investigation activities that will be implemented to complete the Site Evaluation at the site in terms of meeting the site-specific objectives. These tasks generally follow the description of tasks identified in EPA's EE/CA Guidance Document (OSWER Directive 9360.0-32).

Section 5.0 discusses project management and staffing for implementing the Site Evaluation. The Site Evaluation schedule is provided in Section 6.0. References used in developing the Site Evaluation Work Plan are provided in Section 7.0.

2.0 BACKGROUND AND SETTING

The purpose of this section is to summarize and evaluate existing information pertaining to MCB Camp Lejeune and OU 15 (Site 88). The analysis of existing information will serve to provide an understanding of the nature and extent of contamination in order to aid in the site evaluation tasks. The current understanding of the physical setting of the site, the history of the site, and the existing information related to previous environmental investigative activities are described herein.

This section specifically addresses the location and setting of the site, historical events associated with past usage or disposal activities, topography and surface drainage, regional geology and hydrogeology, site-specific geology and hydrogeology, surface water hydrology, climatology, natural resources and ecological features, and land use.

Additional background information is presented in the following documents:

- Phase I Investigation Report (Baker, November, 1996)
- Sample Strategy Plan (March, 1996)
- Draft Site Evaluation Work Plan (May, 1996)
- Initial Assessment Study (IAS) of Marine Corps Base Camp Lejeune, North Carolina (Water and Air Research, 1983)
- Final Site Summary Report, Marine Corps Base, Camp Lejeune (Environmental Science and Engineering, Inc. [ESE], 1990)
- Hydrogeology of Aquifers in Cretaceous and Younger Rocks in the Vicinity of Onslow and Southern Jones Counties, North Carolina (Lyke, 1990)
- Continuous Seismic Reflection Profiling of Hydrogeologic Features Beneath New River, Camp Lejeune, North Carolina (Cardinell, 1990)
- Assessment of Hydrologic and Hydrogeologic Data at Camp Lejeune Marine Corps Base, North Carolina (Harned, 1989)

2.1 MCB Camp Lejeune, North Carolina

This section provides an overview of the physical features associated with MCB Camp Lejeune, North Carolina.

2.1.1 Location and Setting

MCB Camp Lejeune is located within the Coastal Plain Physiographic Province. It is located in Onslow County, North Carolina, approximately 45 miles south of New Bern and 47 miles north of Wilmington. The facility covers approximately 236 square miles. This includes the recent acquisition of approximately 64 square miles west of the facility within the Greater Sandy Run Area of the county. The military reservation is bisected by the New River, which flows in a southeasterly direction and forms a large estuary before entering the Atlantic Ocean.

The eastern border of MCB Camp Lejeune is the Atlantic shoreline. The western and northwestern boundaries are U.S. Route 17 and State Route 24, respectively. The City of Jacksonville, North Carolina, borders MCB Camp Lejeune to the north. MCB Camp Lejeune is depicted in Figure 2-1.

The Greater Sandy Run Area (GSRA) is located in the southeast portion of Onslow County, North Carolina, near the Pender-Onslow County border. The GSRA is approximately 31 miles northeast of Wilmington, North Carolina; 15 miles south of Jacksonville, North Carolina; and 5 miles northwest of the Atlantic Ocean. The GSRA is located south and west of MCB, Camp Lejeune, sharing a common boundary along Route 17 between Dixon and Verona.

The following overview of the Complex was taken from the document "Master Plan, Camp Lejeune Complex, North Carolina" (DoN, 1988). The Complex consists of 12 identifiable developed areas. Of the developed areas, Hadnot Point comprises the most concentrated area of development. This area includes the organizational offices for the Host Activity and for the Headquarters, 26th Marine Amphibious Unit, as well as the Headquarters and regimental areas for the 2nd Marine Division, Marine Expeditionary Force, 6th Marine Expeditionary Brigade, 22nd Marine Expeditionary Unit, 24th Marine Amphibious Unit, the Central Exchange & Commissary and the Naval Dental Clinic Headquarters. Directly north of Hadnot Point are the family housing areas concentrated throughout the wooded areas of the central Complex and along the shores of the New River. Also located in this north central area are major personnel support land uses, including the newly-constructed Naval Hospital, school sites, recreational areas, as well as additional family housing areas (quarters developments, Midway Park and Tarawa Terrace I and II).

The Air Station and Camp Geiger are considered as a single urban area possessing two separate missions and supported by two unrelated groups of personnel. The Marine Corps Air Station (MCAS), New River encompasses 2,772 acres and is located in the northwestern section of the Complex and lies approximately five miles south of Jacksonville. The MCAS includes air support activities, troop housing and personnel support facilities, all of which immediately surround the aircraft operations and maintenance areas.

Camp Geiger, located directly north of MCAS, New River, contains a mixture of troop housing, personnel support and training uses. Currently, the area is utilized by a number of groups which have no direct relationship to one another. The majority of the land surrounding this area is comprised of buffer zones and unbuildable marshland.

The Camp Lejeune Complex contains five other areas of concentrated development, all of which are much smaller in size and population than either Hadnot Point, MCAS New River, or the Camp Geiger area. The oldest of these is the Montford Point area, which is bounded by the New River to the south and west and by Route 24 on the north. New development in Montford Point has been limited, with most of the facilities for troop housing, maintenance, supply and personnel support having been converted from their intended uses. A majority of the MCB training schools requiring classroom instruction are located here and use surrounding undeveloped areas for training operations when required. The French Creek area located directly south of Hadnot Point is occupied by the 2nd Force Service Support Group (2nd FSSG). Its activities are directed toward providing combat service and technical support as required by Headquarters, II Marine Expeditionary Force. Expansion of the French Creek Complex is constrained by the Ordnance Storage Depot explosives safety arc on the south and by the regimental area of Hadnot Point. Onslow Beach, located along the Onslow Bay, east of the New River Inlet, presents assets for amphibious training as well as recreational use. Courthouse Bay is located on one of a series of small bays which are formed by the New River. This area is used for maintenance, storage and training associated with amphibious vehicles and heavy engineering equipment. The Engineering School, also located here, conducts training activities in the large open area located to the southeast of the Courthouse Bay. Another concentrated area of development is the Rifle Range. This area is located on the southwest side of the New River, is singular in purpose and has only a small number of assigned personnel. It was constructed in the early stages of Base development and is used solely for rifle qualification training. The small group of barracks, located at the Rifle Range, are used for two-week periods by troops assigned to range training.

2.1.2 History and Mission of Camp Lejeune

Construction of MCB Camp Lejeune began in 1941 with the objective of developing the "World's Most Complete Amphibious Training Base." Construction of the base started at Hadnot Point, where the major functions of the base are centered. Development at the Camp Lejeune Complex is primarily in five geographical locations under the jurisdiction of the Base Command. These areas include Camp Geiger, Montford Point, Courthouse Bay, Mainside, and the Rifle Range Area. Site 88 is located near Hadnot Point area.

The MCB organization functions as the host command to the two Fleet Marine Force Atlantic (FMFLANT) tenant activities -- Headquarters of the II Marine Expeditionary Division and the 2nd FSSG. The MCB host organization mission is to provide housing, training facilities, logistical support and certain administrative support for tenant units and for other units assigned to MCB Camp Lejeune and to conduct specialized schools and other training maneuvers, as directed.

The mission of the 6th Marine Expeditionary Brigade is to provide the Command element for a brigade-size Marine Air Ground Task Force (MAGTF) with the primary mission of preparing to join up with LantCom MPS equipment and to conduct subsequent combat operations.

The mission of the 2nd Marine Division is to execute amphibious assault operations, and other operations as may be directed, which are supported by Marine aviation and force service support units. With the aircraft wing, the Marine division provides combined arms for service with the Fleet in the seizure or defense of advanced naval bases and for the conduct of land operations essential to the prosecution of a naval campaign.

The mission of the 2nd FSSG is to command, administer and train assigned units in order to provide combat service and technical support as required by Headquarters FMFLANT and its subordinate command in accomplishment of the overall FMFLANT mission.

2.1.3 Previous Investigations

In response to the passage of CERCLA, the DoN initiated the Navy Assessment and Control of Installation Pollutants (NACIP) program to identify, investigate, and clean up past hazardous waste disposal sites at Navy installations. The NACIP investigations were conducted by the Navy Energy and Environmental Support Activity (NEESA) and consisted of Initial Assessment Studies (IAS) and Confirmation Studies. IAS are similar to the CERCLA Preliminary Assessments/Site Investigations (PAs/SIs). Confirmation Studies are similar to a CERCLA Remedial Investigation/Feasibility Study (RI/FS). When the Superfund Amendment and Reauthorization Act (SARA) was passed in 1986, the DoN dissolved the NACIP in favor of the Installation Restoration Program (IRP), which adopted USEPA CERCLA terminology and procedures.

The IAS for MCB Camp Lejeune was conducted by Water and Air Research, Inc., in 1983. The IAS identified a number of sites at MCB Camp Lejeune as potential sources of contamination, Site 88 was not included under the IAS since it was only recently discovered. Based on historical records, aerial photographs, field inspections, and personnel interviews, the IAS identified 76 sites at MCB Camp Lejeune as potential sources of contamination. Of these 76 sites, 27 sites warranted further investigation to assess potential long-term impacts based on contamination; however, characteristics, migration pathways, and pollutant receptors.

2.1.4 Topography and Surface Drainage

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

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

The U.S. Army Corps of Engineers has mapped the limits of 100-year floodplain at MCB Camp Lejeune at 7 feet above msl in the upper reaches of the New River (Water and Air Research, 1983); this increases downstream to 11 feet above msl near the coastal area (Water and Air Research, 1983).

2.1.5 Regional Geology

MCB Camp Lejeune is located in the Atlantic Coastal Plain physiographic province. The sediments of the province consist predominantly of sand, silt, and clay. Other sediments may be present, including peat, shell beds and gravel. Sediments may be of marine or continental origin (Back, 1966). These sediments lay in interfingering beds and lenses that gently dip and thicken to the southeast (ESE, 1991). These sediments range in age from early Cretaceous to Quaternary time and overlie igneous and metamorphic rocks of pre-Cretaceous age. Table 2-1 presents a generalized stratigraphic column for this area (Harned et al., 1989).

United States Geological Survey (USGS) studies at MCB Camp Lejeune indicate that the Base is underlain by sand, silt, clay, calcareous clay and partially consolidated limestone. Aquifers that occur beneath the Base include the surficial, Castle Hayne, Beaufort, Peedee, Black Creek, and upper and lower Cape Fear aquifers. The combined thickness of these sediments beneath the base is approximately 1,500 feet. The locations of four hydrogeologic cross-sections are presented on Figure 2-2. Figure 2-3 shows these cross-sections which illustrate the relationship between the aquifers in this area.

2.1.6 Regional Hydrogeology

The aquifers of primary interest are the surficial aquifer and the aquifer immediately below it, the Castle Hayne. The following summary is a compilation of information, including Harned et al. (1989), and Cardinell et al. (1993).

The surficial aquifer consists of interfingering beds of sand, clay, sandy clay, and silt that contain some peat and shells. These beds are thin and discontinuous, and have limited lateral continuity. This aquifer is not used for water supply MCB at Camp Lejeune.

The thickness of the surficial aquifer ranges from 0 to 73 feet and averages nearly 25 feet over the MCB Camp Lejeune area. It is generally thickest in the interstream divide areas and presumed absent where it is cut by the New River and its tributaries.

The general lithology of the surficial aquifer and the absence of any thick, continuous clay beds are indications of good vertical conductivity within the aquifer. Data compiled by Cardinell estimate the lateral hydraulic conductivity of the surficial aquifer in the MCB Camp Lejeune area 50 feet/day, and is based on a general composition of fine sand mixed with some silt and clay. However, data from slug tests on monitoring wells installed by Baker indicate much lower lateral hydraulic conductivity values, ranging from 0.12 to 9.00 feet/day.

Between the surficial and the Castle Hayne aquifers lies the Castle Hayne confining unit. This unit consists of clay, silt, and sandy clay beds. In general, the Castle Hayne confining unit may be characterized as a group of less permeable beds at the top of the Castle Hayne aquifer that have been partly eroded or incised in places.

The Castle Hayne confining unit is discontinuous, and has a thickness ranging from 0 to 26 feet, averaging about 9 feet where present. There is no discernable trend in the thickness of the confining unit. There is no information in the USGS literature regarding any trend of the depth of the confining unit.

The data compiled by Cardinell, et. al., indicate that the vertical hydraulic conductivity of the confining unit ranged from 0.0014 to 0.41 feet/day. Based on the moderate conductivity values and the thin, discontinuous nature of the confining unit, this unit may only be partly effective in retarding the vertical movement of groundwater between the surficial aquifer.

The Castle Hayne aquifer lies below the surficial aquifer and consists primarily of unconsolidated sand, shell fragments, and fossiliferous limestone. Clay, silt, silty and sandy clay, and indurated limestone also occur within the aquifer. The upper part of the aquifer consists primarily of calcareous sand with some continuous and discontinuous thin clay and silt beds. The calcareous sand becomes more limey with depth. The lower part of the aquifer consists of consolidated or poorly consolidated limestone and sandy limestone interbedded with clay and sand.

The Castle Hayne aquifer is about 150 to 350 feet thick in the area, and thickens eastward across the base. The top of the aquifer lies approximately 20 to 65 feet below the ground surface and dips southward, being deepest at the Atlantic coast, east of the New River. The top of the aquifer also forms a basin in the vicinity of Paradise Point. Estimates of hydraulic conductivity indicate a wide variation in range, from 14 to 91 feet/day.

Onslow County and MCB Camp Lejeune lie in an area where the Castle Hayne aquifer generally contains freshwater. However, the proximity of saltwater in deeper layers just below the aquifer and in the New River estuary is of concern in managing water withdrawals. Over-pumping of the deeper parts of the aquifer could cause encroachment of saltwater. The aquifer generally contains water having less than 250 milligrams per liter (mg/L) chloride throughout the base, except for one well

(USGS-8) in the southern portion of the base that is screened in the lower portion of the aquifer. Chloride was measured at 960 mg/L in a single sample collected in 1989.

Rainfall in the MCB Camp Lejeune area enters the ground in recharge areas, infiltrates the soil, and moves downward until it reaches the surficial aquifer. Recharge areas at Camp Lejeune include the interstream areas. In the aquifer, groundwater flows in the direction of lower hydraulic head until it reaches discharge points or fronts. These discharge areas include the New River and its tributaries, and the ocean. Though most of the rainfall entering the surficial aquifer discharges to local streams, a relatively small amount infiltrates to the Castle Hayne. The surficial aquifer supplies the primary recharge to the Castle Hayne aquifer. Like the surficial aquifer, the Castle Hayne naturally discharges to the New River and major tributaries. However, pumping of the Castle Hayne may locally influence discharge directions.

The potentiometric surface of the surficial aquifer varies 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 potentiometric surface is generally highest in the winter months and lowest in the summer or early fall.

Water levels in wells screened in deeper aquifers, such as the Castle Hayne can be used to establish potentiometric surfaces. Because the Castle Hayne is at least partially confined from the surficial aquifer and is not influenced by rainfall as strongly as the surficial aquifer, the seasonal variations tend to be slower and smaller than in surficial aquifer.

2.1.7 Surface Water Hydrology

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

The dominant surface water feature at MCB Camp Lejeune is the New River. It receives drainage from most of the base. The New River is short, with a course of approximately 50 miles on the central Coastal Plain of North Carolina. Over most of its course, the New River is confined to a relatively narrow channel entrenched in Eocene and Oligocene limestones. South of Jacksonville, the river widens dramatically as it flows across less resistant sands, clays, and marls. At MCB Camp Lejeune, the New River flows in a southerly direction into the Atlantic Ocean through the New River Inlet. Several small coastal creeks drain the area of MCB Camp Lejeune not associated with the New River and its tributaries. These creeks flow into the Intracoastal Waterway, which is connected to the Atlantic Ocean by Bear Inlet, Brown's Inlet, and the New River Inlet (Water and Air, 1983). The New River, the Intracoastal Waterway, and the Atlantic Ocean meet at the New River Inlet.

Water quality criteria for surface waters in North Carolina have been published under Title 15 of the North Carolina Administrative Code. At MCB Camp Lejeune, the New River falls into two classifications: SC (estuarine waters not suited for body-contact sports or commercial shellfishing) and SA (estuarine waters suited for commercial shellfishing). The SC classification applies to three areas of the New River at MCB Camp Lejeune, including the Rifle Range area; the rest of the New River at MCB Camp Lejeune falls into the SA classification (ESE, 1991).

2.1.8 Climatology

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

2.1.9 Natural Resources and Ecological Features

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

The MCB Camp Lejeune is predominantly tree-covered with large amounts of softwood including shortleaf, longleaf, pond, and pines (primarily loblolly), and substantial stands of hardwood species. Approximately 60,000 of the 112,000 acres of MCB Camp Lejeune are under forestry management. Timber producing areas are under even-aged management with the exception of those areas along streams and swamps. These areas are managed to provide both wildlife habitat and erosion control. Forest management provides wood production, increased wildlife populations, enhancement of natural beauty, soil protection, prevention of stream pollution, and protection of endangered species. Upland game species including black bear, whitetail deer, gray squirrel, fox squirrel, quail, turkey, and migratory waterfowl are abundant and are considered in the wildlife management programs.

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

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

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

Site 88 is not within or in close proximity (i.e., one-half mile) to either a natural area or a protected area. Protected areas have only been established for the red-cockaded woodpecker.

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

2.1.10 Land Use and Demographics

MCB Camp Lejeune presently covers an area of approximately 236 square miles. Military and civilian population is approximately 60,000. During World War II, MCB Camp Lejeune was used as a training area to prepare Marines for combat. This has been a continuing function of the facility during the Korean and Vietnam conflicts, and the Gulf War (i.e., Desert Storm). Toward the end of World War II, the camp was designated as a home base for the Second Marine Division. Since that time, Fleet Marine Force (FMF) units also have been stationed here as tenant commands.

The following information was extracted from the document "Master Plan, Camp Lejeune Complex, North Carolina." The existing land use patterns in the various geographic areas within the Marine Corps Base are described in this section and listed, per geographic area, on Table 2-2. The areas described below are depicted on Figure 2-1. In addition, the number of acres comprising each land use category has been estimated and provided on the table.

Present military population of Camp Lejeune is approximately 40,928 active duty personnel. The military dependent community is in excess of 32,081. About 36,086 of these personnel and dependents reside in base housing units. The remaining personnel and dependents live off base. An additional 4,412 civilian employees perform facilities management and support functions. The population of Onslow County has grown from 17,739 in 1940, prior to the formation of the base, to its present population of 121,350.

2.1.11 Water Supply

MCB Camp Lejeune water is supplied entirely from groundwater. Groundwater is obtained from approximately 71 water supply wells and treated to produce a potable water supply. There are eight water treatment plants with a total capacity of approximately 15.8 million gallons per day (mgd). Groundwater usage is estimated at over 7 mgd (Harned, et al., 1989).

The water supply wells are all located within the boundaries of the Base. The average water supply well at the base has a depth of 162 feet, a casing diameter of eight inches, and yields 174 gpm (Harned, et al., 1989). All of the water supply wells utilize the Castle Hayne aquifer. The Castle Hayne aquifer is a highly permeable, semiconfined aquifer that is capable of yielding several hundred to 1,000 gpm in municipal and industrial wells in the MCB Camp Lejeune Area. The water retrieved is typically a hard, calcium bicarbonate type. However, some water supply wells on Base have been closed due to contamination.

The Preliminary Draft Report Wellhead Monitoring Study for MCB, Camp Lejeune, North Carolina (Greenhorne, 1992) was reviewed to locate water supply wells within a 1-mile radius of Site 88. Based on a review of this sources, there is only one supply well located within a one-mile radius of Site 88. The nearest known water supply well (HP603) is located approximately 0.75 miles east - southeast of the site. Presently, this well has been permanently taken out of service.

2.2 Site 88 (Building 25, MWR Dry Cleaners)

This section addresses the setting, site topography and drainage features, site history, site geology and hydrogeology, and previous investigations at Site 88.

2.2.1 Site Location and Setting

Site 88 is referred to as Building 25, Morale, Welfare, and Recreation (MWR) Dry Cleaners. Figure 2-4 provides the location of the site relative to the Hadnot Point Industrial Area. The New River is the nearest surface water body, located approximately 3,000 feet downgradient of Building 25. The site is located near Post Lane and Virginia Dare Drive, as presented in Figure 2-4.

Building 25 has been operating as a dry cleaning facility since the 1940s and is located in a flat area surrounded by barracks, office buildings, and other occupied structures. As can be seen on Figure 2-5, the surrounding buildings include Building 37, the Base Chaplain's Office to the north, Building 43, the Cobbler Shop to the west, Building HP57, a dormitory, to the east and Building 80, a warehouse, to the south.

2.2.2 Site Topography and Drainage

Site 88 is located in the industrial/commercial section of MCB Camp Lejeune referred to as the "Hadnot Point Industrial Area". The site terrain is relatively flat, with elevations of approximately 25 feet above msl. Most of the area is covered by a combination of existing buildings, asphalted streets, and parking areas. Grass areas exist along with a few trees and ornamental shrubbery in the vicinity of the site.

There are no surface water features at the site, however, the New River is located approximately 3,000 feet west of Building 25. During storm events, overland drainage off-site is unlikely as most of the site has a relatively flat topography and run-off is collected by underground storm water drainage systems. Storm water run-off eventually drains into the New River via the drainage collection system. The NC DEHNR stream classifications for this segment of the New River are

SC (aquatic life propagation and survival, fishing, wildlife, and secondary recreation) and SW (nutrient sensitive water that requires limitations on nutrient inputs).

2.2.3 Site History

Building 25 is currently operating as the base dry cleaning facility. Five former underground storage tanks (USTs) were located on the north side of Building 25. The locations of the tanks relative to the building are shown on Figure 2-5. The tanks were known to have been used to store dry cleaning fluids. The USTs were reportedly installed in the 1940s, at the time the building was constructed. These USTs were used in conjunction with the dry cleaning operations until the early 1970s. During this time, Varsol™, a dry cleaning fluid, was stored in the USTs. The Varsol™ was reportedly introduced into the tanks by a feed line that is located in the front (south side) of the building and runs under the building to the rear (north side) where the USTs were located. Due to Varsol's™ flammability, its use was discontinued in the 1970s and replaced with tetrachloroethene (PCE). PCE was stored in 150 gallon aboveground storage tanks (ASTs) outside Building 25 from the 1970s to mid-1980s. Groundwater contamination at Site 88 was suspected during the UST removal conducted in November 1995.

Currently, the dry cleaning machines are equipped with self containment units, eliminating the need for the aboveground tanks. There are two dry cleaning units in operation. One unit was brought on-line in December, 1986, and the second in March, 1995.

2.2.4 Site Geology and Hydrogeology

The sections which follow describe the site specific geology and hydrogeology based on the borings and temporary monitoring wells completed as part of the Phase I Investigation. When applicable, the local geology is placed in the context of the regional geology, as described in the "Hydrogeologic Framework of U.S. Marine Corps Base at Camp Lejeune, North Carolina", Cardinell, et al., 1993.

A fairly consistent depositional sequence was observed in borings throughout Site 88. The subsurface sediments are typical of the southeastern coastal plain geology. The site is underlain by unconsolidated sediments resulting from a near shore depositional environment. This observed sequence is similar to the generalized North Carolina coastal plain sequence shown in Table 2-1. Table 2-1 shows that the Yorktown, Eastover, and Pungo River Formations lie between the Undifferentiated and Belgrade Formations. The Yorktown, Eastover, and Pungo River Formations, however have not been identified at Camp Lejeune.

During this investigation, only the Undifferentiated Formation was encountered at Site 88. The presence or absence of the Belgrade Formation at the site is debatable; however, a description of this unit has been included in the project plans. Shallow borings were advanced to approximately 15 to 20 feet below ground surface (bgs) while four deeper borings were drilled to depths ranging from 47 to 57 beet bgs. The shallow temporary wells installed during the Phase I Investigation were screened in the upper portions of the Undifferentiated Formation (surficial aquifer), while the intermediate wells were screened in the lower portion of the Undifferentiated Formation (surficial aquifer).

The Undifferentiated Formation is comprised of loose to medium dense sands and soft to medium stiff clay. This formation is comprised of several units of Holocene and Pleistocene ages and can consist of a fine to coarse sand, with lesser amounts of silt and clay. At Site 88, this formation appears to extend to a depth of approximately 50 feet bgs. A silt and clay layer is present at approximately 18 feet, however, this layer does not appear consistent below the site.

The Belgrade Formation is typically comprised of fine sand with some shell fragments, silt, and clay of Miocene age. Shell fragments were not identified to be present with the sediments at Site 88, suggesting that the Belgrade is absent at this location. In general, the Undifferentiated Formation (surficial aquifer) appears to continue to a depth of at least 50 feet bgs at the site.

Figure 2-6 shows the location of two geologic cross-sections constructed to represent the subsurface conditions. Figure 2-7 and 2-8 present the geologic cross-section A-A' and B-B', respectively. As can be seen from cross-sections A-A' and B-B', the soils below the site generally consist of fine sand with a trace to little sand and clay. This unit extends to a depth of approximately 50 feet bgs and correlates to the Undifferentiated Formation. A laterally discontinuous layer of clay with little to some silt is present approximately 12 to 18 feet bgs which may be representative of the Belgrade Formation. The clay layer is laterally discontinuous across the site. The inconsistency of a semi-confining layer has been reported in previous investigations conducted at the Hadnot Point Industrial Area (ESE, 1990; Law-Catlin, 1996). In addition, previous studies in the area have noted that as distance from the New River increases, the semi-confining unit slopes or "dips" away from the river and tends to increase in thickness.

During the Phase I Investigation, groundwater was generally encountered from 5 to 10 feet bgs. A complete picture of the groundwater flow regime in the form of a potentiometric map has not been presented in this report. Instead, only relative groundwater elevations and approximate flow directions are shown on Figure 2-9 for the surficial aquifer. Groundwater elevations collected from the temporary monitoring wells were not used for an accurate presentation of groundwater flow due to the fact that measurements were recorded on different days depending on the sampling efforts. The elevations on Figure 2-9 can be used as a guide, however, to give a general indication of the local flow pattern.

In general, groundwater elevations seem to be higher in the area of Building 25 and decrease to the west and southwest. This would suggest a local groundwater flow pattern toward the New River which is to be expected. Moreover, this trend is consistent with groundwater flow patterns described in several other Hadnot Point Investigations (ESE, 1990; Baker 1993; Law-Catlin, 1996). Although groundwater flow direction is difficult to estimate based upon the limited data, elevations recorded from the intermediate wells suggest a slight variation in direction as compared to the shallow wells. The different flow directions are shown on Figure 2-9 by the different colored arrows. Overall, groundwater from both the shallow and deep zones appears to flow in the direction of the New River.

Groundwater head differentials between the shallow and intermediate wells were evaluated to determine if a vertical component of flow exists at Site 88. The data demonstrate a downward component of groundwater movement from the upper portion of the surficial aquifer to the lower portion. This condition impacts the migration of contaminants as they tend to move downward in the direction of vertical groundwater flow.

In addition to migration of contaminants due to groundwater flow, the orientation or "dip" of clay layers in the area of Site 88 can have a direct impact on contaminant migration. For example, vertical migration of contaminants will be greater in areas where these units are thin or absent. In addition, lateral migration of the contaminants will be controlled not only by groundwater flow direction, but also by the orientation or "dip" of the unit. The affect of groundwater flow direction and subsurface conditions on contaminant migration will be further evaluated during the Phase II Investigation.

2.2.5 Initial Investigation

The following section provides information on the initial investigation at Site 88. The information summarized in this document is for the purpose of providing relevant background information which has been used to assess the site. For further details, concerning previous investigative work, the reader is referred to Baker's Phase I Investigation Report (Baker, 1996).

As mentioned above, five USTs were located on the north side of Building 25. These tanks were removed in November 1995 by OHM Remediation Services Corporation (OHM). During removal of the tanks, soil contamination was identified and impact to groundwater was suspected. As a follow-up to the removal of the tanks, a four-well site check was conducted in November 1995 by OHM to identify and/or verify the suspected contaminant impact in the subsurface soil and groundwater. The locations of these four initial temporary monitoring wells were discussed above and are shown of Figure 2-5. The activities and findings of the initial investigation included:

- Installation of three temporary monitoring wells (TW01 through TW03) around the former UST location and one (TW04) on the opposite side (south) of the building.

- Laboratory analysis of subsurface soil samples revealed levels of tetrachloroethene (PCE) ranging from 13 µg/kg to 55 µg/kg in three of the four well borings and 1,2-dichloroethene (DCE, total) at a concentration of 9 µg/kg. No pesticides, polychlorinated biphenyls (PCBs), total petroleum hydrocarbons (TPH), or semivolatile compounds were detected in any of the subsurface soil samples. Several metals were detected in the subsurface soil samples, however, they are assumed to be related to natural site conditions.

- One groundwater sample was collected from each of the four temporary monitoring wells and analyzed for full target compound list (TCL) organics, target analyte list (TAL) metals and TPH. TPH was detected in two of the groundwater samples at 628 µg/L and 552 µg/L. Bis(2-ethylhexyl)phthalate and naphthalene were detected in the groundwater; however, bis(2-theyhexyl)phthalate is considered a laboratory contaminant.

- PCE was detected in all the groundwater samples at concentrations ranging 416 µg/L to 29,200 µg/L. 1,2-dichloroethene was also detected in the samples at concentrations of 154 µg/L and 10,000 µg/L. Trichloroethene was detected at a concentration of 2,750 µg/L. No pesticides or PCBs were detected in the four groundwater samples. The metals iron and nickel were detected at concentrations above North Carolina Water Quality Standards (NCWQS) in all four wells, however they are believed to be associated with natural site conditions.

Additional work at the site was necessary based upon the results of the initial investigation. As described above, the investigation at Site 88 has been divided into two phases. Phase I of the investigation was completed in August 1996. Appendix A contains photographs of general site conditions and activities completed during the Phase I Investigation. The following section provides a summary of the Phase I results. A complete description of site activities and findings is presented in the Draft Phase I Investigation Report (Baker, November, 1996).

2.2.6 Phase I Investigation Summary

Phase I field activities at Site 88 provided the necessary data to estimate the effects of previous site activities on the soil and groundwater. Figure 2-10 illustrates the extent of soil contamination at Site 88 and Figures 2-11 and 2-12 provide the estimated extent of shallow and intermediate groundwater contamination, respectively. Assessing the areal extent of site contamination was accomplished through the acquisition of environmental samples which were analyzed by an on-site laboratory with confirmation samples analyzed by a fixed based laboratory. The following tasks were completed during the Phase I Investigation:

- Subsurface Soil Sampling
- Temporary Monitoring Well Installation
- Groundwater Sampling
- Land Survey
- Well Abandonment

Results of the Phase I Investigation confirmed the presence of volatile organic compounds (VOCs) in both the soil and groundwater at the site. The source of the contamination is assumed to be the former tanks located at the site. The tanks and the soil immediately surrounding them were removed from the site in November 1995, therefore, the primary source of groundwater contamination has been eliminated. However, concentrations of VOCs in the groundwater are significantly higher that allowable state and federal standards.

Five VOCs were detected in the subsurface soil samples collected from Site 88, including cis-1,2-DCE, trichloroethene (TCE), and PCE. The impact to the soils at the site appears to be concentrated in the area near Building 25 and extends slightly to the north-northwest in the direction of Building 43. In general concentrations of VOCs in the soil were shown to have decreased with distance from Building 25 and the area of the former tanks.

Five VOCs were detected in the groundwater at Site 88. The compounds included cis-1,2-DCE, trans-1,2-DCE, 1,1,1-trichloroethane (TCA), TCE, and PCE. PCE was the most frequently detected compound and demonstrated the highest concentrations in the groundwater samples. The concentrations of cis-1,2-DCE, TCE, and PCE exceeded NCWQS and federal maximum contaminant levels (MCLs). The data demonstrate groundwater contamination at the site in both the shallow and intermediate zones in the area of Building 25. Groundwater contamination surrounds Building 25 and extends to the north-northwest in the direction of Building 43.

Figure 2-13 presents the concentrations of total VOCs detected in the groundwater as cross-sectional views. Cross-section A-A' traverses the site from south to north illustrating that total VOCs exist beneath Building 25 at relatively high concentrations. This cross-section also shows high total VOCs at temporary monitoring well TW08.

Cross-section B-B' runs west to east across Site 88. This sectional view does not provide as much detail concerning the location of site contaminants as cross-section A-A'. However, it is important to note the illustration of the shallow contaminant plume in this portion of the site. As shown by cross-section B-B', groundwater contamination in the shallow zone appears to be limited to the area between temporary monitoring wells TW16 and TW07. Although the extent of contamination has not been completely defined, the data suggest that the plume configuration is generally oval shaped with a northwest and southeast directional trend.

As demonstrated by the Phase I Investigation field data, contamination at Site 88 appears to be concentrated in the area of Building 25, however, it has not been thoroughly defined at depth or to the north-northwest in the direction of Building 43. The horizontal and vertical extent of contamination at Site 88 must be delineated through further sampling efforts. This may be accomplished by completing the following items:

- Further definition of the local geology and its effect on the horizontal and vertical migration of contaminants.
- Collection of soil samples in areas of known soil contamination to define exact volumes for remedial alternatives. Specific attention will be placed on the soil beneath Building 25 and the areas near TW08, TW09, and TW15.
- Collection of soil samples during shallow, intermediate, and deep monitoring well installation. In addition to environmental testing, geotechnical analyses will be conducted on these samples to assist in the preparation of groundwater migration and transport models and the selection and design of a remedial alternative.
- Installation of shallow, intermediate, and deep permanent monitoring wells at points within the defined plume boundary and in the direction of contaminant migration. Shallow wells will extend to approximately 20 feet bgs, intermediate wells will extend to approximately 50 feet bgs, and deep wells will extend to approximately 100 feet bgs.
- Installation of temporary shallow and intermediate wells around the perimeter of the estimated contaminant plume.
- Groundwater sampling from shallow, intermediate, and deep temporary and permanent monitoring wells for VOCs.
- Measurement of groundwater elevations to establish the local groundwater flow regime in the shallow aquifer and an examination of potential head differences between shallow, intermediate, and deep monitoring wells.
- Completion of aquifer tests (slug tests) to establish the hydraulic conductivity of the aquifer in question. A comparison of vertical and horizontal conductivity values will be made.
- Upon completion of aquifer tests and the establishment of local groundwater flow patterns, estimates of groundwater flow velocity can be made and corresponding contaminant transport.

3.0 DATA QUALITY AND SAMPLING OBJECTIVES

The purpose of this section is to define the site evaluation data quality and sampling objectives in order to fulfill the overall goals of characterizing the problems at Site 88, assessing potential impacts to the public health and environment, and identifying feasible remedial alternatives for remediating the site. The specific site evaluation objectives presented in this section have been identified based on review and evaluation of existing background information.

3.1 Data Quality Objectives

Data Quality Objectives (DQOs) are qualitative and quantitative statements that ensure data of known and appropriate quality are obtained during the site evaluation. The DQOs associated with each field sampling and analysis program are discussed and presented in this section. The DQOs were developed using the following three stages:

- Stage 1 - Identify decision types
- Stage 2 - Identify data uses/needs
- Stage 3 - Design data collection program

Stage 1 of the DQO process takes place during project scoping. This stage involves the evaluation of existing information and the development of objectives for field data collection efforts.

Stage 2 of the DQO process involves definition of the quality and quantity of data that will be required to meet the objectives established in Stage 1.

Stage 3 involves the design of a data collection program to meet the requirements identified in Stage 2.

3.1.1 Stage 1 - Identification of Decision Types

As part of the Stage 1 DQO process, available information from the initial UST removal report and the Phase I Investigation were reviewed in order to describe current site conditions, evaluate existing data, and assess the adequacy of the data. This was documented in Section 2.0 of this Work Plan. From this review and evaluation, site evaluation objectives have been developed to (1) assess the nature of the threat posed by the release or potential release of hazardous substances; (2) characterize the site with respect to the environmental setting; and (3) evaluate potential remedial alternatives. These objectives are presented in Section 3.2.

3.1.2 Stage 2 - Identification of Data Uses/Needs

The data quality and quantity required to support the site evaluation objectives developed during Stage 1 are identified in Stage 2 of the DQO process. With respect to the site evaluation objectives, data will be required to address specific environmental media at each site. Data uses for each environmental media are presented in Section 3.1.2.1. Site-specific data needs are discussed in Section 3.1.2.2.

3.1.2.1 Data Uses for Environmental Media

The site evaluation data uses can be described in general purpose categories. These categories include the following:

- Site Characterization - Data are used to determine the nature and extent of contamination at a site. Site characterization data are generated through the sampling and analysis of waste sources and environmental media.

- Health and Safety - Data are typically used to establish the level of protection needed for investigators or workers at a site, and if there should be an immediate concern for the population living within the site vicinity.

- Risk Assessment - Data are used to evaluate the threat posed by a site to public health and the environment. Risk assessment data are generated through the sampling and analysis of environmental media, particularly where the potential for human exposure is great (e.g., surface soil, potable groundwater supplies).

- Evaluation of Alternatives - Data are used to evaluate various remedial technologies. Engineering data are collected in support of remedial alternative evaluation and to develop cost estimates for remediating the site. This may involve conducting bench or pilot-scale studies to determine the effectiveness or *implementability* of the technology.

- Engineering Design of Alternatives - Data collected during the Site Evaluation can be used for engineering purposes to develop a preliminary data base in reference to the performance of various remedial technologies. Data types collected during the Site Evaluation which are applicable to the RD process include waste characterization and preliminary volume estimates (these estimates can be further defined during the remedial design/remedial action via additional field verification sampling).

The above discussion of data uses was extracted from the document entitled Data Quality Objectives for Remedial Response Activities: Development Process (OSWER Directive 9355.0-7B). It has been presented in this Work Plan to provide the user with an understanding of the rationale for determining the site-specific site evaluation objectives as well as the rationale for the proposed sampling and analytical program this site evaluation.

With respect to the above data uses, an understanding of the site background, site history, and contaminant migration and exposure pathways are required in order to define the data needs (or data limitations). This "background" information was presented in Section 2.0 for the site. The site-specific data needs are presented in Section 3.1.2.2. Site evaluation objectives, which have been formed to meet the data needs, are presented in Section 3.2.

3.1.2.2 Site-Specific Data Needs

Operable Unit No. 15 (Site 88)

- Establish boundaries of subsurface soil contamination. Collect specific geologic and geotechnical data for evaluation of remedial alternatives.
- Determine the extent of VOC contamination in the shallow, intermediate, and deep aquifer zones.
- Provide hydrogeologic parameters of the shallow, intermediate, and deep portion of the aquifer.
- Establish subsurface geologic conditions, identifying any confining units at the site.

The type and quality of data required to meet the criteria listed above are presented in Section 4.0. The data quality levels differ with respect to the end use of the data. Level IV data quality are generally required in risk assessments, characterizing the nature and extent of contamination, and to support subsequent investigations. Level III data quality is appropriate for risk assessments, site characterization, and evaluating treatment alternatives. Level II data quality is appropriate for field screening (e.g., ENSYS Screening). Level I data is appropriate for field measurements such as static water level, specific conductance, and pH. The analytical methods also differ with respect to the end use of the data. For this site evaluation, USEPA methods and Contract Laboratory Program (CLP) methods will be used when applicable.

This field investigation will employ the use of Levels III and IV data. Level III data includes field screening activities, however data submitted for fixed-based confirmation will be conducted in accordance with CLP, DQO Level IV. When applicable, samples collected during this field investigation will be analyzed in accordance with CLP. For analyses where CLP is not applicable USEPA approved methods will be employed. Geotechnical testing and groundwater engineering parameters will be conducted in accordance with Level II DQOs.

3.1.3 Stage 3 - Design Data Collection Program

The data collection program for Site 88 has been designed to meet the objectives outlined in the following sections. Section 4.0 of the Site Evaluation Work Plan provides a general description of the various sampling programs for the Site 88. Sections 3.0 through 5.0 of the FSAP provide the specific details of these sampling programs.

The site evaluation field activities are being completed in two phases. Phase I, completed in August 1996, included the installation of temporary shallow and intermediate monitoring wells to better define the horizontal and vertical extent of contamination. The Phase II activities are based on the recommendations presented in the Phase I report and will include the installation of temporary and permanent shallow, intermediate, and deep monitoring wells.

During the Phase II Investigation, groundwater samples will be collected from the newly installed temporary and permanent monitoring wells. Soil samples will be collected from specific soil borings and the borings used for monitoring well installation. These samples will be used to define the limits of soil contamination and will provide geotechnical information to be used in remedial efforts.

3.2 Study Objectives

The criteria necessary to meet each objective along with a general description of the study or investigation required to obtain the information are presented in Table 3-1.

4.0 SITE EVALUATION TASKS

This section identifies the tasks and field investigations required to complete site evaluation activities at Site 88.

4.1 Task 1 - Project Management

Project management activities involve daily technical support and guidance, budget and schedule review and tracking, preparation and review of invoices, personnel resources planning and allocation, preparation of monthly progress reports, and communication with LANTDIV and the Activity.

4.2 Task 2 - Subcontract Procurement

Task 2 involves the procurement of services such as drilling, surveying, laboratory analysis, and data validation. Procurement of these services will be performed in accordance with the Navy Clean Contract Procurement Manual.

4.3 Task 3 - Field Investigations

The field investigations will be conducted under Task 3. An overview of the field investigation to be conducted at the site is presented in the following subsections. Specific details with respect to the sampling procedures, locations and number of samples, and analytical methods are provided in the Field Sampling and Analysis Plan (FSAP) and the Quality Assurance Project Plan (QAPP). The field investigations described below will provide data to meet the overall site evaluation objectives presented in Section 3.0 of this Site Evaluation Work Plan. Table 4-1 summarizes the sampling and analytical requirements.

The field investigation has been separated into two phases, Phase I and Phase II. Phase I of the investigation was completed in August 1996. Preparation of the Phase II Project Plans has been based on the results of the Phase I Investigation. The following sections describe the items accomplished during Phase I and outline the activities that will encompass Phase II.

4.3.1 Phase I

As part of the Phase I Investigation, 15 shallow, and 4 intermediate soil borings with associated temporary monitoring wells were installed in the vicinity of Building 25. The wells were installed using a truck-mounted drill rig in August 1996. In addition, soil and groundwater samples were collected at each location. Data collected during this portion of the field program identified subsurface soil contamination and impact to the groundwater by VOCs. Groundwater contamination was identified in the area surrounding Building 25 to a depth of at least 50 feet bgs. The results of the Phase I Investigation were presented in section 2.2.6. For complete details the reader is referred to the Draft Phase I Investigation Report (Baker, 1996).

4.3.2 Phase II

Base on the results of the Phase I field investigation, further delineation of soil and groundwater contamination at Site 88 is required. This will be accomplished through additional soil borings and the installation of both temporary and permanent monitoring wells.

4.3.2.1 Soil Investigation

The majority of the contaminated soil at the site was removed during the initial UST closure in November 1995. However, the Phase I Investigation completed in August 1996, confirmed that contaminated soil remains in some portions of the site.

Soil samples will be collected from borings intended for monitoring well construction, from borings advanced beneath Building 25 and from borings in locations in which soil contamination was identified during the Phase I Investigation. The proposed locations of the soil borings and monitoring wells are shown on Figure 4-1.

The locations of the soil borings are based upon analytical data collected during the Phase I Investigation. Soil contamination was identified in the area surrounding Building 25 extending to the northwest. The proposed soil borings illustrated on Figure 4-1 have been placed at their respective locations with the intent of defining the extent and volume of soil contamination at Site 88. Soil samples will be collected from each of the 13 soil borings intended for monitoring well construction. In addition, 4 soil borings will be advanced in the area local to Building 25, and two borings will be located inside Building 25 to evaluate soil conditions beneath the building. Therefore, a total of 19 soil borings will be advanced at Site 88 for the purposes of defining soil contamination. This is reflected in Table 4-1.

Of these 19 borings it is anticipated that only those located within or near the estimated area of soil contamination, shown on Figure 4-1, will detect VOCs. These key soil borings/monitoring wells are highlighted in red on Figure 4-1. As shown on the figure, they have been located in areas of the site which will determine the amount of impacted soil at the Site 88.

Two subsurface soil samples will be collected from each of the soil borings during the second phase of the investigation to delineate specific areas of impacted soil. If the depth to groundwater is greater than 10 feet bgs or there is exceedance of contamination (visual or by monitoring instrument), one additional subsurface soil sample will be collected from a middle depth.

The subsurface soil samples will be analyzed on-site via a mobile laboratory for TCL VOCs. Ten percent of all media sampled also will be analyzed for TCL VOCs at a fixed base analytical laboratory to confirm the results of the mobile laboratory. Select samples will be chosen from areas of high, medium, and low contaminant concentration areas to confirm the on-site results. Additional borings will be installed if deemed necessary to delineate the extent of the contamination. Specific soil samples will also be analyzed for total organic carbon (TOC), bulk density, permeability, and grain size. These samples will be collected in areas of high, medium, and low contaminant concentration areas to provide a representative sample of site conditions for remedial purposes.

4.3.1.2 Groundwater Investigation

A minimum of 7 shallow and 7 intermediate temporary monitoring wells will installed to determine the extent of horizontal and vertical contaminant migration at the plume boundary. These wells will be installed to the west and north of Building 25 to establish the contaminant plume in this area of the site. The proposed locations of the temporary wells are shown on Figure 4-2. If contamination is detected in these wells, additional temporary wells will be installed, sampled, and analyzed on-site until the contamination is sufficiently delineated.

Once the outer boundary of the plume has been established through on-site analyses, permanent monitoring wells will be installed. It is estimated that 3 shallow and 3 intermediate wells will be installed at the perimeter of the estimated contaminant plume. The proposed locations of these permanent wells are shown on Figure 4-2. Additional monitoring well clusters, consisting of 6 shallow, 5 intermediates, and 4 deep wells, will be installed to establish contaminant concentrations and delineate the vertical extent of groundwater contamination surrounding Building 25. Final locations of the permanent monitoring wells will be based upon the on-site analytical results.

The groundwater samples will be analyzed on-site via mobile laboratory for TCL VOCs. Ten percent of all media sampled also will be analyzed for TCL VOCs at a fixed base analytical laboratory to confirm the results of the mobile laboratory. The locations of the fixed base samples will be based on the on-site analytical results. Select groundwater samples will be chosen from areas of high, medium, and low contaminant concentration levels. Groundwater samples will be analyzed for field measurements, including pH, temperature, conductivity, turbidity, and dissolved oxygen (Level II quality) in the field. Additional laboratory analyses will be performed for nitrate, nitrite, iron, sulfate, sulfide, methane, oxygen reduction potential, chloride total suspended solids (TSS), and, total dissolved solids (TDS) on 5 groundwater samples in order to assist the evaluation of remedial alternatives and assist in remedial design. Groundwater measurements will be taken to determine groundwater flow direction. The proposed groundwater sampling locations for the Phase II Investigation are shown on Figure 4-2. A summary of the sampling and analytical requirements for Site 88 is provided on Table 4-1.

In addition to the installation of the temporary and permanent monitoring wells, four temporary wells installed during the initial investigation (25-TW01 through 25-TW04) will be abandon by pulling the 1 inch PVC casing from the ground and backfilling the boring with soil or cement grout as necessary. As these wells were constructed as "temporary" they do not contain sand packs which provide a good hydraulic connection to the aquifer. In addition, they are not properly sealed from surface water infiltration with bentonite or grout. Due to the methods used during temporary well construction they are not suitable as representative sampling points and will be abandoned during the Phase II Investigation.

4.3.3 Surveying

A complete site survey of Building 25 and the surrounding area was completed during the Phase I Investigation. The survey included current site features, including the nearby fence lines, nearby buildings, access roads, sidewalks, utilities, existing monitoring wells, temporary monitoring wells, and newly installed shallow and intermediate monitoring wells. Additional surveying will be completed during Phase II to locate newly installed temporary and permanent monitoring wells at the site.

4.3.4 Investigation Derived Waste Handling

Drill cuttings or excavated soils will be collected and contained in a rolloff box. If visual contamination or elevated HNu readings are not exhibited, and if toxicity characteristic and leaching procedure (TCLP) and RCRA analyses determine the material to be non-hazardous, the cuttings will be transported to Lot 203 and spread out around the area. One rigid storage tank with a capacity of 1,000 gallons will be stationed at the site for containing groundwater development and purge water. One sample will be collected from the tank and analyzed for full TCL organics, TAL total metals, TSS and TDS. If the results of the analyses demonstrate that the liquids are non-hazardous the contacts of the tank will be taken to the treatment facility of Lot 203 for disposal. Additional details regarding IDW handling and disposal are provided in Section 6.8 of the FSAP.

4.4 Task 4 - Sample Analysis and Validation

This task involves efforts relating to the following post-field sampling activities:

- Sample Management
- Laboratory Analysis
- Data Validation

Sample management activities involve: coordination with laboratories; tracking of samples submitted for analysis; tracking of analyses received; and tracking of information related to samples submitted and received from a third party validator. Sample management also involves resolving technical or administrative problems (e.g., reanalysis, resubmission of information).

Laboratory analysis begins when the samples are shipped from the field and received by the laboratory. Validation begins when the "raw" laboratory data is received by the validator from Baker. Baker will first receive the data from the laboratory, log it into a database for tracking purposes, and then forward it to the validator. A validation report will be expected within three weeks following receipt of laboratory data packages by the validator. CLP data will be validated per the CLP criteria as outlined in the following document:

- USEPA, Hazardous Site Control Division, Laboratory Data Validation Functional Guidelines for Evaluating Organics Analyses, 1994.

All other data will be validated in accordance with the method of analysis using the National Functional Guidelines as a reference.

4.5 Task 5 - Data Evaluation

This task involves efforts related to the data once it is received from the laboratory and is validated. It also involves the evaluation of any field-generated data including: water level measurements, test boring logs, and other field notes. Efforts under this task will include the tabulation of validated data and field data, generation of test boring logs and monitoring well construction diagrams, generation of geologic cross-sections, and the generation of other figures associated with field notes or data received from the laboratory (e.g., sampling location maps).

4.6 Task 6 - Human Health Evaluation Process

4.6.1 Site Location and Characterization

A background section will be presented at the beginning of the risk assessment to provide an overview of the characteristics of the site. This section will provide the site location, a general site description, and the site-specific chemicals as discussed in past reports. The physical characteristics of the site and the geographical areas of concern will be discussed. This site description will help to characterize the exposure setting.

4.6.2 Data Summary

Because decisions regarding data use may influence the resultant risk assessment, careful consideration must be given to the treatment of those data. For purposes of risk evaluation, the site at MCB Camp Lejeune may be partitioned into operable units, sites, and areas of concern for which chemical concentrations will be characterized and risks will be evaluated. Sites will be grouped into operable units if they are close to one another, have similar contamination, and/or may impact the same potential receptors. In selecting data to include in the risk assessment, the objective is to characterize, as accurately as possible, the distribution and concentration of chemicals at each site.

Data summary tables will be developed for each medium sampled (e.g., surface water, sediment, groundwater, soil). Each data summary table will indicate the frequency of detection, observed range of concentrations, average background concentrations (inorganics), and the means and upper 95 percent confidence limit value for each contaminant detected in each medium. The arithmetic or geometric mean and the upper 95 percent confidence limit of that mean will be used in the summary of potential chemical data. The selection of arithmetic or geometric means will depend on whether the sample data are normally or log-normally distributed. In the calculation of the 95 percent confidence limit mean, concentrations presented as "ND" (nondetect) will be incorporated at 1/2 the analytical quantitation limit for organics and detection limit for inorganics. In cases where there is a question about the distribution of the data set, a statistical test will be used to determine the best distributional assumption for the data set.

4.6.3 Identifying Chemicals of Potential Concern

The criteria to be used in selecting the Contaminants of Potential Concern (COPCs) from the constituents detected during the sampling and analytical phase of the investigation are: historical information, prevalence, mobility, persistence, toxicity, established state and federal criteria and standards , comparison to blank data or base-specific naturally occurring levels (i.e., background), comparison to Region III Risk Based Concentrations (RBCs), and comparison to anthropogenic levels. The criteria chosen to establish the COPC are derived from the USEPA's Risk Assessment Guidance for Superfund (USEPA, 1989).

All of the available sample data will undergo review upon initiation of the risk assessment. Common laboratory contaminants such as acetone, methylene chloride, phthalate esters, toluene, and methyl ethyl ketone will be addressed only if concentrations are 10 times greater than the corresponding blanks. In addition, chemicals that are not common laboratory contaminants will be evaluated if they are greater than five times the laboratory blank. The number of chemicals analyzed in the risk assessment will be a subset of the total number of chemicals detected at a site based on the elimination criteria discussed previously.

Tables will be prepared that list chemical concentrations for all media by site. Data will be further grouped according to organic and inorganic species within each table.

4.6.4 Exposure Assessment

The objectives of the exposure assessment at MCB Camp Lejeune will be to characterize the exposure setting, identify exposure pathways, and quantify the exposure. When characterizing the exposure setting, the potentially exposed populations will be described. The exposure pathway will identify the source and the mechanism of medium for the released chemical (e.g., groundwater), the point of potential human contact with the contaminated medium, and the exposure route(s) (e.g., ingestion). The magnitude, frequency, and duration for each exposure pathway identified will be quantified during this process.

The identification of potential exposure pathways at the site will include the activities described in the subsections that follow.

Analysis of the Probable Fate and Transport of Site- Specific Chemicals

To determine the environmental fate and transport of the chemicals of concern at the site, the physical/chemical and environmental fate properties of the chemicals will be reviewed. Some of these properties include volatility, photolysis, hydrolysis, oxidation, reduction, biodegradation, accumulation, persistence, and migration potential. This information will assist in predicting potential current and future exposures. It will help in determining those media that are currently receiving site-related chemicals or may receive site-related chemicals in the future. Sources that may be consulted in obtaining this information include computer databases (e.g., AQUIRE, ENVIROFATE), as well as the open literature.

The evaluation of fate and transport may be necessary where the potential for changes in future chemical characteristics is likely and for those media where site-specific data on the chemical distribution is lacking.

Identification of Potentially Exposed Human Populations

Human populations, that may be potentially exposed to chemicals at the MCB Camp Lejeune, include base personnel and their families, base visitors, and on-site workers and recreational fishermen. The Base Master Plan will be consulted to confirm or modify these potential exposures. Current military personnel and future residents could be exposed to chemicals as they carry out activities at the site located at MCB Camp Lejeune. The list of potential receptors and pathways to be evaluated will be refined during discussions with regulators prior to performing the baseline risk assessment (BRA).

Identification of Potential Exposure Scenarios Under Current and Future Land Uses

The exposure scenarios will be finalized after consulting with the Base Master Plan, USEPA and the State of North Carolina. Generally, current and future exposure pathways will be considered preliminarily as follows:

- Soil Pathway
  - Direct ingestion (current military personnel and construction worker)
  - Dermal contact (current military personnel and construction worker)

- Groundwater
  - Direct ingestion (future residents)
  - Inhalation (future residents)
  - Dermal contact (future residents)

Exposure Point Concentrations

After the potential exposure points and potential receptors have been defined, exposure point concentrations must be calculated. The chemical concentrations at these contact points are critical in determining intake and, consequently, risk to the receptor. The data from site investigations will be used to estimate exposure point concentrations.

The upper 95 percent confidence limits of the means will be used throughout the risk assessment. In cases where maximum concentrations are exceeded by upper 95 percent confidence limit, the maximum concentrations will be used.

Exposure doses will be estimated for each exposure scenario from chemical concentrations at the point of contact by applying factors that account for contact frequency, contact duration, average body weight, and other route-specific factors such as breathing rate (e.g., inhalation). These factors will be incorporated into exposure algorithms that convert the environmental concentrations into exposure doses. Intakes will be reported in milligrams of chemical taken in by the receptor (i.e., ingested, inhaled, etc.) per kilogram body weight per day (mg/kg-day). Intakes for potentially exposed populations will be calculated separately for the appropriate exposure routes and chemicals.

4.6.5 Toxicity Assessment

Toxicity values (i.e., numerical values derived from dose-response toxicity data for individual compounds) will be used in conjunction with the intake determinations to characterize risk. Toxicity values may be taken or derived from the following sources (note that the most up-to-date toxicity information obtained from IRIS and/or HEAST will be used in the exposure assessments):

- Integrated Risk Information System (IRIS) - The principal toxicology database, which provides updated information from USEPA on cancer slope factors, reference doses, and other standards and criteria for numerous chemicals.
- Health Effects Assessment Summary Tables (HEAST) - A tabular summary of noncarcinogenic and carcinogenic information contained in IRIS.

For some chemicals, toxicity values (i.e., reference doses) may have to be derived if the principal references previously mentioned do not contain the required information. These derivations will be provided in the risk assessment for review by USEPA Region IV. The toxicity assessment will include a brief description of the studies on which selected toxicity values were based, the uncertainty factors used to calculate noncarcinogenic reference doses (RfDs), the USEPA weight-of-evidence (WOE) classification for carcinogens, and their respective slope factors.

4.6.6 Risk Characterization

Risk characterization involves the integration of exposure doses and toxicity information to quantitatively estimate the risk of adverse health effects. Quantitative risk estimates based on the reasonable maximum exposures to the site contaminants will be calculated based on available information. For each exposure scenario, the potential risk for each chemical will be based on intakes from all appropriate exposure routes. Carcinogenic risk and noncarcinogenic hazard indices are assumed to be additive across all exposure pathways and across all of the chemicals of concern for each exposure scenario. Potential carcinogenic risks will be evaluated separately from potential noncarcinogenic effects, as discussed in the following subsections.

Carcinogenic Risk

For the potential carcinogens that are present at the site, the carcinogenic slope factor (q_1^*) will be used to estimate cancer risks at low dose levels. Risk will be directly related to intake at low levels of exposure. Expressed as an equation, the model for a particular exposure route is:

$$\text{Excess lifetime cancer risk} = \text{Estimated dose} \times \text{carcinogenic slope factor;}$$
$$\text{or CDI} \times q_1^*$$

Where: CDI = Chronic daily intake

This equation is valid only for risk less than 10^{-2} (1 in 100) because of the assumption of low dose linearity. For sites where this model estimates carcinogenic risks of 10^{-2} or higher, an alternative model will be used to estimate cancer risks as shown in the following equation:

$$\text{Excess lifetime cancer risk} = 1 - \exp(-\text{CDI} \times q_1^*)$$

Where: exp = the exponential

For quantitative estimation of risk, it will be assumed that cancer risks from various exposure routes are additive. Since there are no mathematical models that adequately describe antagonism or synergism, these issues will be discussed in narrative fashion in the uncertainty analysis.

Noncarcinogenic Risk

To assess noncarcinogenic risk, estimated daily intakes will be compared with reference doses RfD for each chemical of concern. The potential hazard for individual chemicals will be presented as a hazard quotient (HQ). A hazard quotient for a particular chemical through a given exposure route is the ratio of the estimated daily intake and the applicable RfD, as shown in the following equation:

$$\text{HQ} = \text{EDI/RfD}$$

Where: HQ = Hazard quotient
EDI = Estimated daily intake or exposure (mg/kg-day)
RfD = Reference dose (mg/kg-day)

To account for the additivity of noncarcinogenic risk following exposure to numerous chemicals through a variety of exposure routes, a hazard index (HI), which is the sum of all the hazard quotients, will be calculated. Ratios greater than one, or unity, indicate the potential for adverse effects to occur. Ratios less than one indicate that adverse effects are unlikely. This procedure assumes that the risks from exposure to multiple chemicals are additive, an assumption that is probably valid for compounds that have the same target organ or cause the same toxic effect. In some cases when the HI exceeds unity it may be appropriate to segregate effects (as expressed by the HI) by target organ since those effects would not be additive. As previously mentioned, where information is available about the antagonism or synergism of chemical mixtures, it will be appropriately discussed in the uncertainty analysis.

4.6.7 Preliminary Remediation Goals

This section discusses the Preliminary Remediation Goals (PRGs) (standard or criteria-based and/or risk-based) which are determined using information on media and chemicals of potential concern, the most appropriate future land use, potential exposure pathways, toxicity information, and potential standard or criteria. The development of PRGs will assist in the initiation of remedial alternatives and in the selection of analytical limits of detection. Risk-based PRGs established at this time are initial, and do not establish that clean up to meet these goals is warranted. Therefore, a risk-based PRG will be considered a final remediation level only after appropriate analysis in the RI/FS and Record of Decision (ROD).

The initial step in developing PRGs is to identify media of potential concern. Important media at these sites include groundwater, soil, surface water, and sediment. Chemicals of potential concern include any chemical reasonably expected to be at the sites. These chemicals may have been previously detected at the site, may be presented based on site history, or may be present as degradation products. Identifying future land use for the site is used to determine risk-based PRGs. In general, residential land use should be used as a conservative estimation for the PRGs. Chemical-specified standards and criteria are evaluated as PRGs because they are often readily available and provide preliminary indication about the goals that a remedial action may have to attain. For groundwater Safe Drinking Water Act (SDWA) maximum contaminant levels (MCLs), and state drinking water standards, and are common ARARs.

In general, chemical-specific standards and criteria are not available for soil; however, some states have promulgated soil standards (e.g., PCB clean-up levels) that may be criteria appropriate to use as PRGs. Risk-based PRGs will be obtained from USEPA, Region III, Risk-Based Concentration Table (USEPA, 1996). The risk-based PRGs will be reviewed and modified after the completion of the baseline risk assessment. This modification will involve adding or subtracting chemicals of concern, media, pathways or revising individual chemical-specific goals. Table 4-2 provides PRGs for Site 88, respectively.

4.6.8 Uncertainty Analysis

There is uncertainty associated with any risk assessment. The exposure modeling can produce very divergent results unless standardized assumptions are used and the possible variation in others are clearly understood. Similarly, toxicological assumptions, such as extrapolating from chronic animal studies to human populations, also introduce a great deal of uncertainty into the risk assessment. Uncertainty in a risk assessment may arise from many sources including:

- Environmental chemistry sampling and analysis.
- Misidentification or failure to be all-inclusive in chemical identification.
- Choice of models and input parameters in exposure assessment and fate and transport modeling.
- Choice of models or evaluation of toxicological data in dose-response quantification.
- Assumptions concerning exposure scenarios and population distributions.

The variation of any factor used in the calculation of the exposure concentration will have an impact on the total carcinogenic and noncarcinogenic risk. The uncertainty analysis will qualitatively discuss non-site and site-specific factors that may product uncertainty in the risk assessment. These factors may include key modeling assumptions, exposure factors, assumptions inherent in the development of toxicological end points, and spatio-temporal variance in sampling.

4.7 Task 7 - Site Evaluation Report

This task is intended to cover all work efforts related to the preparation of the document providing the findings once the data have been evaluated under Task 5. The task covers the preparation of a Draft Phase I and Final Phase II Site Evaluation Report. The Phase I Investigation report was submitted in November 1996. This task ends when the Final Site Evaluation report is submitted.

4.8 Task 8 - Meetings

This task involves providing technical support to LANTDIV during the Site Evaluation. It is anticipated that the following meetings will be required:

- A remedial project management (RPM) meeting with LANTDIV/EMD, USEPA Region IV, and the NC DEHNR prior to submission of the Final Project Plans. This meeting took place on January 9, 1997. The parties involved discussed the results of the Phase I investigation and prepared the scope of work for the second phase of work. Recommendations generated during this meeting have been included in this document.

- A Restoration Advisory Board (RAB) meeting to present the findings of the Site Evaluation after the Phase II Investigation has been completed. This meeting will present the final recommendations for Site 88.

The meetings will be attended by the Baker Project Manager and Project Engineer.

5.0 PROJECT MANAGEMENT AND STAFFING

The Baker Project Team will be managed by Mr. Matthew D. Bartman. The primary responsibilities of the Project Manager will be to monitor the technical performance, project costs, and schedule, and to maintain close communication with the Navy Technical Representative, Ms. Katherine Landman. The Project Manager will report to Mr. John W. Mentz, who will be responsible to provide program level support and overall QA/QC, respectively.

The Project Team will consist of a Project Engineer, Project Geologist, Health and Safety Specialist, Risk Assessment Specialist and technical support staff as shown in Figure 5-1.

6.0 PROJECT SCHEDULE

The proposed project schedule for Operable Unit No. 15 (Site 88) is presented as Table 6-1 and is based on the availability of government funding. The Phase II field work outlined in the Site Evaluation Work Plan is expected to be conducted in April 1997.

7.0 REFERENCES

Back, W., 1966 Hydrochemical Facies and Groundwater Flow Patterns in Northern Part of Atlantic Coastal Plain. Geological Survey Professional Paper 498-A. United States Government Printing Office, Washington D.C.

Baker Environmental, Inc. Phase I Investigation report Operable Unit No. 15 (Site 88). November, 1996.

Camp Lejeune Federal Facility Agreement (FFA). December 6, 1989.

Cardinell, A.P., Berg, S.A., and Lloyd, O.B. Jr. 1993. Hydrogeologic Framework of U.S. Marine Corps Base at Camp Lejeune, North Carolina. United States Geological Survey. Water Resources Investigation Report 93-4049.

Cardinell, Alex P., DA Harned, and SA Berg, 1990. Continuous Seismic Reflection Profiling of Hydrogeologic Features Beneath New River, Camp Lejeune, North Carolina. USGS. Water-Resource Investigations Report 89-4195.

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

ESE, 1990. Site Summary Report. Final. Marine Corps Base, Camp Lejeune, North Carolina.

Greenhorne & O'Mara, Inc, 1992. Preliminary Draft Report Wellhead Monitoring Study - Marine Cops Base Camp Lejeune, North Carolina. Prepared for Department of the Navy. December 1992.

Harned, D.A., Lloyd, O.B. Jr., and Treece, M.W. Jr., 1989. Assessment of Hydrologic and Hydrogeologic Data at Camp Lejeune Marine Corps Base, North Carolina. USGS. Water Resources Investigations Report 89-4096.

Law-Catlin, 1996. Leaking Underground Storage Tank Comprehensive Site Assessment Hadnot Point Fuel Farm. Marine Corps Base, Camp Lejeune, North Carolina.

Lyke, William and MD Winner Jr, 1990. Hydrogeology of Aquifers in Cretaceous and Younger Rocks in the Vicinity of Onslow and Southern Jones Counties, North Carolina. USGS. Water-Resources Investigations Report 89-4128.

U.S. Environmental Protection Agency (USEPA), 1993. Guidance for Conducting Non-Critical Removal Actions Under CERCLA. Office of Emergency and Remedial Response, OSWER Directive 9360.0-32, August 1993.

USEPA, 1996. EPA Region III Risk-Based Concentration Table. May 30, 1996.

USEPA, 1989. Risk Assessment Guidance for Superfund Volume I Human Health Evaluation Manual (Part A). Office of Emergency and Remedial Response. December 1989.

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

TABLES

TABLE 2-1

GEOLOGIC AND HYDROGEOLOGIC UNITS OF NORTH CAROLINA'S COASTAL PLAIN
FINAL SITE EVALUATION PROJECT PLANS
OPERABLE UNIT 15 (SITE 88)
MCB, CAMP LEJEUNE, NORTH CAROLINA

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

Notes:

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

Source: Harned et al., 1989.

TABLE 2-2

LAND UTILIZATION: DEVELOPED AREAS LAND USE(1)
SITE EVALUATION PROJECT PLANS - CTO-0356
MCB, CAMP LEJEUNE, NORTH CAROLINA

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

Note:

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

TABLE 3-1

SITE EVALUATION OBJECTIVES FOR OPERABLE UNIT NO. 15 (SITE 88)
CTO-0356
MARINE CORPS BASE CAMP LEJEUNE, NORTH CAROLINA

Medium or Area of Concern	Site Evaluation Objective	Criteria for Meeting Objective	Proposed Investigation/Study
1. Site 88 - Soil	Assess human health associated with exposure to soil at the site during Phase II activities.	Characterize contaminant levels in subsurface soil at the site.	Soil Investigation Risk Assessment
	Determine whether VOC contamination from soil is migrating to groundwater.	Characterize groundwater and subsurface soil quality in the vicinity of Building 25.	Soil and Groundwater Investigation
	Establish limits of VOC soil contamination beneath Building 25 and adjacent areas. Collect appropriate geologic and geotechnical information for remedial action. Evaluate Remedial Alternatives.	Characterize and evaluate soil contaminant levels beneath Building 25 and specific areas recognized during the Phase I investigation.	Soil Investigation
2. Site 88 - Groundwater	Assess the extent of groundwater contamination.	Determine the horizontal and vertical extent of groundwater contamination.	Groundwater Investigation
	Assess health risks posed by potential future usage of the groundwater.	Evaluate groundwater quality and compare to state and federal standards and criteria and health-based remediation levels.	Groundwater Investigation Risk Assessment
	Define hydrogeologic characteristics for fate and transport evaluation and remedial technology evaluation.	Estimate hydrogeologic characteristics of the aquifer (flow direction, transmissivity, permeability, etc.).	Groundwater Investigation
	Evaluate Remedial Alternatives	Characterize and evaluate groundwater contaminant levels in the vicinity of Building 25.	Groundwater Investigation

TABLE 4-1

SUMMARY OF SAMPLING AND ANALYTICAL REQUIREMENTS
OPERABLE UNIT NO. 15 (SITE 88)
SITE EVALUATION PROJECT PLANS - CTO 0356
MARINE CORPS BASE, CAMP LEJEUNE, NORTH CAROLINA

Study Area	Investigation	Baseline Number Of Samples(1)	Analysis
Site 88 - Phase I	Soil Borings	13 Soil borings/monitoring wells ● 2 soil samples from above the water table ● 1 soil sample if depth to groundwater exceeds 10 ft. bgs. 6 Soil borings ● 2 soil samples from above the water table ● 1 soil sample if depth to groundwater exceeds 10 ft. bgs.	TCL VOCs - Mobile Laboratory TCL VOCs - Fixed base laboratory(2)
		5 Soil borings for evaluation of remedial alternatives (3)	TOC Bulk Density Permeability Grain Size
	Groundwater	Temporary Monitoring Wells ● 7 shallow ● 7 intermediate Permanent Monitoring Wells placed at perimeter of contaminant plume ● 3 shallow (Type II) ● 3 intermediate (Type II) Permanent Monitoring Wells placed within/near contaminant plume ● 6 shallow (Type II) ● 5 intermediate (Type II) ● 4 deep (Type III)	TCL VOCs - Mobile Laboratory TCL VOCs - Fixed base laboratory(2)
		Permanent Monitoring Wells for evaluation of remedial alternatives (3) ● 5 (Type II or Type III)	Dissolved oxygen Nitrate Nitrite Iron Sulfate Sulfide Methane Oxygen reduction potential pH Temperature Chloride Total Suspended Solids Total Dissolved Solids

TABLE 4-1 (continued)

SUMMARY OF SAMPLING AND ANALYTICAL OBJECTIVES
OPERABLE UNIT NO. 16 (SITES 89 AND 93)
REMEDIAL INVESTIGATION/FEASIBILITY STUDY PROJECT PLANS - CTO 0344
MARINE CORPS BASE, CAMP LEJEUNE, NORTH CAROLINA

Notes:

(1) Baseline Number of samples does not include QA/QC
(2) Ten percent of all media sampled also will be analyzed for TCL VOC at a fixed base analytical laboratory
(3) Selected samples from areas of the site demonstrating high, medium, and low contaminant concentrations (5 samples total)

TOC - Total Organic Carbon
VOA - Volatile Organic Analysis
TCL - Target Compound List
bgs - below ground surface(1)

TABLE 4-2

PRELIMINARY REMEDIATION GOALS
OPERABLE UNIT NO. 15 (SITE 88)
SITE EVALUATION, CTO 0356
MARINE CORPS BASE, CAMP LEJEUNE, NORTH CAROLINA

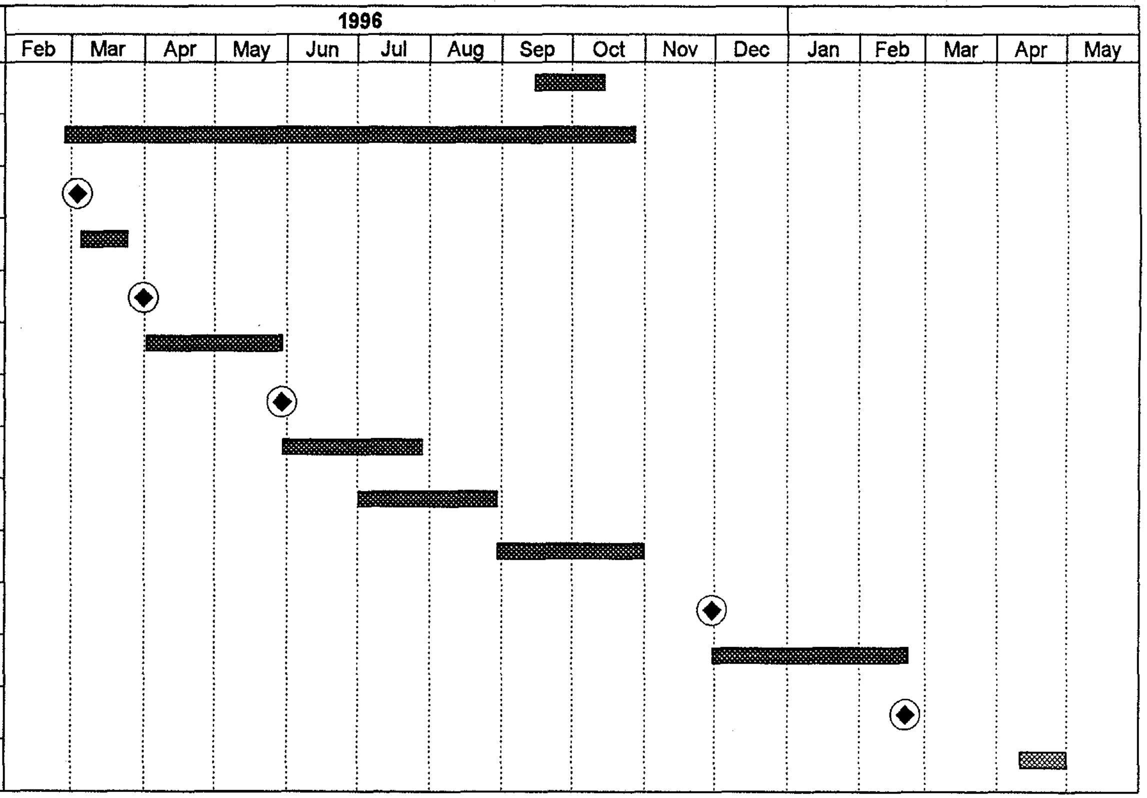
Medium	Contaminant of Concern	Preliminary Remediation Goal	Unit	Basis of Goal
Soil	Tetrachloroethane	40	µg/kg(1)	Risk(3)
	Cis-1,2-Dichloroethene	200	µg/kg	Risk
	Trans-1,2-Dichloroethene	300	µg/kg	Risk
	Trichloroethene	20	µg/kg	Risk
	Vinyl Chloride	10	µg/kg	Risk
Groundwater	Tetrachloroethane	0.7	µg/L(2)	NCWQS(4)
	Cis-1,2-Dichloroethene	70	µg/L	NCWQS
	Trans-1,2-Dichloroethene	70	µg/L	NCWQS
	Trichloroethene	2.8	µg/L	NCWQS
	Vinyl Chloride	0.015	µg/L	NCWQS

Notes:

(1) µg/kg - microgram per kilogram
(2) µg/L - microgram per liter
(3) Risk - EPA Region III Soil Screening Levels - Transfers from Soil to Groundwater
(4) NCWQS - North Carolina Water Quality Standard

Table [illegible]-1
Site Evaluation Schedule
Operable Unit 15 (Site 88), MCB Camp Lejeune, North Carolina

Task Name	Duration	Start	Finish
UST Tank Removal	30ed	9/15/96	10/15/96
RI/FS Project Plans	244ed	2/27/96	10/28/96
Site Visit	1ed	3/3/96	3/4/96
Prepare Sample Strategy Plan	20ed	3/5/96	3/25/96
Scoping Conference Call	1ed	4/1/96	4/2/96
Prepare Draft RI/FS Project Plans	58ed	4/2/96	5/30/96
Submit Draft RI/FS Project Plans	1ed	5/30/96	5/31/96
Agency Review	60ed	5/30/96	7/29/96
Phase I Investigation	60ed	7/1/96	8/30/96
Phase I Report	63ed	8/30/96	11/1/96
RAC Implementation	1ed	11/30/96	12/1/96
Prepare Final Project Plans	62d	11/30/96	2/21/97
Submit Final Project Plans	1d	2/21/97	2/21/97
Phase II Investigation Planned	20ed	4/11/97	5/1/97



Actual ▨ Planned ▨

FIGURES

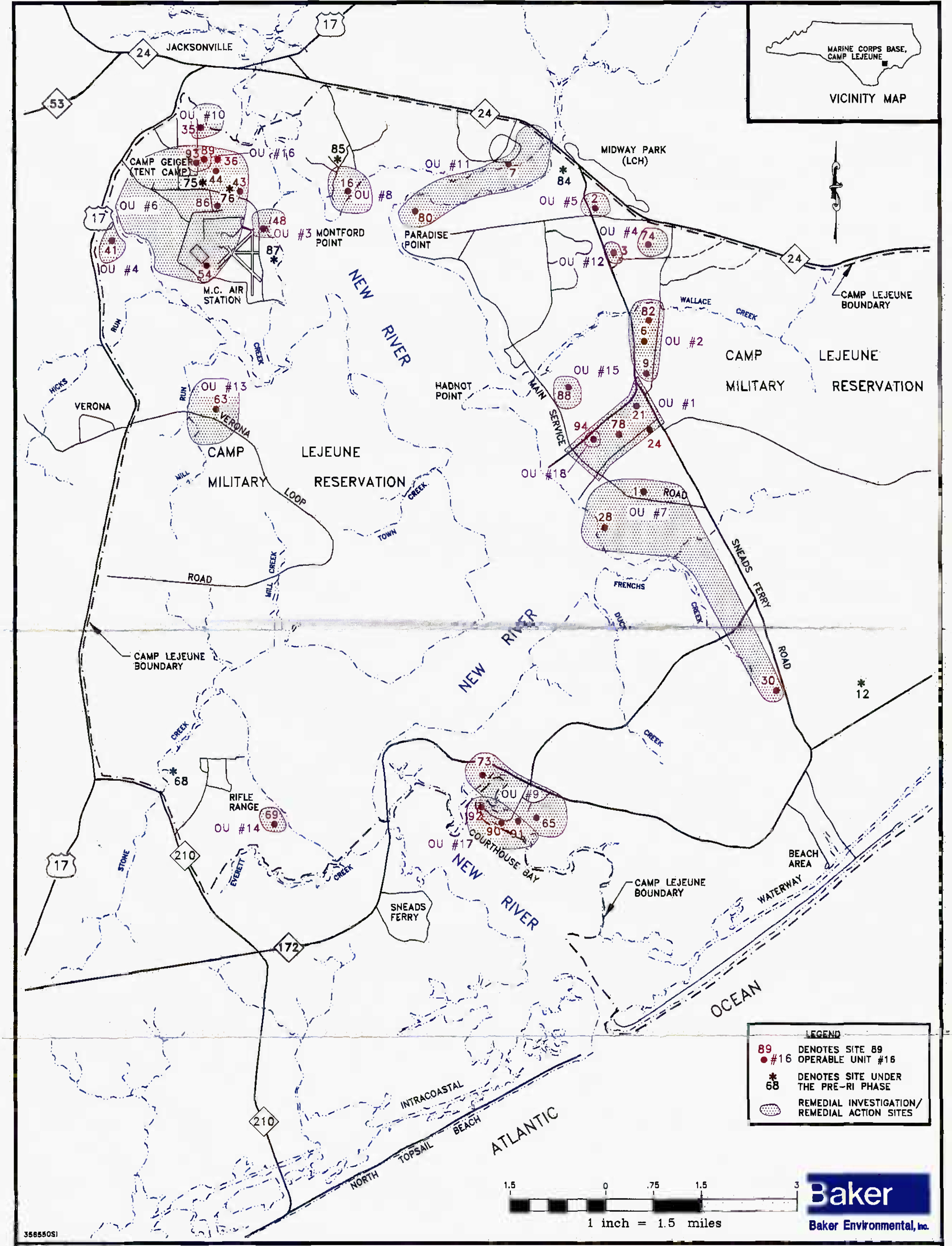
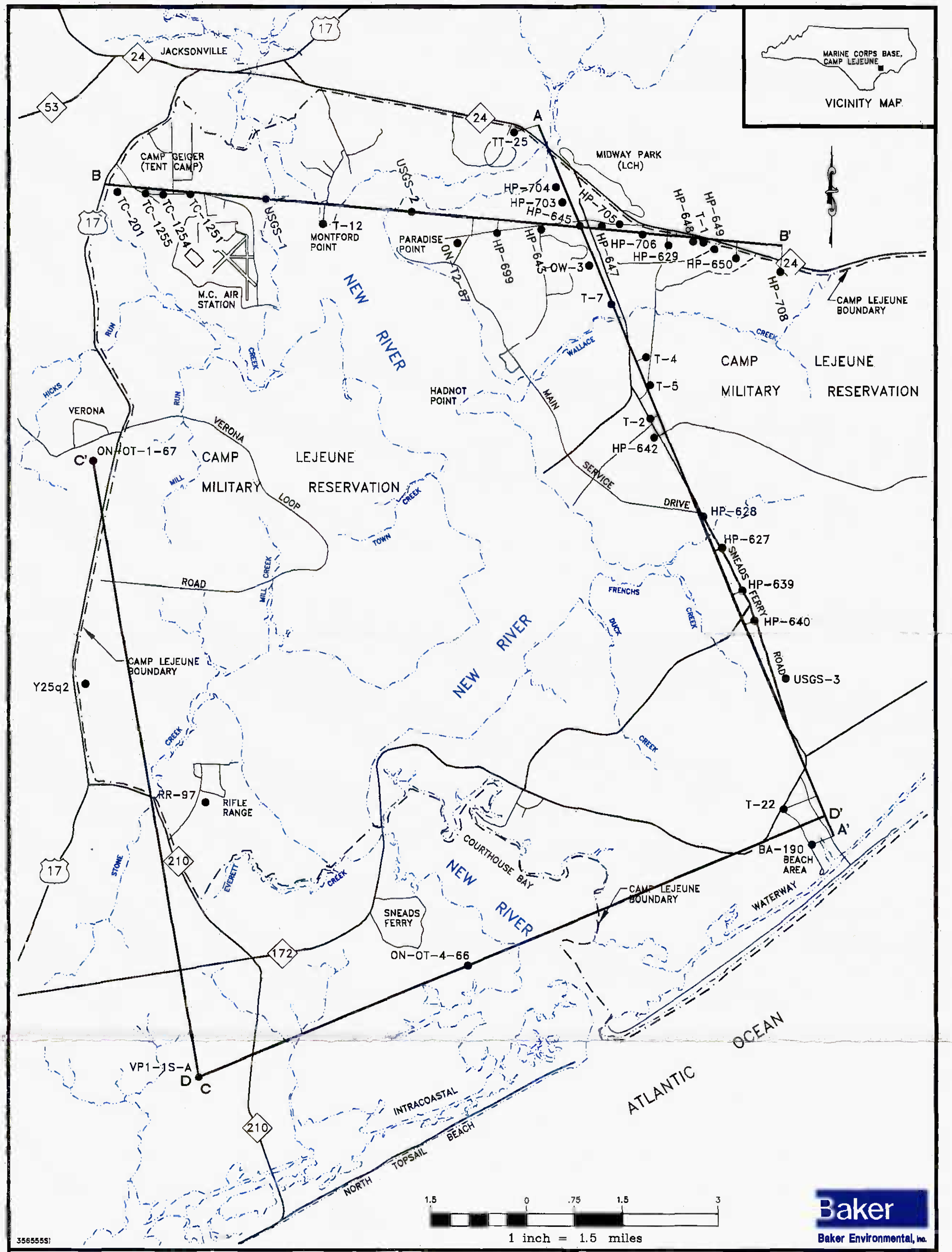


FIGURE 2-1
OPERABLE UNITS AND SITE LOCATIONS AT MARINE CORPS BASE CAMP LEJEUNE
CTO-0356

MARINE CORPS BASE, CAMP LEJEUNE
NORTH CAROLINA

01760Z B1Y

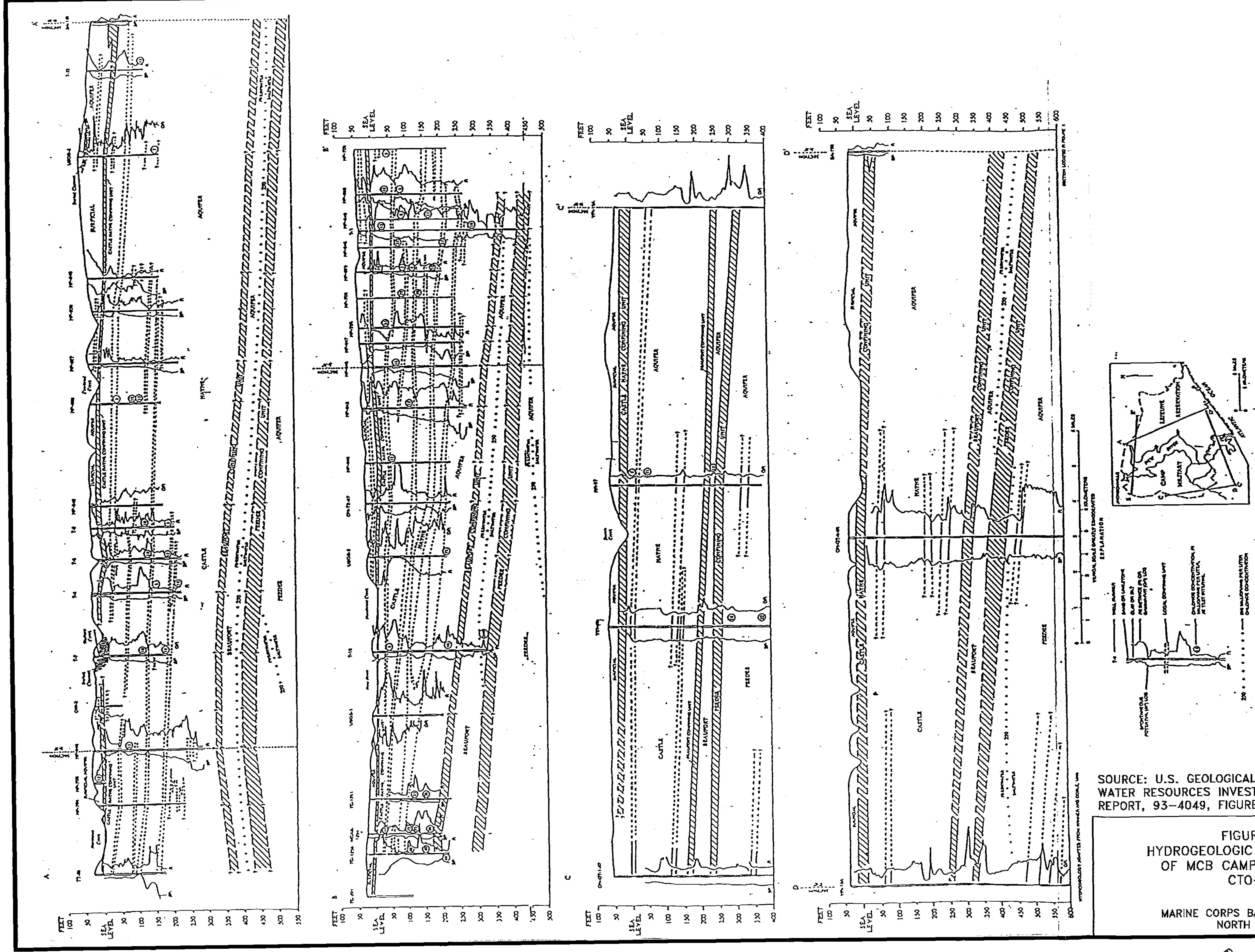


SOURCE: U.S. GEOLOGICAL SURVEY,
WATER-RESOURCES INVESTIGATIONS
REPORT, 93-4049, FIGURE 9

FIGURE 2-2
LOCATION OF HYDROGEOLOGIC CROSS-SECTIONS
MARINE CORPS BASE, CAMP LEJEUNE
CTO-0356

MARINE CORPS BASE, CAMP LEJEUNE
NORTH CAROLINA

356554SI

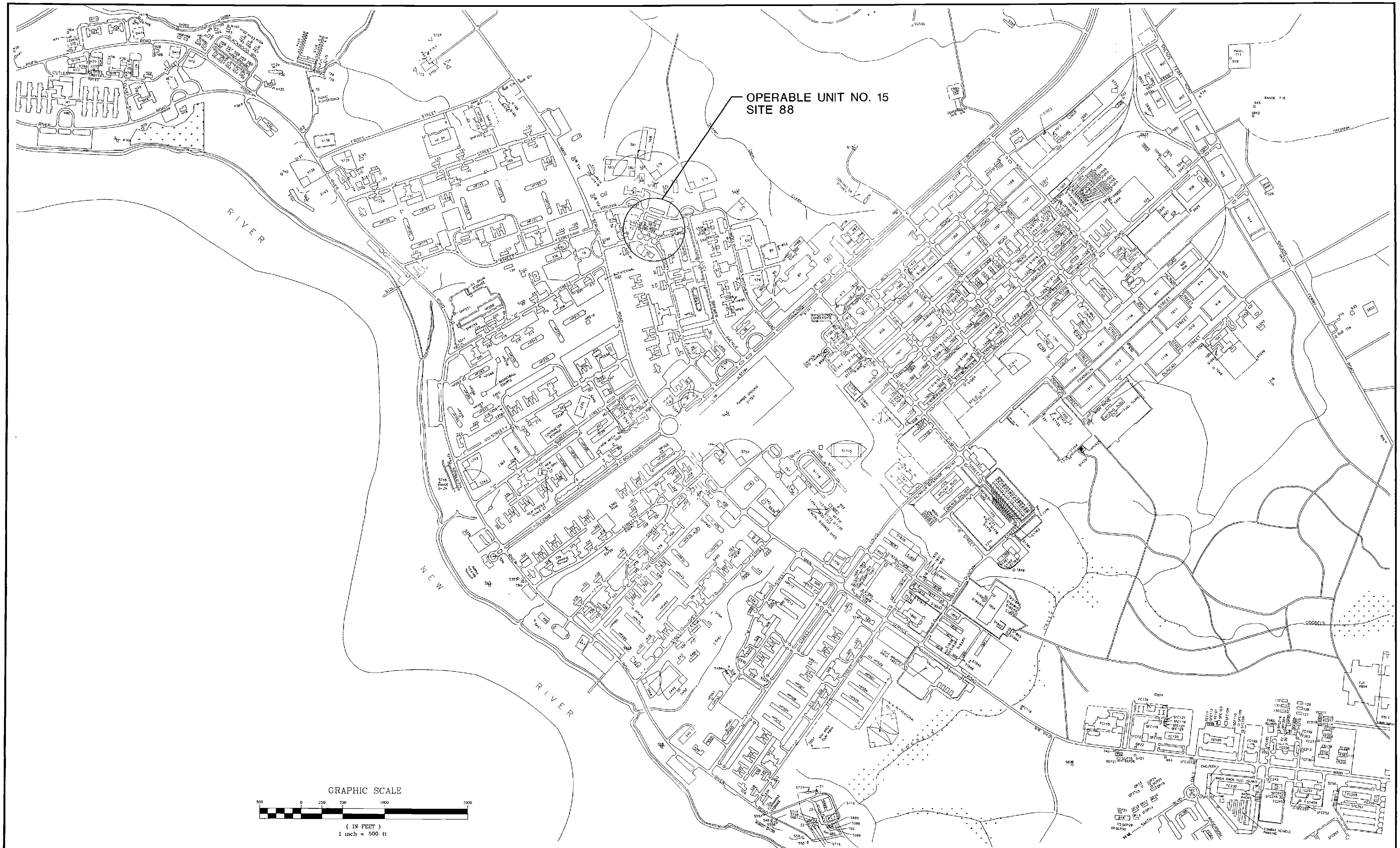


SOURCE: U.S. GEOLOGICAL SURVEY,
WATER RESOURCES INVESTIGATIONS
REPORT, 93-4049, FIGURE 9

FIGURE 2-3
HYDROGEOLOGIC CROSS-SECTIONS
OF MCB CAMP LEJEUNE AREA
CTO-0356

MARINE CORPS BASE, CAMP LEJEUNE
NORTH CAROLINA

01760Z012



(02/18/97 12 55 27) (PRF S \PAPER\356503PP PRF) (TBL K \PEN\SRD TBL)

K \19356\PP\356503PP DWG

LEGEND

SOURCE LANTDIV, FEBRUARY 1992

DATE FEBRUARY 1997
SCALE 1"= 500"
DRAWN WJH
REVIEWED JPT
S O # 62470-356-0000-07000
CADD# 356503PP

NORTH

MARINE CORPS BASE
CAMP LEJEUNE, NORTH CAROLINA

BAKER ENVIRONMENTAL,Inc
Coraopolis, Pennsylvania

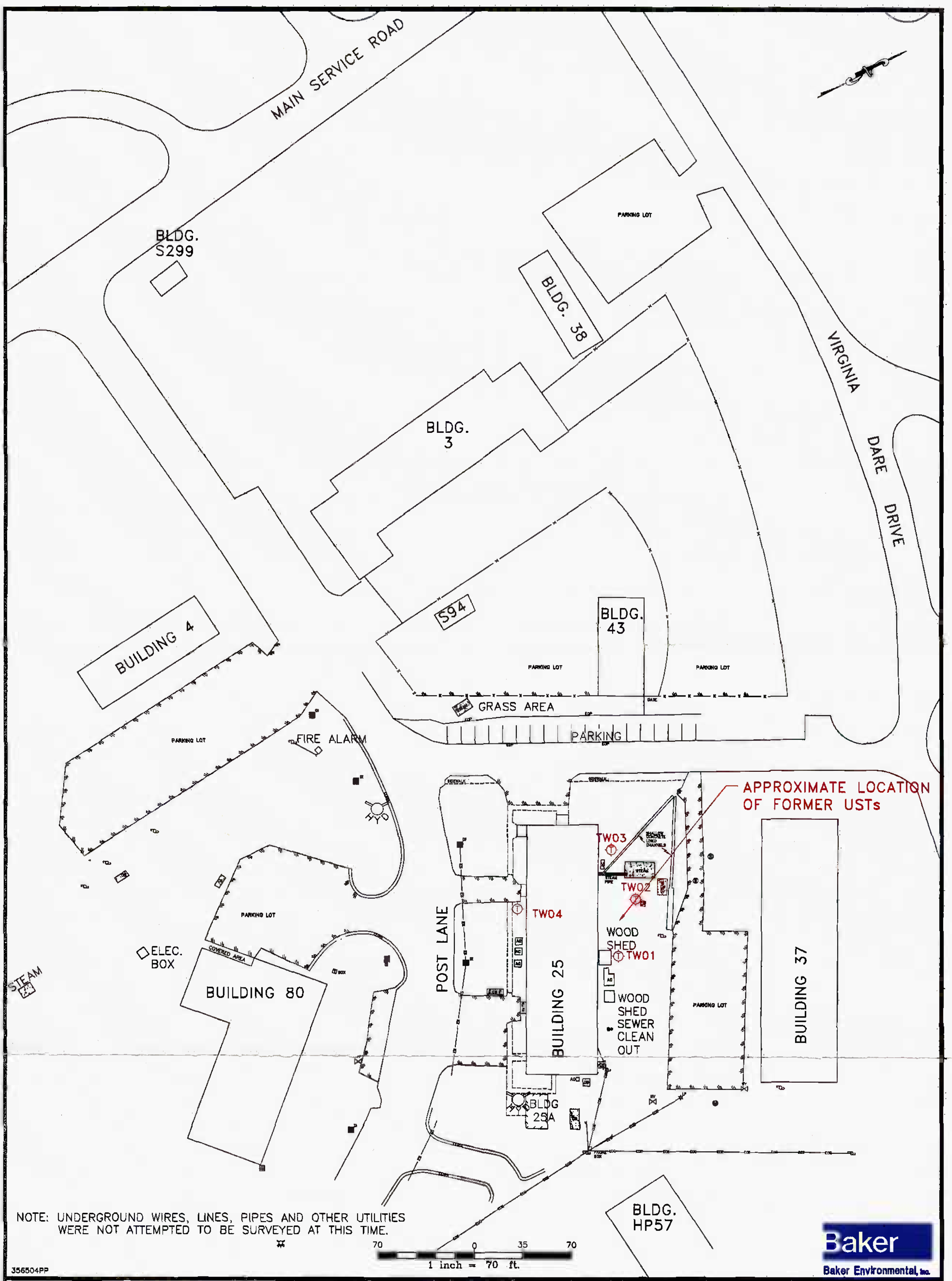
Baker
Baker Environmental, Inc.

HADNOT POINT INDUSTRIAL AREA
OPERABLE UNIT NO. 15 – SITE 88

SCALE 1"=500'

DATE FEBRUARY 1997

FIGURE NO
2-4



NOTE: UNDERGROUND WIRES, LINES, PIPES AND OTHER UTILITIES WERE NOT ATTEMPTED TO BE SURVEYED AT THIS TIME.

LEGEND

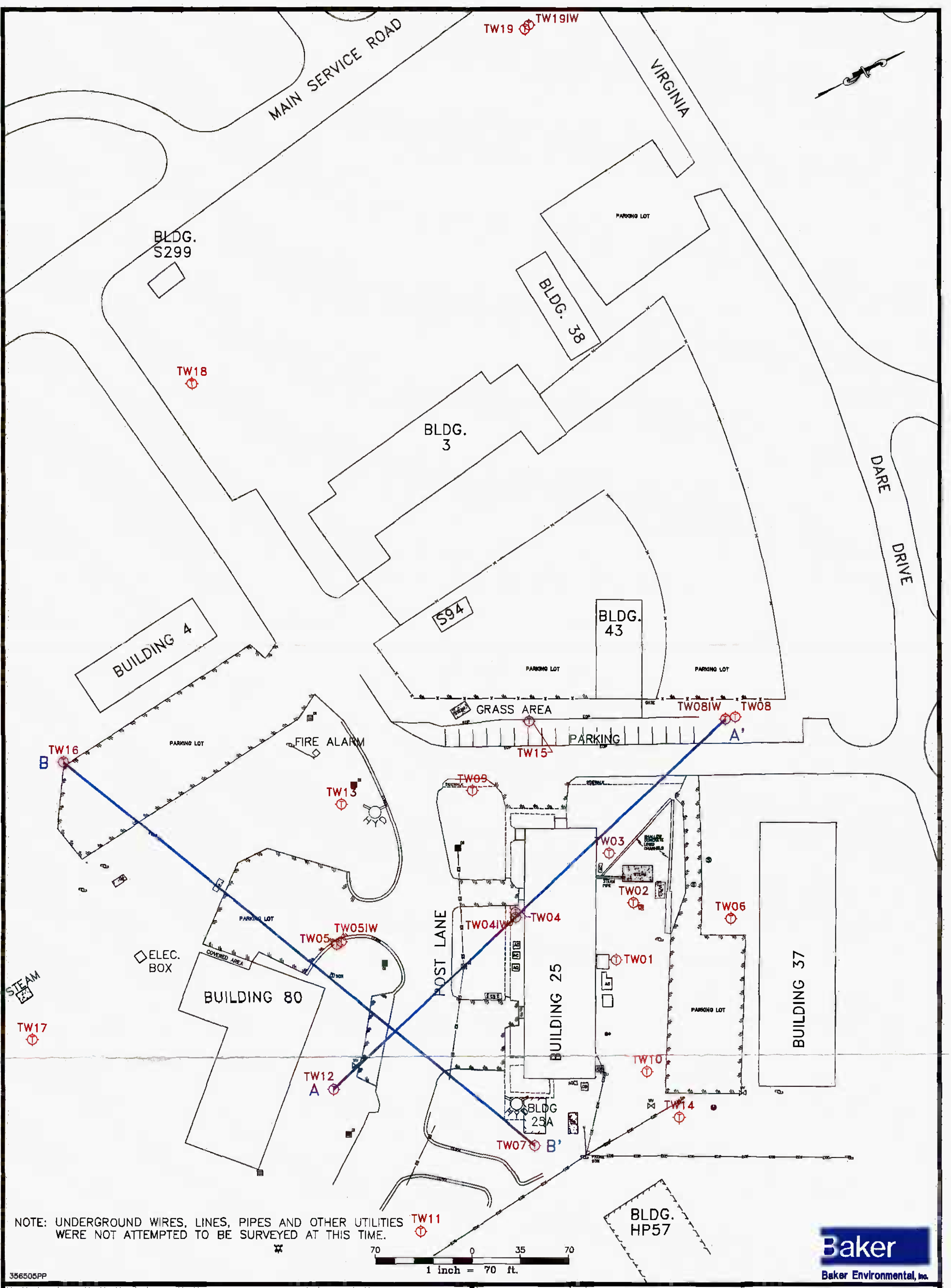
	UTILITY POLE	—ES—	STORM DRAIN
●	MAN HOLE, SEWER	—x—	FENCE
⊛	TREE (ALL TYPES)	—EOE—	POWER LINES
⌘	FIRE HYDRANT	—^—	APHALT
■	DROP INLET/CATCH BASIN	▭	EXISTING BUILDING
TW01	TEMPORARY MONITORING WELL	▨	CONCRETE

SOURCE: LANIER SURVEYING CO., SEPT. 1996 AND LANTDIV, 1991.

FIGURE 2-5
SITE LOCATION MAP
SITE 88
BUILDING 25, MWR DRY CLEANERS

MARINE CORPS BASE, CAMP LEJEUNE
NORTH CAROLINA

01760Z B2ZY



NOTE: UNDERGROUND WIRES, LINES, PIPES AND OTHER UTILITIES WERE NOT ATTEMPTED TO BE SURVEYED AT THIS TIME.

Baker Environmental, Inc.

LEGEND

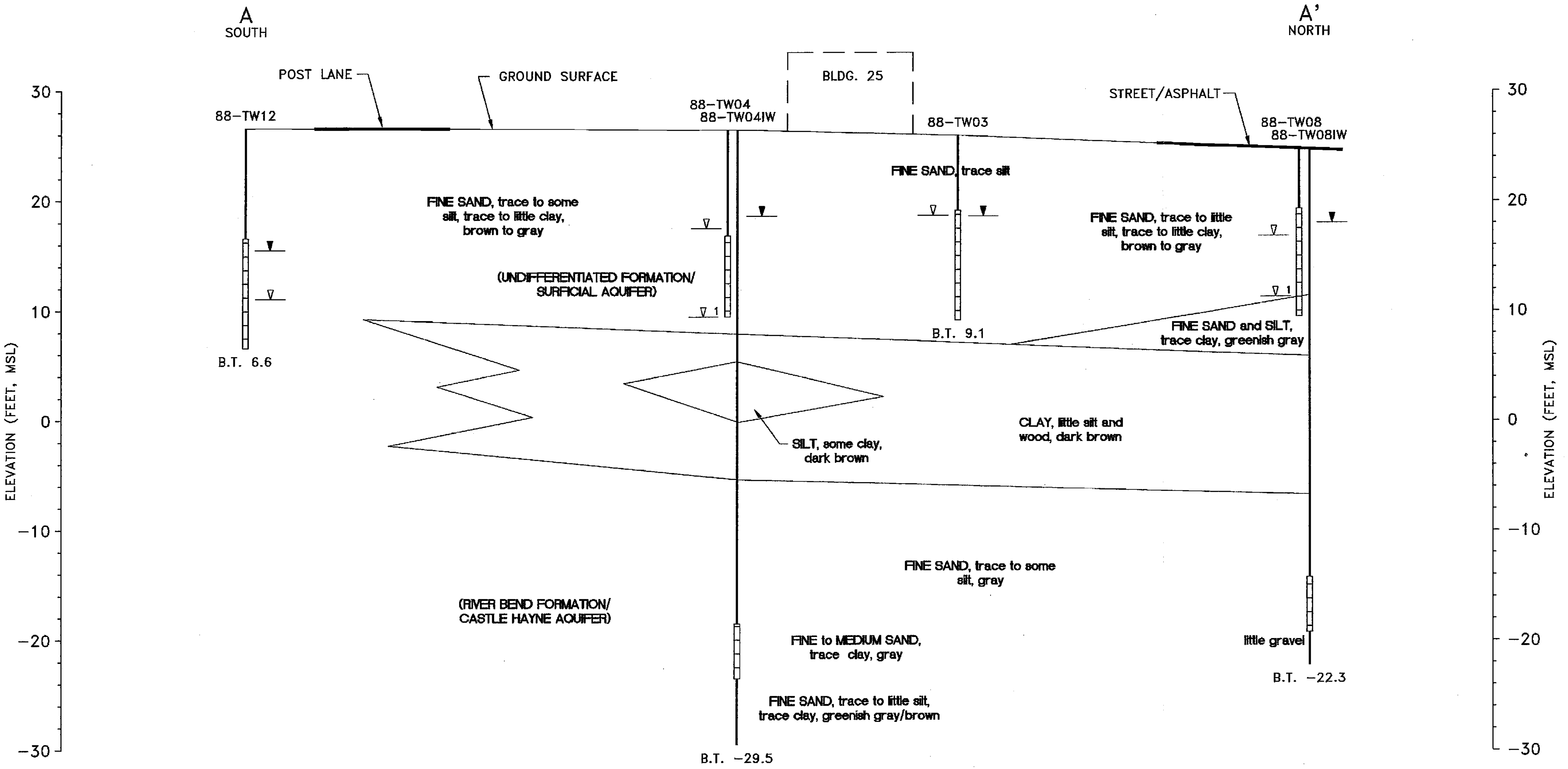
◌	UTILITY POLE	—SS—	STORM DRAIN
⊚	MAN HOLE, SEWER	—×—	FENCE
✿	TREE (ALL TYPES)	—EOE—	POWER LINES
◆	EXISTING WELLS	—⋔—	APHALT
⌘	FIRE HYDRANT	▭	EXISTING BUILDING
■	DROP INLET/CATCH BASIN	▨	CONCRETE
TW19 ⦶	TEMPORARY MONITORING WELL		

SOURCE: LANIER SURVEYING CO., SEPT. 1996 AND LANTDIV, 1991.

FIGURE 2-6
CROSS-SECTION LOCATION MAP
SITE 88
BUILDING 25, MWR DRY CLEANERS

MARINE CORPS BASE, CAMP LEJEUNE
NORTH CAROLINA

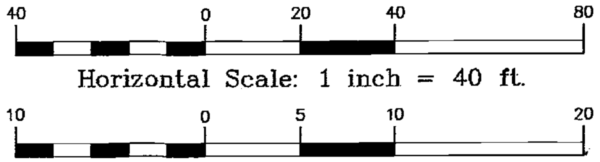
356506PP



Baker
Baker Environmental, Inc.

LEGEND

▽	STATIC GROUNDWATER ELEVATION IN SHALLOW WELL
▽ 1	STATIC GROUNDWATER ELEVATION IN INTERMEDIATE WELL
▼	GROUNDWATER ENCOUNTERED DURING DRILLING
B.T. X'	BORING TERMINATED, ELEVATION MSL
▯	WELL SCREEN INTERVAL
———	ESTIMATED
– – – –	PROJECTED



Horizontal Scale: 1 inch = 40 ft.

Vertical Scale: 1 inch = 10 ft.

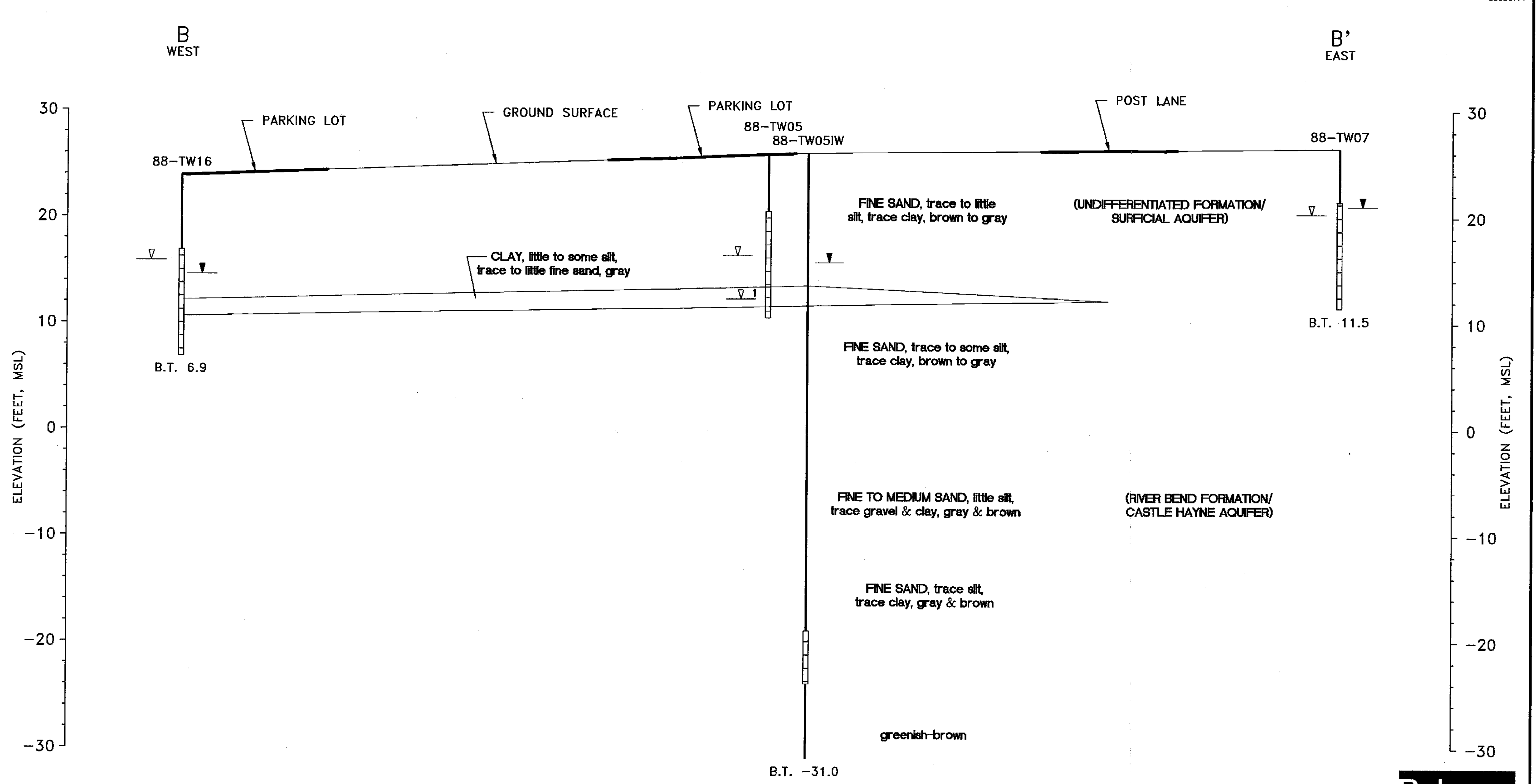
THE SOIL BORING INFORMATION IS CONSIDERED TO BE REPRESENTATIVE OF SUBSURFACE CONDITIONS AT THE RESPECTIVE BORING LOCATIONS. SUBSURFACE CONDITIONS INTERPOLATED BETWEEN BORINGS ARE ESTIMATED BASED ON ACCEPTED SOIL ENGINEERING PRINCIPLES AND GEOLOGIC JUDGEMENT.

FIGURE 2–7
HYDROGEOLOGIC CROSS–SECTION A–A'
SITE 88 – BLDG. 25 MWR DRY CLEANERS
PHASE I INVESTIGATION

MARINE CORPS BASE, CAMP LEJEUNE
NORTH CAROLINA

01760Z B32

356507PP



Baker

Baker Environmental, Inc.

LEGEND

∇	STATIC GROUNDWATER ELEVATION IN SHALLOW WELL
∇ 1	STATIC GROUNDWATER ELEVATION IN INTERMEDIATE WELL
▼	GROUNDWATER ENCOUNTERED DURING DRILLING
B.T. X'	BORING TERMINATED, ELEVATION MSL
▯	WELL SCREEN INTERVAL
———	ESTIMATED
– – – –	PROJECTED

40 0 20 40 80

Horizontal Scale: 1 inch = 40 ft.

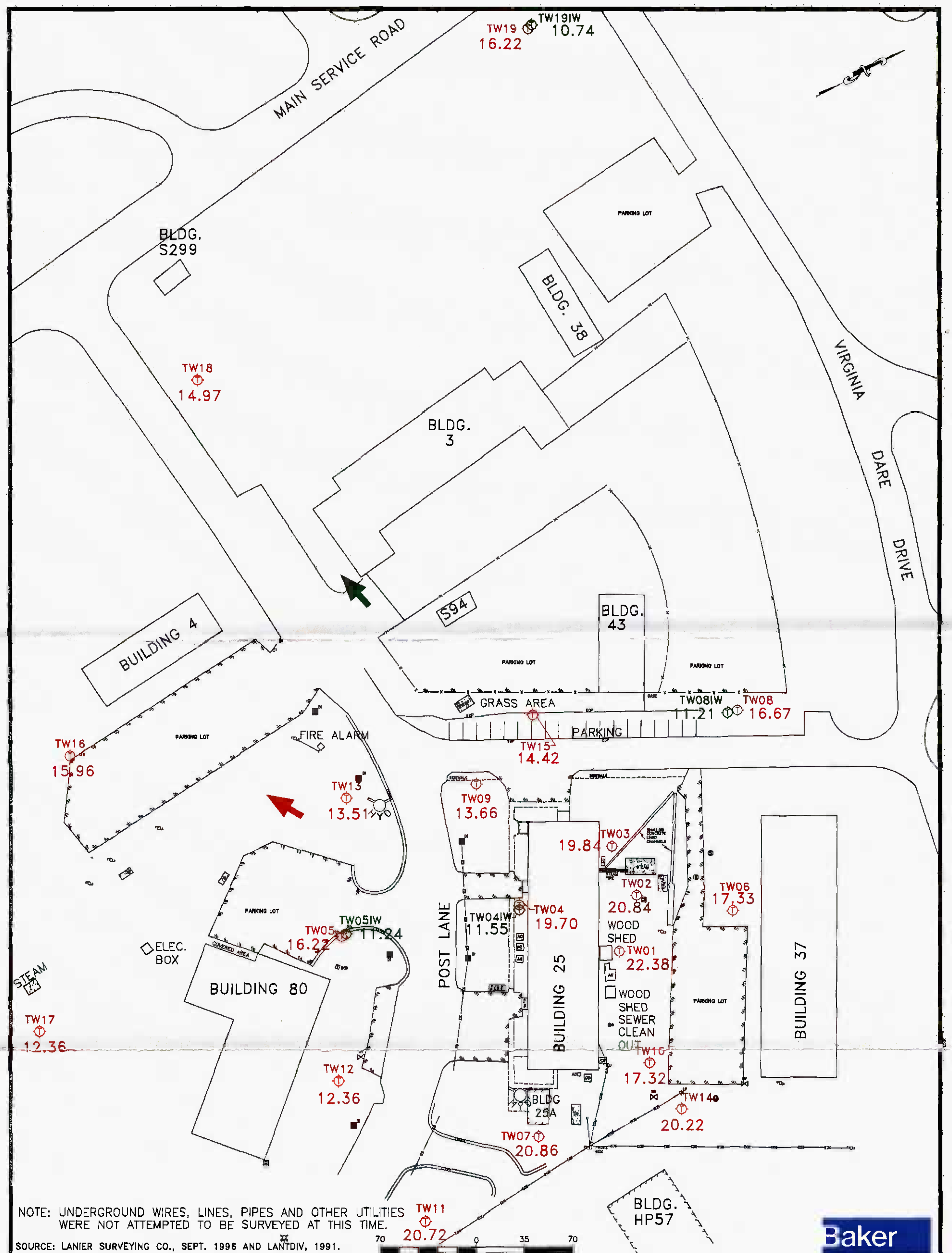
10 0 5 10 20

Vertical Scale: 1 inch = 10 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 2-8
HYDROGEOLOGIC CROSS-SECTION B-B'
SITE 88 - BLDG. 25 MWR DRY CLEANERS
PHASE I INVESTIGATION

MARINE CORPS BASE, CAMP LEJEUNE
NORTH CAROLINA



NOTE: UNDERGROUND WIRES, LINES, PIPES AND OTHER UTILITIES WERE NOT ATTEMPTED TO BE SURVEYED AT THIS TIME.

SOURCE: LANIER SURVEYING CO., SEPT. 1996 AND LANTDIV, 1991.

35650BPP

Baker Environmental, Inc.

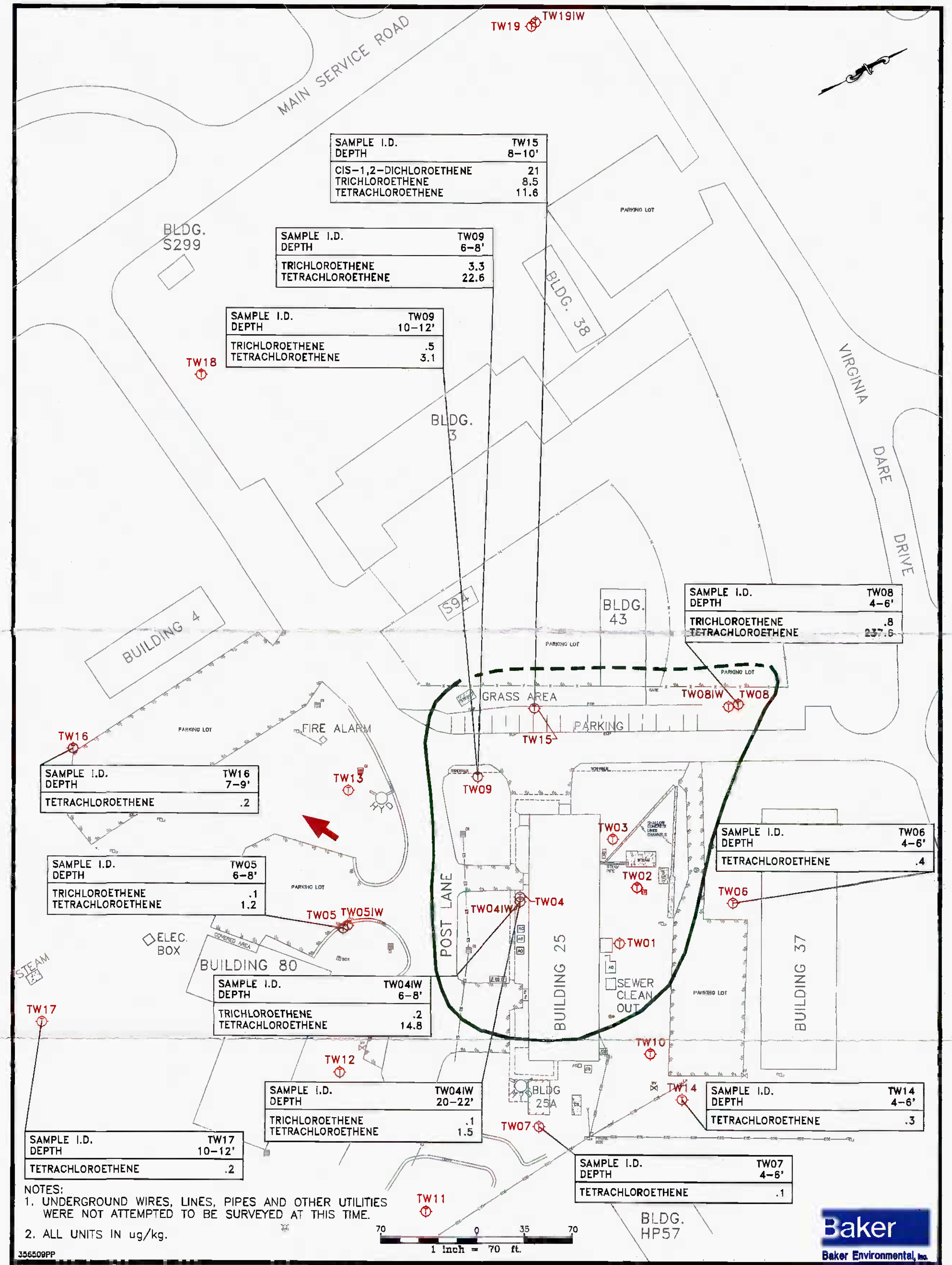
LEGEND

▫	UTILITY POLE	─▫─	STORM DRAIN
⊙	MAN HOLE, SEWER	─×─	FENCE
✱	TREE (ALL TYPES)	─E─	POWER LINES
◆	EXISTING WELLS	─‗─	APHALT
⌘	FIRE HYDRANT	☐	EXISTING BUILDING
■	DROP INLET/CATCH BASIN	▨	CONCRETE
TW19 ⏀	TEMPORARY MONITORING WELL		
→	APPROXIAMTE GROUNDWATER FLOW DIRECTION SURFICIAL AQUIFER		
TW05IW ⏀	TEMPORARY MONITORING WELL		
→	APPROXIAMTE GROUNDWATER FLOW DIRECTION		

FIGURE 2-9
GROUNDWATER ELEVATIONS
SITE 88
BUILDING 25, MWR DRY CLEANERS

MARINE CORPS BASE, CAMP LEJEUNE
NORTH CAROLINA

017607 BHV



SAMPLE I.D.	TW15
DEPTH	8–10'
CIS-1,2-DICHLOROETHENE	21
TRICHLOROETHENE	8.5
TETRACHLOROETHENE	11.6

SAMPLE I.D.	TW09
DEPTH	6–8'
TRICHLOROETHENE	3.3
TETRACHLOROETHENE	22.6

SAMPLE I.D.	TW09
DEPTH	10–12'
TRICHLOROETHENE	.5
TETRACHLOROETHENE	3.1

SAMPLE I.D.	TW08
DEPTH	4–6'
TRICHLOROETHENE	.8
TETRACHLOROETHENE	237.6

SAMPLE I.D.	TW16
DEPTH	7–9'
TETRACHLOROETHENE	.2

SAMPLE I.D.	TW06
DEPTH	4–6'
TETRACHLOROETHENE	.4

SAMPLE I.D.	TW05
DEPTH	6–8'
TRICHLOROETHENE	.1
TETRACHLOROETHENE	1.2

SAMPLE I.D.	TW04IW
DEPTH	6–8'
TRICHLOROETHENE	.2
TETRACHLOROETHENE	14.8

SAMPLE I.D.	TW04IW
DEPTH	20–22'
TRICHLOROETHENE	.1
TETRACHLOROETHENE	1.5

SAMPLE I.D.	TW14
DEPTH	4–6'
TETRACHLOROETHENE	.3

SAMPLE I.D.	TW17
DEPTH	10–12'
TETRACHLOROETHENE	.2

SAMPLE I.D.	TW07
DEPTH	4–6'
TETRACHLOROETHENE	.1

NOTES:
1. UNDERGROUND WIRES, LINES, PIPES AND OTHER UTILITIES WERE NOT ATTEMPTED TO BE SURVEYED AT THIS TIME.
2. ALL UNITS IN ug/kg.

Baker
Baker Environmental, Inc.

LEGEND

☌	UTILITY POLE
⊙	MAN HOLE, SEWER
✲	TREE (ALL TYPES)
⌘	FIRE HYDRANT
▤	DROP INLET/CATCH BASIN
TW19 ⊕	TEMPORARY MONITORING WELL
▬▬	APPROXIMATE BOUNDARY OF SOIL CONTAMINATION
▬ ▬ ▬	ESTIMATED BOUNDARY OF SOIL CONTAMINATION
—ES—	STORM DRAIN
—×—	FENCE
—EOE—	POWER LINES
═	APHALT
▭	EXISTING BUILDING
▨	CONCRETE
➡	APPROXIMATE GROUNDWATER FLOW DIRECTION

SOURCE: LANIER SURVEYING CO., SEPT. 1996 AND LANTDIV, 1991.

FIGURE 2-10
SUBSURFACE SOIL CONTAMINATION
BY ON-SITE ANALYSIS
SITE 88
BUILDING 25, MWR DRY CLEANERS
MARINE CORPS BASE, CAMP LEJEUNE
NORTH CAROLINA

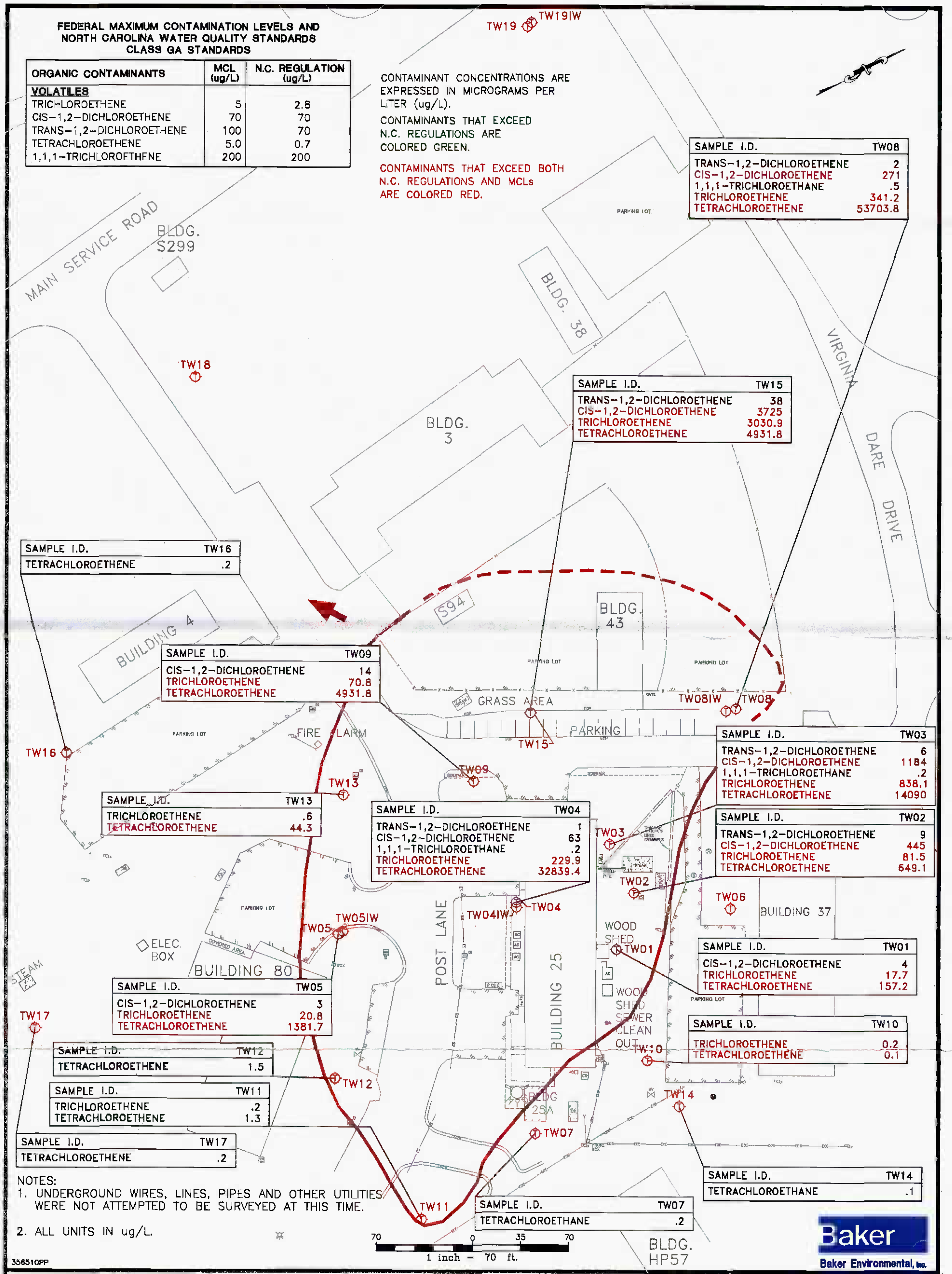
FEDERAL MAXIMUM CONTAMINATION LEVELS AND NORTH CAROLINA WATER QUALITY STANDARDS CLASS GA STANDARDS

ORGANIC CONTAMINANTS	MCL (ug/L)	N.C. REGULATION (ug/L)
VOLATILES		
TRICHLOROETHENE	5	2.8
CIS-1,2-DICHLOROETHENE	70	70
TRANS-1,2-DICHLOROETHENE	100	70
TETRACHLOROETHENE	5.0	0.7
1,1,1-TRICHLOROETHENE	200	200

CONTAMINANT CONCENTRATIONS ARE EXPRESSED IN MICROGRAMS PER LITER (ug/L).

CONTAMINANTS THAT EXCEED N.C. REGULATIONS ARE COLORED GREEN.

CONTAMINANTS THAT EXCEED BOTH N.C. REGULATIONS AND MCLs ARE COLORED RED.



SAMPLE I.D.	TW08
TRANS-1,2-DICHLOROETHENE	2
CIS-1,2-DICHLOROETHENE	271
1,1,1-TRICHLOROETHANE	.5
TRICHLOROETHENE	341.2
TETRACHLOROETHENE	53703.8

SAMPLE I.D.	TW15
TRANS-1,2-DICHLOROETHENE	38
CIS-1,2-DICHLOROETHENE	3725
TRICHLOROETHENE	3030.9
TETRACHLOROETHENE	4931.8

SAMPLE I.D.	TW16
TETRACHLOROETHENE	.2

SAMPLE I.D.	TW09
CIS-1,2-DICHLOROETHENE	14
TRICHLOROETHENE	70.8
TETRACHLOROETHENE	4931.8

SAMPLE I.D.	TW03
TRANS-1,2-DICHLOROETHENE	6
CIS-1,2-DICHLOROETHENE	1184
1,1,1-TRICHLOROETHANE	.2
TRICHLOROETHENE	838.1
TETRACHLOROETHENE	14090

SAMPLE I.D.	TW13
TRICHLOROETHENE	.6
TETRACHLOROETHENE	44.3

SAMPLE I.D.	TW04
TRANS-1,2-DICHLOROETHENE	1
CIS-1,2-DICHLOROETHENE	63
1,1,1-TRICHLOROETHANE	.2
TRICHLOROETHENE	229.9
TETRACHLOROETHENE	32839.4

SAMPLE I.D.	TW02
TRANS-1,2-DICHLOROETHENE	9
CIS-1,2-DICHLOROETHENE	445
TRICHLOROETHENE	81.5
TETRACHLOROETHENE	649.1

SAMPLE I.D.	TW01
CIS-1,2-DICHLOROETHENE	4
TRICHLOROETHENE	17.7
TETRACHLOROETHENE	157.2

SAMPLE I.D.	TW05
CIS-1,2-DICHLOROETHENE	3
TRICHLOROETHENE	20.8
TETRACHLOROETHENE	1381.7

SAMPLE I.D.	TW10
TRICHLOROETHENE	0.2
TETRACHLOROETHENE	0.1

SAMPLE I.D.	TW12
TETRACHLOROETHENE	1.5

SAMPLE I.D.	TW11
TRICHLOROETHENE	.2
TETRACHLOROETHENE	1.3

SAMPLE I.D.	TW17
TETRACHLOROETHENE	.2

SAMPLE I.D.	TW14
TETRACHLOROETHANE	.1

SAMPLE I.D.	TW07
TETRACHLOROETHANE	.2

NOTES:

1. UNDERGROUND WIRES, LINES, PIPES AND OTHER UTILITIES WERE NOT ATTEMPTED TO BE SURVEYED AT THIS TIME.
2. ALL UNITS IN ug/L.

35651OPP

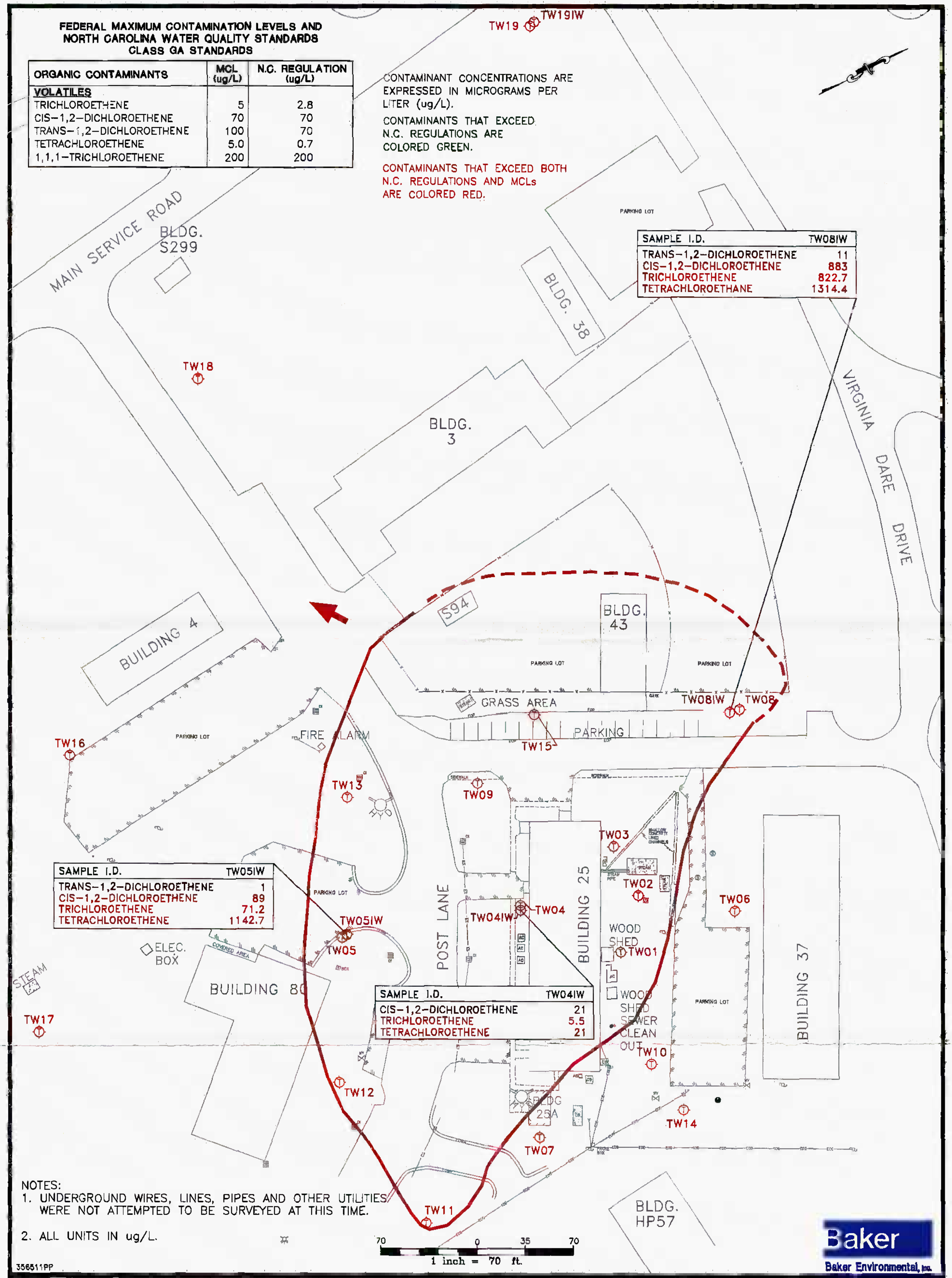
Baker
Baker Environmental, Inc.

LEGEND

	UTILITY POLE
	MAN HOLE, SEWER
	TREE (ALL TYPES)
	FIRE HYDRANT
	DROP INLET/CATCH BASIN
TW19	TEMPORARY MONITORING WELL
	APPROXIMATE BOUNDARY OF GROUNDWATER CONTAMINATION
	ESTIMATED BOUNDARY OF GROUNDWATER CONTAMINATION
ES	STORM DRAIN
	FENCE
EOE	POWER LINES
	APHALT
	EXISTING BUILDING
	CONCRETE
	APPROXIMATE GROUNDWATER FLOW DIRECTION

SOURCE: LANIER SURVEYING CO., SEPT. 1996 AND LANTDIV, 1991.

FIGURE 2-11
VOLATILE ORGANIC COMPOUNDS IN GROUNDWATER (SHALLOW WELLS) BY ON-SITE ANALYSIS
SITE 88
BUILDING 25, MWR DRY CLEANERS
MARINE CORPS BASE, CAMP LEJEUNE
NORTH CAROLINA



FEDERAL MAXIMUM CONTAMINATION LEVELS AND
NORTH CAROLINA WATER QUALITY STANDARDS
CLASS GA STANDARDS

ORGANIC CONTAMINANTS	MCL (ug/L)	N.C. REGULATION (ug/L)
VOLATILES		
TRICHLOROETHENE	5	2.8
CIS-1,2-DICHLOROETHENE	70	70
TRANS-1,2-DICHLOROETHENE	100	70
TETRACHLOROETHENE	5.0	0.7
1,1,1-TRICHLOROETHENE	200	200

CONTAMINANT CONCENTRATIONS ARE EXPRESSED IN MICROGRAMS PER LITER (ug/L).

CONTAMINANTS THAT EXCEED N.C. REGULATIONS ARE COLORED GREEN.

CONTAMINANTS THAT EXCEED BOTH N.C. REGULATIONS AND MCLs ARE COLORED RED.

SAMPLE I.D.	TW08IW
TRANS-1,2-DICHLOROETHENE	11
CIS-1,2-DICHLOROETHENE	883
TRICHLOROETHENE	822.7
TETRACHLOROETHANE	1314.4

SAMPLE I.D.	TW05IW
TRANS-1,2-DICHLOROETHENE	1
CIS-1,2-DICHLOROETHENE	89
TRICHLOROETHENE	71.2
TETRACHLOROETHENE	1142.7

SAMPLE I.D.	TW04IW
CIS-1,2-DICHLOROETHENE	21
TRICHLOROETHENE	5.5
TETRACHLOROETHENE	21

NOTES:
1. UNDERGROUND WIRES, LINES, PIPES AND OTHER UTILITIES WERE NOT ATTEMPTED TO BE SURVEYED AT THIS TIME.
2. ALL UNITS IN ug/L.

356511PP

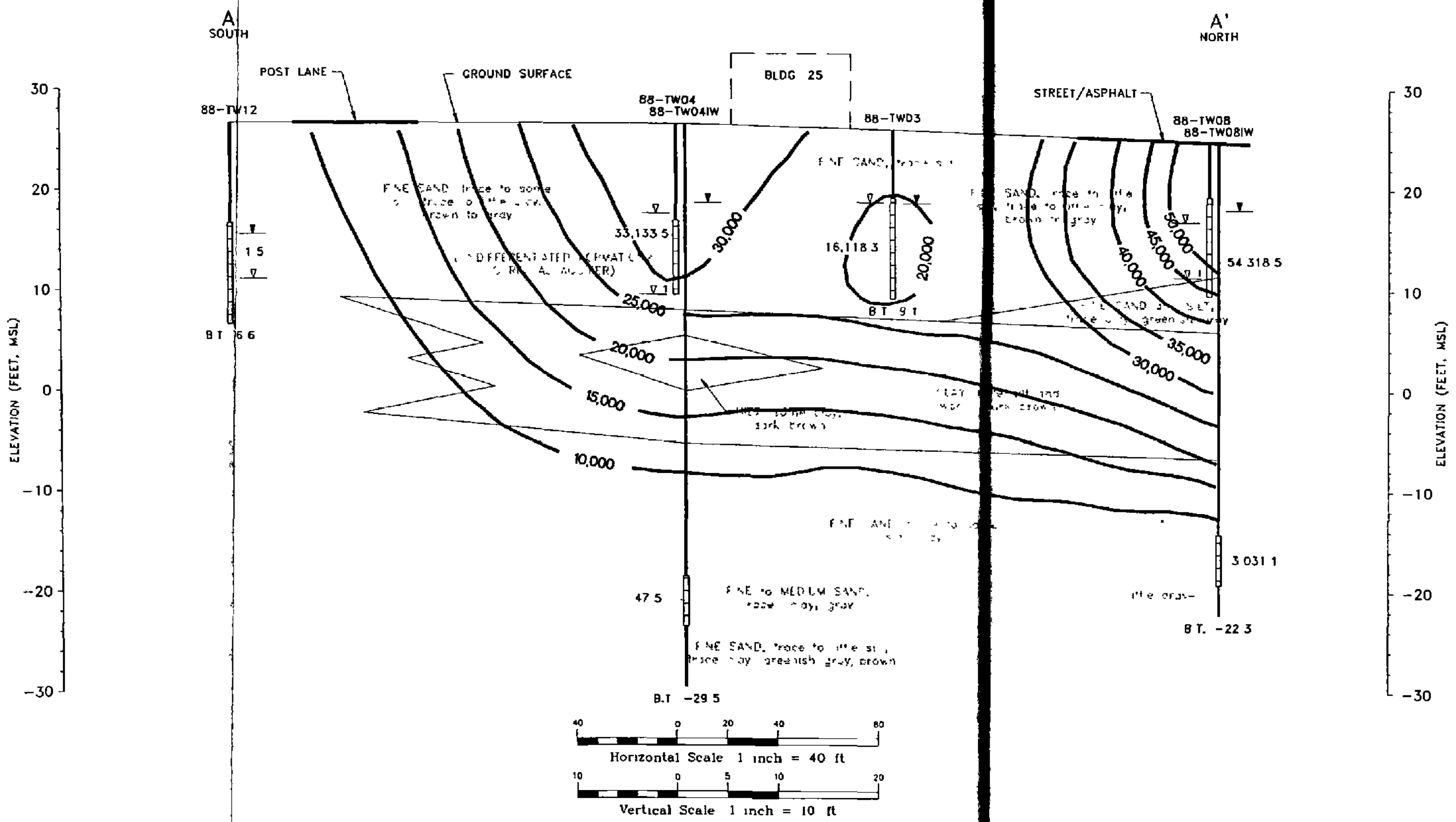
Baker Environmental, Inc.

LEGEND

☎	UTILITY POLE
●	MAN HOLE, SEWER
✽	TREE (ALL TYPES)
✕	FIRE HYDRANT
▤	DROP INLET/CATCH BASIN
TW19 ⦶	TEMPORARY MONITORING WELL
━━	APPROXIMATE BOUNDARY OF GROUNDWATER CONTAMINATION
━ ━ ━	ESTIMATED BOUNDARY OF GROUNDWATER CONTAMINATION
—ES—	STORM DRAIN
—x—	FENCE
—EOE—	POWER LINES
—\\\\—	APHALT
☐	EXISTING BUILDING
▨	CONCRETE
➡	APPROXIMATE GROUNDWATER FLOW DIRECTION

SOURCE: LANIER SURVEYING CO., SEPT. 1996 AND LANTDIV, 1991.

FIGURE 2-12
VOLATILE ORGANIC COMPOUNDS IN GROUNDWATER (INTERMEDIATE WELLS) BY ON-SITE ANALYSIS
SITE 88
BUILDING 25, MWR DRY CLEANERS
MARINE CORPS BASE, CAMP LEJEUNE
NORTH CAROLINA



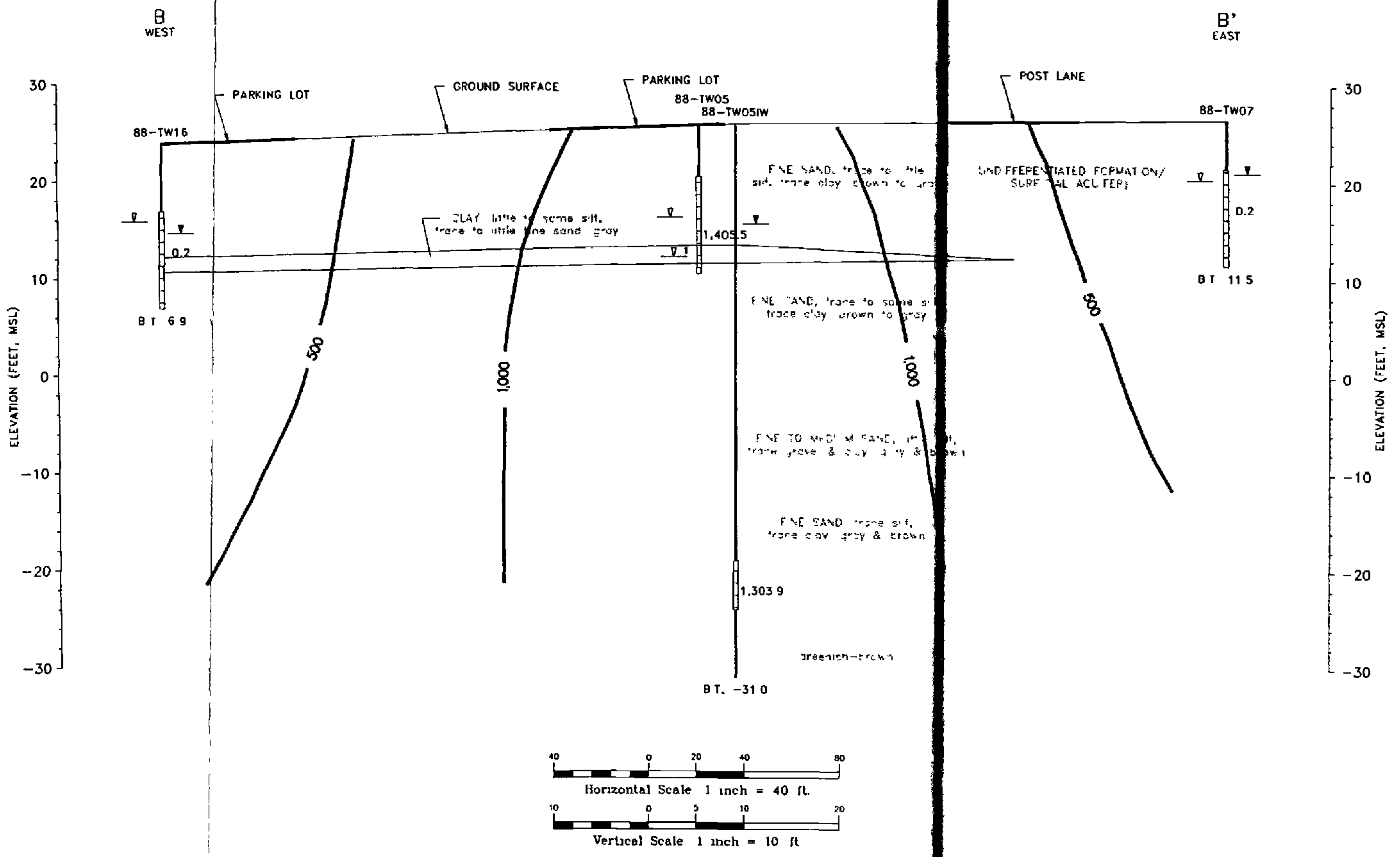
THE SOIL BORING INFORMATION IS CONSIDERED TO BE REPRESENTATIVE OF SUBSURFACE CONDITIONS AT THE RESPECTIVE BORING LOCATIONS. SUBSURFACE CONDITIONS INTERPOLATED BETWEEN BORINGS ARE ESTIMATED BASED ON ACCEPTED SOIL ENGINEERING PRINCIPLES AND GEOLOGIC JUDGEMENT

LEGEND

▽	STATIC GROUNDWATER ELEVATION IN SHALLOW WELL
▽ I	STATIC GROUNDWATER ELEVATION IN INTERMEDIATE WELL
▼	GROUNDWATER ENCOUNTERED DURING DRILLING
B T X'	BORING TERMINATED, ELEVATION MSL
▯	WELL SCREEN INTERVAL
———	ESTIMATED
– – –	PROJECTED

NOTE:

1) CONCENTRATIONS ARE EXPRESSED IN ug/L OR ppb



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.

REVISIONS

DRAWN WJH
REVIEWED JPT
S.O.# 62470-356-0000-07000
CADD# 356502PP

NORTH

CTO - 0356
MARINE CORPS BASE, CAMP LEJEUNE
NORTH CAROLINA

BAKER ENVIRONMENTAL, Inc
Coraopolis, Pennsylvania

Baker
Baker Environmental, Inc.

TOTAL VOLATILE ORGANIC CONCENTRATIONS IN GROUNDWATER ON CROSS-SECTIONS A-A' AND B-B'
SITE 88 - BUILDING 25 MWR DRY CLEANERS
PHASE I INVESTIGATION

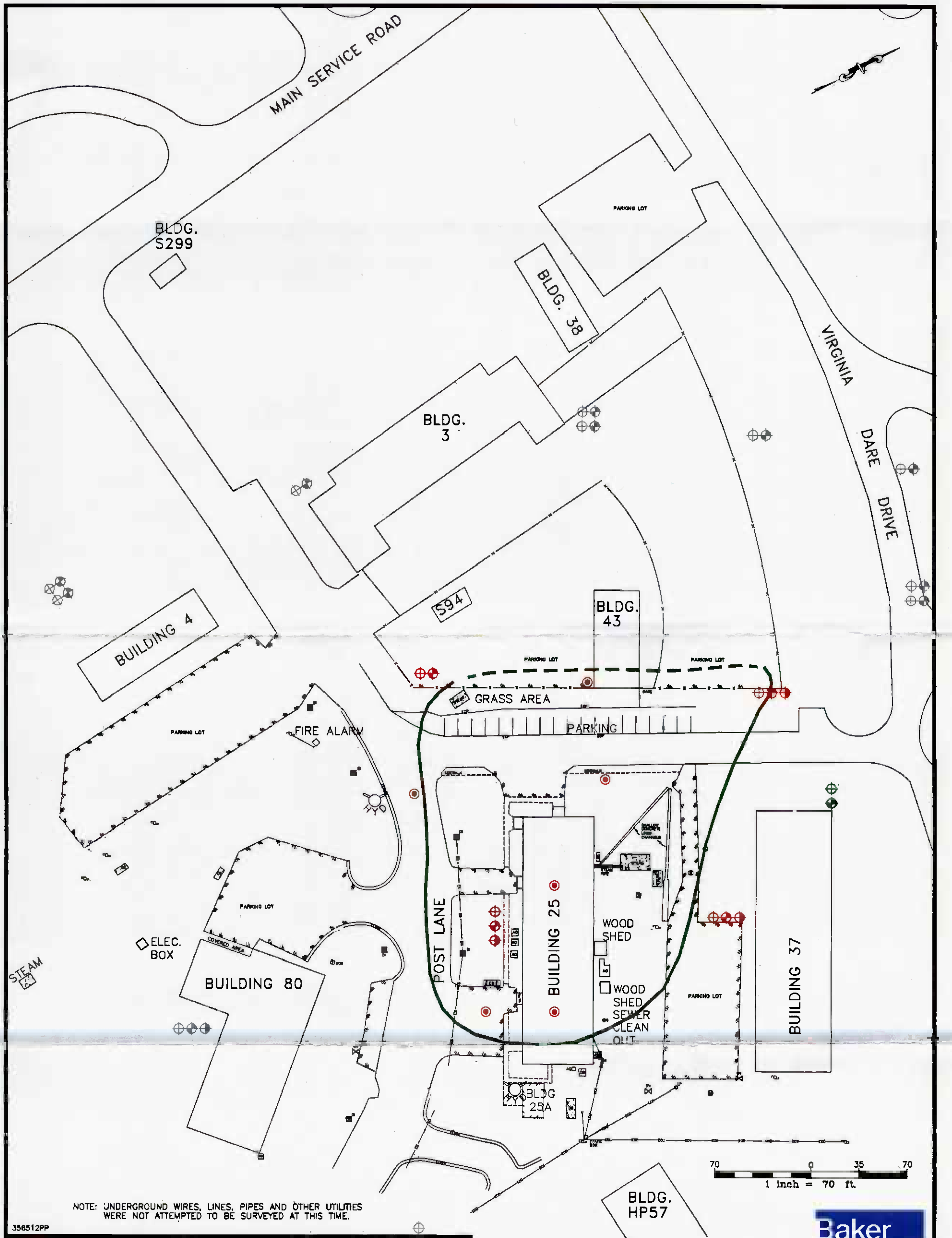
SCALE AS SHOWN
DATE JANUARY 1997

FIGURE NO.
2-13

K:\19356\PP\356502PP.DWG

(02/18/97 12:54 15) (PRF. S:\PAPER\356502PP.PRF) (TBL. K:\PEN\SRD.TBL)

01760203X



NOTE: UNDERGROUND WIRES, LINES, PIPES AND OTHER UTILITIES WERE NOT ATTEMPTED TO BE SURVEYED AT THIS TIME.

356512PP

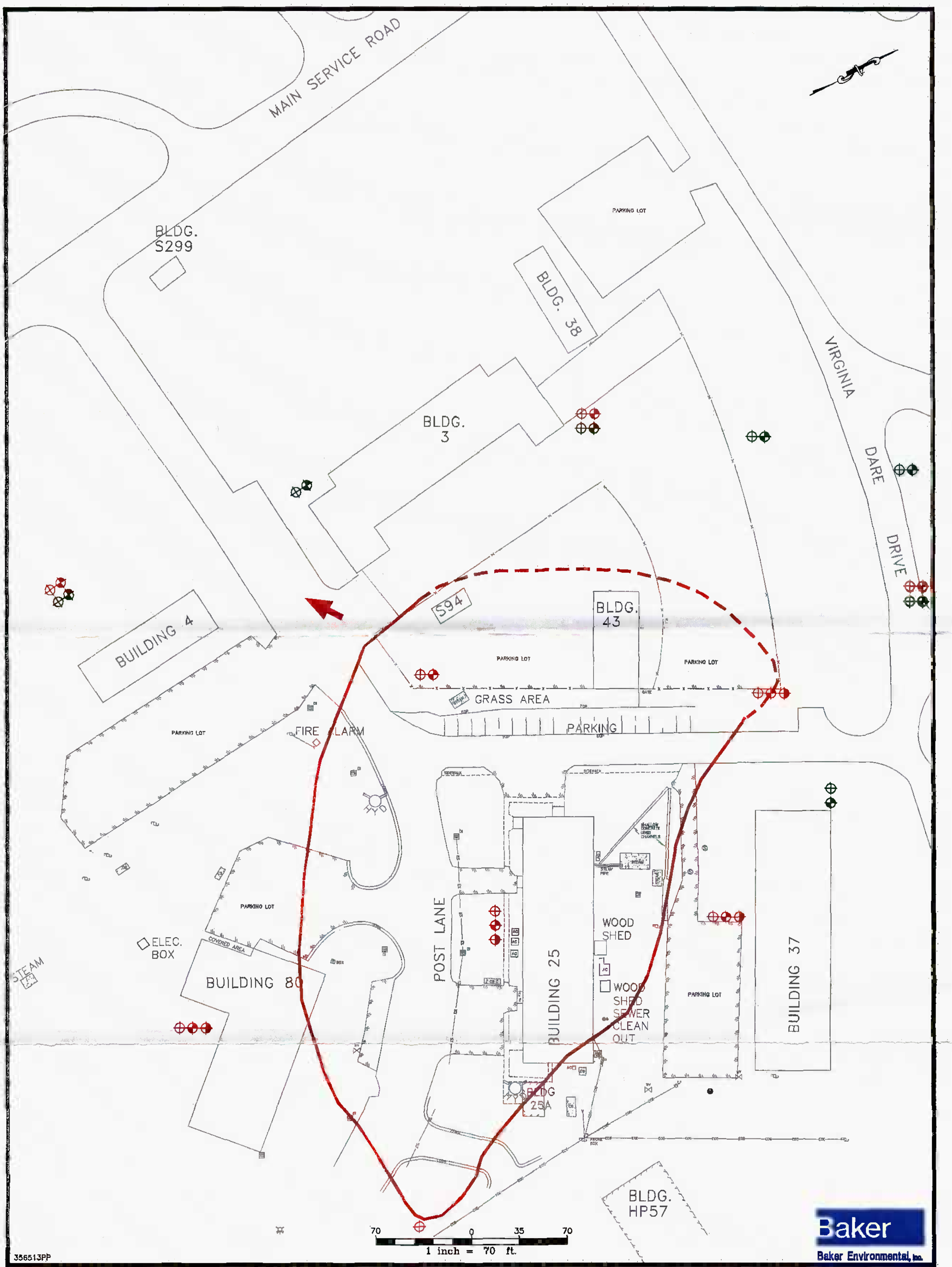
LEGEND

⊕	PROPOSED SHALLOW PERMANENT MONITORING WELL		UTILITY POLE
⊕	PROPOSED INTERMEDIATE PERMANENT MONITORING WELL	●	MAN HOLE, SEWER
⊕	PROPOSED DEEP PERMANENT MONITORING WELL		TREE (ALL TYPES)
⊕	PROPOSED SHALLOW TEMPORARY MONITORING WELL		STORM DRAIN
⊕	PROPOSED INTERMEDIATE TEMPORARY MONITORING WELL		FENCE
	FIRE HYDRANT		POWER LINES
■	DROP INLET/CATCH BASIN		APHALT
◉	PROPOSED SOIL BORING LOCATION	▭	EXISTING BUILDING
	APPROXIMATE BOUNDARY OF SOIL CONTAMINATION	▨	CONCRETE
	ESTIMATED BOUNDARY OF SOIL CONTAMINATION		APPROXIMATE GROUNDWATER FLOW DIRECTION

SOURCE: LANIER SURVEYING CO., SEPT. 1998 AND LANTDIV, 1991.

FIGURE 4-1
PROPOSED SOIL
SAMPLE LOCATIONS
SITE 88
BUILDING 25, MWR DRY CLEANERS
MARINE CORPS BASE, CAMP LEJEUNE
NORTH CAROLINA

017407B5K



Baker
Baker Environmental, Inc.

LEGEND

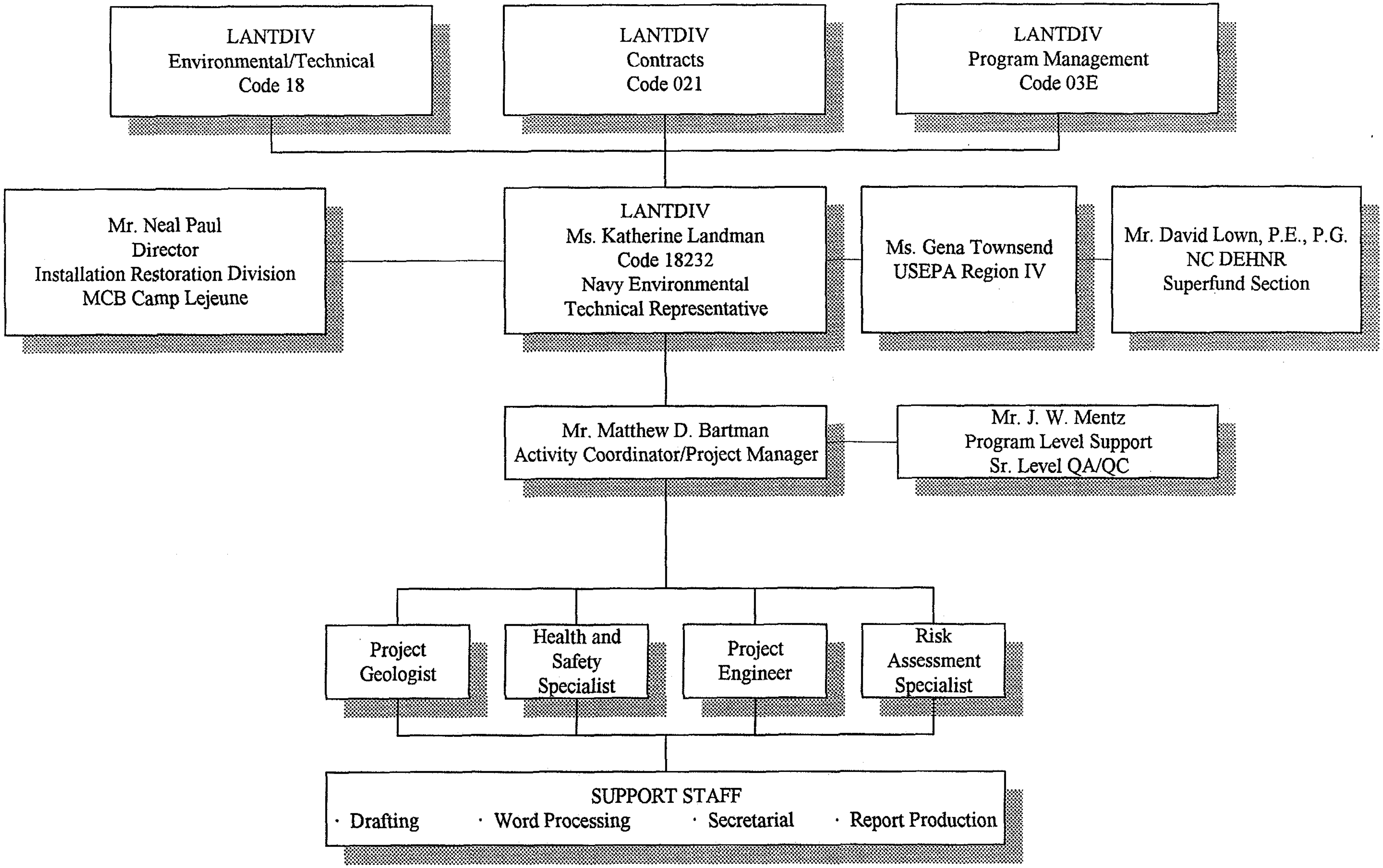
⊕ PROPOSED SHALLOW PERMANENT MONITORING WELL
⊕ PROPOSED INTERMEDIATE PERMANENT MONITORING WELL
⊕ PROPOSED DEEP PERMANENT MONITORING WELL
⊕ PROPOSED SHALLOW TEMPORARY MONITORING WELL
⊕ PROPOSED INTERMEDIATE TEMPORARY MONITORING WELL
→ APPROXIMATE GROUNDWATER FLOW DIRECTION
— APPROXIMATE BOUNDARY OF GROUNDWATER CONTAMINATION
– – ESTIMATED BOUNDARY OF GROUNDWATER CONTAMINATION

SOURCE: LANIER SURVEYING CO., SEPT. 1996 AND LANTDIV, 1991.

FIGURE 4-2
PROPOSED TEMPORARY AND PERMANENT MONITORING WELLS
SITE 88
BUILDING 25, MWR DRY CLEANERS
MARINE CORPS BASE, CAMP LEJEUNE
NORTH CAROLINA

FIGURE 5-1

PROJECT ORGANIZATION



APPENDIX A
PHASE I INVESTIGATION PHOTOGRAPHS

Photo # WP-1 Northern side of Building 25. The former UST system was located in the central portion of the photograph where very little grass is present. The grate in the foreground of the photograph is associated with underground steam lines.

Photo # WP-2 Southern side of Building 25. Post Lane runs along the south side of the building. The parking lot in the foreground is associated with Building 4.

Photo # WP-3 Installing temporary intermediate well TW04IW on the south side of Building 25. The temporary wells were installed using hollow stem augers and a truck-mounted drill rig. This particular well was installed at a depth of 50 feet below ground surface.

Photo # WP-4 Work proceeding at temporary well location TW15. This well was located west of Building 25. The cobbler shop (Building 43) can be seen in the photograph.

Photo # WP-5 Preparation of a temporary monitoring well, consisting of 1 inch diameter PVC and a synthetic filter sleeve. The filter, reduces the amount of fine grain material entering the well.

Photo # WP-6 Decontamination and IDW management area located next to Building 25. The western end of Building 25 appears on the right side of the photograph while dormitory HP-57 appears on the left.

FINAL

SITE EVALUATION
FIELD SAMPLING AND ANALYSIS PLAN

OPERABLE UNIT NO. 15 (SITE 88)
MCB CAMP LEJEUNE, NORTH CAROLINA

CONTRACT TASK ORDER 0356

FEBRUARY 21, 1997

Prepared for:

DEPARTMENT OF THE NAVY
ATLANTIC DIVISION
NAVAL FACILITIES
ENGINEERING COMMAND
Norfolk, Virginia

Under:

LANTDIV CLEAN Program
Contract N62470-89-D-4814

Prepared by:

BAKER ENVIRONMENTAL, INC.
Coraopolis, Pennsylvania

TABLE OF CONTENTS

Page

1.0 INTRODUCTION 1-1

2.0 SITE BACKGROUND 2-1

3.0 SAMPLING OBJECTIVES 3-1

4.0 SAMPLING LOCATIONS AND FREQUENCY 4-1
  4.1 Soil Investigation 4-1
    4.1.1 Sampling Locations 4-1
    4.1.2 Analytical Requirements 4-2
  4.2 Groundwater Investigation 4-2
    4.2.1 Phase I 4-2
    4.2.2 Phase II 4-2
  4.3 Surveying 4-3
  4.4 Quality Assurance/Quality Control Samples 4-3
  4.5 Investigation Derived Waste Management 4-4

5.0 SAMPLE DESIGNATION 5-1

6.0 INVESTIGATIVE PROCEDURES 6-1
  6.1 Soil Sample Collection 6-1
    6.1.1 Split-Spoon Sample Collection Procedures 6-2
    6.1.2 Soil Sample Laboratory Submission Procedures 6-2
  6.2 Temporary Monitoring Well Installation 6-3
  6.3 Permanent Monitoring Well Installation 6-4
    6.3.1 Shallow Monitoring Well 6-4
    6.3.2 Intermediate and Deep Monitoring Well 6-5
  6.4 Well Development 6-7
  6.5 Groundwater Sample Collection 6-8
  6.6 Decontamination 6-10
  6.7 Monitoring and Data Collection Equipment 6-10
  6.8 Investigation Derived Waste Handling 6-11
    6.8.1 Responsibilities 6-11
    6.8.2 Sources of Investigation Derived Wastes 6-11
    6.8.3 Designation of Potentially Hazardous and Nonhazardous Investigation Derived Wastes 6-12
    6.8.4 Investigation Derived Waste Sampling and Analysis 6-12
    6.8.5 Labeling 6-13
    6.8.6 Container Log 6-13
    6.8.7 Container Storage 6-13
    6.8.8 Container Disposition 6-13
    6.8.9 Disposal of Contaminated Materials 6-14

7.0 SAMPLE HANDLING AND ANALYSIS 7-1
  7.1 Sample Preservation and Handling 7-1

TABLE OF CONTENTS
(Continued)

Page

7.2 Chain-of-Custody 7-1
7.3 Field Logbook 7-1

8.0 SITE MANAGEMENT 8-1
8.1 Field Team Responsibilities 8-1
8.2 Reporting Requirements 8-1

9.0 REFERENCES 9-1

LIST OF TABLES

4-1 Summary of Sampling, Analytical, and Data Quality Objectives

LIST OF FIGURES

6-1 Typical Shallow Groundwater Monitoring Well Construction Diagram
6-2 Typical Intermediate Groundwater Monitoring Well Construction Diagram
6-3 Typical Deep Groundwater Monitoring Well Construction Diagram

APPENDICES

A Soil Sample Acquisition
B Justification Criteria for Use of PVC Well Casing and Screen Material
C Groundwater Sample Acquisition
D Decontamination of Sampling and Monitoring Equipment
E Decontamination of Drill Rigs and Monitoring Well Equipment
F On-Site Water Quality Testing
G Water Level, Water-Product Level Measurements and Well Depth Measurements
H Photoionization Detector (PID) HNU Models PI 101 and DL 101
I Sample Preservation and Handling
J Chain-of-Custody
K Field Logbook

ACRONYMS AND ABBREVIATIONS

ASTM	American Society for Testing and Materials
bgs	Below Ground Surface
CLP	Contract Laboratory Program
CTO	Contract Task Order
DEHNR	Department of Environment, Health, and Natural Resources
DO	Dissolved Oxygen
DOT	Department of Transportation
DQO	Data Quality Objective
ECBSOPQAM	Environmental Compliance Branch Standard Operating Procedures and Quality Assurance Manual
EMD	Environmental Management Division
ESD	Environmental Services Division
FID	Flame Ionization Detector
FSAP	Field Sampling and Analysis Plan
ID	Inside Diameter
IDW	Investigation Derived Waste
L/min	Liter per Minute
LANTDIV	Atlantic Division, Naval Facilities Engineering Command
MCB	Marine Corps Base
MS/MSD	Matrix Spike/Matrix Spike Duplicate
NFESC	Naval Facilities Engineering Service Center
NTU	Nephelometric Turbidity Unit
OD	Outside Diameter
OU	Operable Unit
PCB	Polychlorinated Biphynel
PID	Photoionization Detector
POL	Petroleum/Oil/Lubricant
PSI	Pounds per Square Inch
PVC	Polyvinyl Chloride
QA/QC	Quality Assurance/Quality Control
QAPP	Quality Assurance Project Plan
RCRA	Resource Conservation and Recovery Act
SOP	Standard Operating Procedure

ACRONYMS AND ABBREVIATIONS
(Continued)

TAL	Target Analyte List
TCL	Target Compound List
TCLP	Toxicity Characteristic Leaching Procedure
TDS	Total Dissolved Solids
TOC	Total Organic Carbon
TSDF	Treatment, Storage, and Disposal Facility
TSS	Total Suspended Solids
USCS	Unified Soil Classification System
USEPA	United States Environmental Protection Agency
VOC	Volatile Organic Compound
WQP	Water Quality Parameters

1.0 INTRODUCTION

This Field Sampling and Analysis Plan (FSAP) presents the proposed Site Evaluation field activities that are to be conducted at Operable Unit (OU) No. 15 (Site 88) at Marine Corps Base (MCB), Camp Lejeune, North Carolina. The Site Evaluation field activities are being conducted in two phases. Phase I was completed in August 1996 and included the installation of temporary monitoring wells to define the horizontal and vertical extent of contamination. Phase II of the investigation will include the installation soil borings and additional temporary monitoring wells, as well as, permanent shallow, intermediate, and deep monitoring wells. The FSAP is part of the Project Plans, which also contain the Work Plan, and Quality Assurance Project Plan.

The primary purpose of the FSAP is to provide guidance for all project field activities by describing in detail the sampling and data collection methods to be used to implement the various field tasks identified in the Site Evaluation Work Plan for Site 88. This document also helps to ensure that project activities are carried out in accordance with the United States Environmental Protection Agency (USEPA) Region IV and Naval Facilities Engineering Service Center (NFESC) standard operating procedures so that data obtained during the field investigation are of sufficient quantity and quality to evaluate the nature and extent of contamination in various media, estimate human health and environmental risks, and to evaluate potential technologies for remediation of contaminated media.

The draft version of this FSAP, (Baker, 1996) provided the guidance for the project field activities completed during the Phase I Investigation. This final version presents all of the activities planned for the second phase of work. The Phase II field work will begin after the submission of the final Project Plans. The Phase I Report, which summarized the associated field program, was submitted in November 1996. The final FSAP addresses the recommendations of the Phase I Report and modifies the Phase II scope of work, as necessary.

The FSAP is divided into nine sections. Section 1.0 is the introduction. Sections 2.0 and 3.0 contain the site background information and sampling objectives, respectively. These sections are covered in the Work Plans and so they are not repeated in the FSAP. Section 4.0 discusses sample locations and frequency. The section discusses soil and groundwater sampling strategy separately. Section 5.0 provides information on sample designation. Investigative procedures which discusses sample collection, well installation, and investigative derived waste management is contained in Section 6.0. Section 7.0 provides information on sample handling and analysis. Site management activities, including field team responsibilities, and reporting requirements are discussed in Section 8.0 Finally, Section 9.0 provides a list of references used in preparing the document.

2.0 SITE BACKGROUND

A description of the history and setting of MCB, Camp Lejeune and Site 88 is contained in Section 2.0 of the Site Evaluation Work Plan. Therefore, this information is not repeated in the FSAP. Additional material concerning the Site Background is also contained in the Draft Phase I Investigation Report (Baker, 1996).

3.0 SAMPLING OBJECTIVES

The sampling and data quality objectives (DQOs) for field investigations at Site 88 are summarized in Section 3.0 of the Site Evaluation Work Plan.

4.0 SAMPLING LOCATIONS AND FREQUENCY

This section of the FSAP describes the location and frequency of environmental samples to be collected during the sampling program. Support activities, sampling locations, sample matrix, constituents to be analyzed for and Quality Assurance/Quality Control (QA/QC) requirements are discussed within this section. Detailed investigation procedures, sampling handling, and analytical requirements are provided in Sections 6.0 and 7.0, respectively.

The following investigations and support activities will be conducted at Site 88 during the second phase of the field investigation:

- Surveying to identify the locations of all soil borings and monitoring wells installed during the Phase II Investigation. Each of the new locations will be located relative to the existing site map completed during the Phase I Investigation.
- Soil Investigation to identify the amount of contaminated soil beneath Building 25 and the surrounding area.
- Groundwater Investigation to define the vertical and horizontal extent of groundwater contamination at the site.
- Collection of QA/QC samples.
- Investigative derived waste management.

Each activity and investigation is described in the following subsections.

4.1 Soil Investigation

The soil investigation at Site 88 during Phase II will determine the horizontal and vertical extent of volatile organic compound (VOC) contamination in specific areas of the site, including the area near Building 25 and extending to the northwest. Particular emphasis will be placed on the volume of impacted soil, and potential remedial alternatives. The following subsections provide a description of the proposed investigation.

4.1.1 Sampling Locations

During the Phase II field activities soil samples will be collected from each of the 13 monitoring well locations. In addition, 6 individual soil borings are required to accurately identify the extent and volume of soil contamination local to Building 25. The locations of the soil borings and monitoring wells are depicted on Figures 4-1 and 4-2 of the Work Plan. Although soil samples will be collected at each of the boring locations, it is expected that only those borings located local to Building 25 will detect VOC contamination. Two subsurface soil samples will be collected from each of the proposed temporary and permanent soil boring/ monitoring well locations. One of the subsurface soil samples will be collected from just above the water table and the second sample will be collected from within the soil/water interface to obtain information relevant for groundwater modeling. If the depth to groundwater is greater than 10 feet bgs or there is evidence of contamination, one additional subsurface soil sample (for a total of three samples) will be collected from a middle depth.

4.1.2 Analytical Requirements

All subsurface soil samples will be analyzed on-site via mobile laboratory for Target Compound List (TCL) volatiles. Ten percent of all samples analyzed on-site will also be analyzed for TCL VOCs at a fixed base analytical laboratory to confirm the results of the mobile laboratory on a routine, 28-day turnaround time. Samples chosen for fixed based analysis will be selected from areas exhibiting high, medium, and low contaminant concentration levels. In order to evaluate engineering alternatives and assist in the remedial design, 5 of the subsurface soil samples will be analyzed for total organic carbon (TOC), bulk density, permeability, and grain size. The number of samples, analytical methods, data quality objectives, and laboratory turnaround times are presented in Table 4-1.

4.2 Groundwater Investigation

The groundwater investigation will be continued at Site 88 during the Phase II field program. The investigation will delineate the extent of contamination in the surficial aquifer and Castle Hayne aquifer resulting from activities at the site. The following subsections provide a description of the proposed groundwater investigation at Site 88.

4.2.1 Phase I

The Phase I Investigation, completed in August 1996, utilized temporary monitoring wells to confirm the presence of groundwater contamination in the shallow and intermediate zones at Site 88. This investigative effort produced considerable data, however, the horizontal extent of the contaminated plume northwest of the site near Building 43 was not defined. In addition, samples collected from intermediate temporary wells installed to depths of approximately 45 feet bgs detected VOCs at concentrations above the applicable water quality standards. The results of the Phase I Investigation were used to prepare the scope of work for the Phase II Investigation.

4.2.2 Phase II

All monitoring wells installed during the Phase II investigation will utilize a standard truck mounted drill rig for installation as described in Section 6.3. The following subsections describe well construction and provide information on groundwater sample collection and analysis.

4.2.1.1 Well Construction and Locations

The proposed groundwater investigation was based on the results of the Phase I field activities. During the Phase II Investigation, temporary wells will be installed to further define the extent of groundwater contamination in the shallow, intermediate and deep aquifer zones. Seven shallow and 7 intermediate temporary wells will be installed around the perimeter of the estimated contaminant plume. Upon further definition of the contamination, 3 shallow (Type II) monitoring wells (flush-mounted) and 3 intermediate (Type II) monitoring wells will be installed within the surficial aquifer at an estimated depths of 25 and 50 feet bgs, respectively. The proposed locations of the monitoring wells is shown on Figure 4-2 of the workplan.

In addition, 6 shallow (Type II) monitoring wells, 5 intermediate, and 4 deep (Type III) wells will be installed within the contaminant plume and near Building 25. Intermediate depth (Type II) monitoring wells will be installed to determine the extent of vertical contaminant migration and groundwater flow direction to approximately 50 feet bgs. Deep (Type III) monitoring wells will be installed to assess the groundwater conditions at depth. It is estimated that the deep monitoring wells at Site 88 will extend to depths of approximately 100 feet bgs. The specific construction details and depths of the Type III wells will be determined in the field following further characterization of the site specific geology.

Shallow monitoring wells will be constructed of 2-inch PVC pipe, with 15 feet of 0.01-inch slot well screen. Intermediate and deep monitoring wells will be constructed of the same materials, except that 5 feet of well screen will be used instead of 15 feet as in the shallow wells. Section 6.3 presents specific details on procedures for monitoring well installation.

4.2.1.2 Sampling and Analysis

One round of groundwater samples will be collected from the proposed monitoring wells. Samples will be collected using low flow purging and sampling methodology. Section 6.5 presents specific details on procedures for groundwater sampling. Groundwater measurements will be taken to confirm groundwater flow direction.

Each of the groundwater samples collected from the monitoring wells will be analyzed for TCL VOCs (Level IV data quality) on a routine laboratory turnaround time. Five groundwater samples will be analyzed for dissolved oxygen, Total Suspended Solids (TSS)/Total Dissolved Solids (TDS), nitrate, nitrite, iron, sulfate, sulfide, methane, oxidation reduction potential, and chloride. These parameters will be used in the evaluation of remedial alternatives will assist in remedial design. Groundwater field measurements, including pH, conductivity, turbidity, dissolved oxygen (D.O.) and temperature (Level II quality), also will be collected in the field. Groundwater level measurements will be taken to confirm groundwater flow direction. The requested analytical parameters are presented on Table 4-1.

4.3 Surveying

The existing survey at Site 88 includes current site features, such as the nearby fence lines, buildings, access roads, sidewalks, utilities, existing monitoring wells, temporary monitoring wells, and newly installed shallow and intermediate monitoring wells. These features were surveyed during the Phase I Investigation. The site survey will be expanded during the second phase of the investigation to include newly installed temporary and permanent monitoring wells and any relevant features as part of the second phase of the field investigation.

For each newly installed monitoring well, the location and elevation of a reference point on top of the polyvinyl chloride (PVC) riser and the elevation of the ground surface will be surveyed. Survey points will include a latitude coordinate, a longitude coordinate, and an elevation expressed in feet above mean sea level. The vertical accuracy of the survey will be within 0.01 feet and the horizontal accuracy will be within 0.1 feet. All survey points will be correlated to the North Carolina State Plane Coordinate System.

4.4 Quality Assurance/Quality Control Samples

Quality assurance/quality control (QA/QC) requirements for this investigation are presented in the Quality Assurance Project Plan (QAPP). The following QA/QC samples will be collected during field sampling activities:

- Trip Blanks

  Trip blanks are defined as samples which originate from the analyte-free water taken from the laboratory to the sampling site, kept with the investigative samples throughout the sampling event, and returned to the laboratory with the volatile organic analysis (VOA) samples. The blanks will only be analyzed for volatile organics. The purpose of a trip blank is to determine if samples were contaminated during storage and transportation back to the laboratory. One trip blank will accompany each cooler containing samples for VOA.

- Equipment Rinsates (Equipment Blanks)

  Equipment rinsates are defined as samples which are obtained by running organic-free water over/through sample collection equipment after it has been cleaned. Equipment rinsates will be collected daily during each sampling event. One rinsate per media sampled per day will be collected. For example, if groundwater and soil samples were collected on one given day, two rinsates would be collected. Initially, samples from every other day will be analyzed. If analytes pertinent to the project are found in the rinsates, the remaining samples must be analyzed. The results from the rinsates will be used to evaluate the decontamination methods. This comparison is made during data validation and the rinsates are analyzed for the same parameters as the related samples. One equipment rinsate will be collected per media sampled per day of field sampling.

- Field Blanks

  Field blanks consist of the source water used in decontamination. Field blanks will be collected by pouring the water from the container directly into sample bottles. Field blanks should not 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. One field blank will be prepared at the commencement of the project.

- Field Duplicates

  Field duplicates for soil samples are collected, homogenized, and split. All samples except VOAs are homogenized and split. Volatiles are not mixed, but select segments of soil are taken from the length of the core and placed in sampling jars. The duplicates for water samples should be collected simultaneously. The water samples will not be composited. Field duplicates will be collected at a frequency of 10 percent.

- Matrix Spike/Matrix Spike Duplicates

  Matrix Spike/Matrix Spike Duplicate (MS/MSD) samples are collected to evaluate the matrix effect of the sample upon the analytical methodology. A matrix spike and matrix spike duplicate must be performed for each group of samples of a similar matrix. MS/MSD samples will be collected at a frequency of 5 percent.

4.5 Investigation Derived Waste Management

Drill cuttings or excavated soils will be collected and contained in a rolloff box. One rigid storage tank with a capacity of 1,000 gallons will be stationed at the site for containing groundwater development and purge water. A composite soil sample from the rolloff box will be collected and analyzed for full toxicity characteristics leaching procedure (TCLP) (organics and inorganics), RCRA hazardous waste characterization (corrosivity, reactivity, and ignitability), and PCBs. One sample will be collected from the tank and analyzed for full TCL organics, TAL total metals, TSS and TDS. Additional details regarding IDW handling and disposal are provided in Section 6.8.

5.0 SAMPLE DESIGNATION

In order to identify and accurately track the various samples, all samples collected during this investigation, including QA/QC samples, will be designated with a unique number. The number will serve to identify the investigation, the site, the sample media, sampling location, the depth (soil) or round (groundwater) of sample, and QA/QC qualifiers.

The sample designation format is as follows:

Site#-Media/Station# or QA/QC-Depth/Round

An explanation of each of these identifiers is given below.

Site#	This investigation includes Site 88.
Media	SB = Soil Boring (soil sample from a boring) GW = Groundwater
Station#	Each soil test boring or monitoring well will be identified with a unique identification number.
QA/QC	(FB) = Field Blank (D) = Duplicate Sample (following depth/round) (TB) = Trip Blank (ER) = Equipment Rinsate
Depth/Round	Depth indicators will be used for soil samples. The number will reference the depth interval of the sample. For example: 00 = ground surface to 1 foot below ground surface 01 = 1 to 3 feet below ground surface 02 = 3 to 5 feet below ground surface 03 = 5 to 7 feet below ground surface Round indicator will be used for groundwater samples. For example: 01 = initial round of sampling 02 = second round of sampling

Under this sample designation format the sample number 88-GW05IW-01D refers to:

88-GW05IW-01D	Site 88
88-GW05IW-01D	Groundwater sample
88-GW05IW-01D	Monitoring well #5
88-GW05IW-01D	Intermediate monitoring well
88-GW05IW-01D	Round 1
88-GW05IW-01D	Duplicate (QA/QC) sample

Sample Number 88-SB01-05 refers to:

88-SB01-05	Site 88
88-SB01-05	Soil Boring Sample
88-SB01-05	Soil Boring #1
88-SB01-05	Fifth soil sample - 9 to 11 feet bgs

Sample Number 88-TBSB-01 refers to:

88-TBSB-01	Site 88
88-TBSB-01	Trip Blank QA/QC Sample
88-TBSB-01	Soil Boring QA/QC Sample
88-TBSB-01	QA/QC Sample Number

Sample Number 88-ERGW01 refers to:

88-ERGW01	Site 88
88-ERGW01	Equipment rinsate QA/QC Sample
88-ERGW01	Groundwater QA/QC Sample
88-ERGW01	QA/QC Sample Number

This sample designation format will be followed throughout the project. Required deviations to this format in response to field conditions will be documented.

6.0 INVESTIGATIVE PROCEDURES

The investigative procedures to be used for Site 88 will be discussed in the following subsections. These procedures include soil sample collection, monitoring well installation, well development, groundwater sample collection, in-situ slug tests, surveying, water level measurements, decontamination procedures and handling of site investigation derived wastes. Note that all of these procedures will comply with the field methods described in the USEPA, Region IV, Environmental Services Division (ESD), Environmental Compliance Branch Standard Operating Procedures and Quality Assurance Manual (ECBSOPQAM), February 1, 1991. Additional guidance from other sources such as American Society for Testing and Materials (ASTM) may be used, but if the ASTM and ESD methods conflict, the ESD procedure will be used. Additionally, in instances where the ESD has no standard operating procedures (SOP), other guidance sources will be used, such as manufacturer's SOP manuals. Field deviations will be recorded in the field logbook and discussed with the project manager.

6.1 Soil Sample Collection

All soil samples will be collected using split-spoon sampling methods. Soil samples will be collected from borings advanced by a truck mounted rig and during installation of monitoring wells. All boring locations will receive utility clearance from the appropriate on-base personnel. Appendix A contains Baker Environmental, Inc. (Baker's) SOP for soil sample acquisition. The SOP provides the general procedures for sample collection. However, details concerning specific actions at Site 88 are explained in the following paragraphs.

Soil samples from borings, advanced by a drilling rig using hollow-stem augers, will be collected using a split-spoon sampler. A split-spoon sampler is a steel tube, split in half lengthwise, with the halves held together by threaded collars at either end of the tube. This devise can be driven into unconsolidated material using a drive weight connected to the drilling rig. A split-spoon sampler (used for performing Standard Penetration Tests) is 2-inches outer diameter (OD) and 1-3/8-inches ID. This standard spoon is available in two common lengths providing either 20-inch or 26-inch internal longitudinal clearance for obtaining 18-inch or 24-inch long samples, respectively. Split-spoons capable of obtaining 24-inch long samples will be utilized during this investigation.

Split-spoon samples will be collected continuously from the ground surface to the water table in each soil boring at Site 88. Soil samples that will be converted into shallow monitoring wells will be advanced to approximately 25 feet bgs. Soil borings converted into intermediate monitoring wells will be advanced to a depth of approximately 50 feet bgs, while deep monitoring wells extend to an estimated depth of 100 feet bgs. The physical characteristics of the samples will be described by the site geologist. The soil will be classified according to the Unified Soil Classification System (USCS). Soil sample descriptions will be recorded on-site in the field geologist's logbook. Soil descriptions and details of the drilling operations will be recorded on a standard boring log at a later date.

Selected split-spoon soil samples will be submitted to the laboratory for analysis. The samples will be collected continuously in 2-foot increments to the top of the water table. Surface soil samples may not be collected using a split-spoon sampler because a sufficient quantity of sample cannot typically be retained from 0- to 12-inches using this sampling devise. Hence, surface soil samples may be collected using a stainless-steel spoon, hand auger, or by advancing the augers and retaining the soil cuttings. For soil borings only, split-spoon samples will be collected from approximately one foot bgs to the top of the water table; for soil borings advanced for monitoring well installation, split-spoon samples will be collected continuously from one foot bgs to the top of the water table. Below the water table, soil samples will be collected at 5-foot intervals, or at intervals recommended by the on-site geologist.

6.1.1 Split-Spoon Sample Collection Procedures

The following procedure will be used for collecting soil samples in spilt-spoons:

1. Advance the borehole to the desired depth using the applicable drilling techniques. For shallow and intermediate wells, this will involve hollow stem augering. Installation of the deep monitoring wells will employ mud rotary drilling methods. The split-spoon will be lowered into the borehole inside the hollow-stem auger (this will ensure that undisturbed material will be sampled).

2. The subsurface soil samples will be collected by driving the split-spoon with blows from a 140-pound hammer falling 30-inches in accordance with SOP F102 Soil and Rock Sample Acquisition. The sampler will be driven 24-inches. Once at the desired depth, the split-spoon will be pulled from the borehole.

3. Record in the field logbook the number of blows required to effect each six inches of penetration or fraction thereof. The first six inches is considered to be a seating drive. The sum of the number of blows required for the second and third six inches of penetration is termed the penetration resistance, N. If the sampler is drive less than 18-inches, the penetration resistance is the number for the last one foot of penetration. (If less than one foot is penetrated, the logs shall state the number of blows and the fraction of one foot penetrated.) In cases where samples are driven 24-inches, the sum of second and third 6-inch increments will be used to calculate the penetration resistance. (Refusal of the split-spoon will be noted at 50 blows over an interval equal to or less than 6-inches; the interval driven will be noted with the blow count.)

4. Bring the sampler to the surface and remove both ends and one half of the split-spoon such that the soil recovered rests in the remaining half of the barrel. Record the HNu photoionization detector (PID) measurements. The on-site geologist will describe the recovery (length), composition, structure, consistency, color, condition, etc., of the recovered soil. Once the physical description is complete, the soil will be placed into sample jars (see below for procedures concerning submitting soil samples to the laboratory).

5. Split-spoon samplers shall be decontaminated after each use and prior to the initial use at a site according to the procedures outlined in Section 6.6.

6. Repeat this operation until the borehole has been advanced to the selected depth. Split-spoon samples will be collected continuously until groundwater is encountered once groundwater is encountered, samples will be collected at five foot intervals or at intervals recommended by the on-site geologist.

6.1.2 Soil Sample Laboratory Submission Procedures

The following procedure will be used for submitting soil samples to the laboratory:

1. After sample collection, soil for volatile organic analysis will be placed directly into the sample jar. Small aliquots will be collected from discrete locations over the entire length of the sample interval, representative of the soil types

encountered, and placed in the sample jar with minimum disturbance. The VOA sample jar will be filled completely, without headspace, to minimize volatilization. Sample bottles will be labeled prior to sample collection. Soil samples for VOCs should not be mixed.

2. A small, representative portion of sample will be set aside for description purposes. The remaining soil will be removed from the split-spoon sampler. Prior to filling laboratory containers for additional laboratory analysis, the soil sample should be mixed, in a stainless-steel bowl with stainless-steel spoons, as thoroughly as possible to ensure that the sample is as representative as possible of the sample interval.

3. Record all pertinent sampling information such as soil description, sample depth, sample number and location, and the time of sample collection in the field logbook in addition to the above mentioned items. Additionally, the sample bottles will be labeled as outlined in Section 5.0, sample designation.

4. The sample jars will be stored in a cooler with ice until laboratory shipment.

5. The samples will be packed on ice for shipping. Chain-of-Custody Forms and Sample Request Forms will be properly filled out and enclosed or attached (Section 7.0). Custody seals will be attached to the shipping package to ensure security until the samples reach the laboratory.

6. Decontaminate the split-spoon sampler as described in Section 6.6. Replace disposable latex gloves between sample stations to prevent cross-contamination of the samples.

6.2 Temporary Monitoring Well Installation

During this field investigation, temporary shallow and intermediate monitoring wells will be installed. The following items describe the well installation procedures for the temporary monitoring wells.

- Activity personnel will approve all temporary monitoring well locations. These locations shall be free of underground or overhead utility lines.
- A borehole will be advanced by a standard drill rig using hollow stem augers to just below the water table (so that samples can be collected for laboratory analysis).
- Soil samples will be collected continuously during borehole advancement. Samples will be collected according to the procedures outlined in Section 6.1.
- Upon completion of the borehole to the desired depth, the shallow or intermediate monitoring well construction materials will be installed.
- PVC is the material selected for shallow monitoring well construction. It was selected on the basis of its low cost, ease of use, and flexibility. USEPA Region IV requires justification of using polyvinyl chloride (PVC); this justification is included in Appendix B.

- Fifteen feet of 1-inch ID, Schedule 40, #10 slot (0.010 inch) screen with a bottom cap will be installed. The screen will be connected to threaded, flush-joint, PVC riser. The riser will extend 2 to 3 feet above the ground surface. A PVC slip-cap, vented to the atmosphere, will be placed at the top of the riser. The top of the well screen will be placed such that two feet of the screen (as subsurface conditions permit) extends above the water table to allow for seasonal groundwater fluctuations.

6.3 Permanent Monitoring Well Installation

Permanent shallow, intermediate, and deep monitoring wells will be installed during the Phase II field program. The following items list the well installation procedures for these monitoring wells.

6.3.1 Shallow Monitoring Well

Shallow monitoring wells will be installed to monitor the shallow water-bearing zone (water table). It is estimated that these monitoring wells will be installed to approximately 25 feet bgs. The procedure for the installation and construction of shallow monitoring wells is presented below (also see Figure 6-1):

- Activity personnel will approve all shallow monitoring well locations. These locations shall be free of underground or overhead utility lines.

- A borehole will be advanced by a drilling rig using hollow-stem augers to just below the water table (so that samples can be collected for laboratory analysis). Initially, the boreholes will be advanced with 3-1/4-inch ID augers. After the borehole has been advanced to its final depth, the borehole will be over drilled with 6-1/4-inch ID augers (for monitoring well installation only).

- Soil (split-spoon) samples will be collected continuously during borehole advancement. Samples will be collected according to the procedures outlined in Section 6.1.

- Upon completion of the borehole to the desired depth, shallow monitoring well construction materials will be installed (inside the hollow-stem augers).

- PVC is the material selected for shallow monitoring well construction. It was selected on the basis of its low cost, ease of use, and flexibility. USEPA Region IV requires justification of using PVC; this justification is included in Appendix B.

- Fifteen feet of 2-inch ID, Schedule 40, #10 slot (0.010 inch) screen with a bottom cap will be installed. The screen will be connected to threaded, flush-joint, PVC riser. The riser will extend 2 to 3 feet above the ground surface. A PVC slip-cap, vented to the atmosphere, will be placed at the top of the riser. The top of the well screen will be placed such that two feet of the screen (as subsurface conditions permit) extends above the water table to allow for seasonal groundwater fluctuations.

- The annular space around the screen will be backfilled with a well-graded medium to course sand (No. 1 or No. 2 Silica Sand) as the hollow-stem augers are being withdrawn from the borehole. Sand shall be placed from the bottom of the soil boring to approximately two feet above the top of the screened interval. A lesser distance above the top of the screened interval may be packed with sand if the monitoring well is very shallow to allow for placement of sealing material.

- A bentonite seal at least 24-inches thick, unless shallow groundwater conditions are encountered, will be placed above the sand pack. The bentonite shall be allowed to hydrate for at least 8 hours before further completion of the shallow monitoring well.
- The annular space above the bentonite seal will be backfilled with a cement-bentonite grout consisting of either two parts sand per one part of cement and water, or three to four percent bentonite powder (by dry weight) and seven gallons of potable water per 94 pound bag of Portland cement.
- The depth intervals of all backfilled materials shall be measured with a weighted measuring tape to the nearest 0.1 foot and recorded in the field logbook.
- For aboveground completion of shallow monitoring wells, the top of each monitoring well will be protected with the installation of four, 3-inch diameter, 5-foot long steel pipes which will be installed around the outside of the concrete apron. The steel pipes shall be embedded to a minimum depth of 2.5 feet in 3,000 pounds per square inch (psi) concrete. Each pipe shall also be filled with concrete. A concrete pad shall be placed at the same time the pipes are installed. The pad will be a minimum of 4-feet by 4-feet by 6-inches, extending two feet below the ground surface in the annular space and set two inches into the ground elsewhere. If water table conditions prevent having a 24-inch bentonite seal and the concrete pad as specified, the concrete pad depth should be decreased. Two weep holes will be drilled into opposite sides of the protective casing just above the concrete pad. The protective casing and steel pipes will be painted with day-glow yellow paint, or equivalent.
- Most monitoring wells at Site 88 will be completed at the ground surface or "flush-mounted". This is necessary in high-traffic areas such as the conditions at Site 88. The shallow monitoring wells shall be completed at the surface using a "flush" man-hole type cover. If the monitoring well is installed through a paved surface, concrete surface, or high traffic area, the annular space shall be grouted to a depth of at least 2.5-feet and the monitoring well shall be finished with a concrete collar. The concrete shall be crowned to meet the finished grade of the surrounding pavement, as required. If appropriate, the vault around the buried wellhead will have a water drain to the surrounding soil and a watertight cover.
- All monitoring wells will have a locking cap connected to the protective casing. Each monitoring well will be tagged which will contain general monitoring well construction information and marked as "Test Well - Not For Consumptive Use."

Figure 6-1 depicts a typical Type II monitoring well construction diagram.

6.3.2 Intermediate and Deep Monitoring Wells

Procedures for the installation and construction of Type II intermediate monitoring wells and deep Type III wells are presented below:

- Activity personnel will approve all intermediate and deep monitoring well locations. These locations shall be free of underground or overhead utility lines.

- A borehole will be advanced by a drilling rig using hollow-stem augers to just below the water table (so that samples can be collected for laboratory analysis). Initially, the boreholes will be advanced with 3-1/4-inch ID augers.

- Continuous 2-foot split-spoon samples will be collected while the borehole is advanced. Samples will be collected according to the procedures outlined in Section 6.1.

- The borehole will be further advanced until completion using mud rotary drilling. The reason mud rotary drilling will be used is because of the unconsolidated formation and drilling depths anticipated. A tricone drill bit with an OD of 7-7/8-inches will be used to advance the borehole.

- Additional split-spoon samples will be collected at approximately 5 to 10-foot intervals during borehole advancement (mud rotary drilling). If a clay layer is encountered which may serve as a potential confining unit, continuous samples will be collected to determine the thickness of the layer. Samples will be collected according to the procedures outlined in Section 6.1.

- Upon completion of the borehole to the desired depth, intermediate and deep monitoring well construction materials will be installed (inside the hollow-stem augers).

- PVC is the material selected for intermediate and deep monitoring well construction. It was selected on the basis of its low cost, ease of use, and flexibility. USEPA Region IV requires justification of using PVC; this justification is included in Appendix B.

- Five to ten feet of 2-inch ID, Schedule 40, #10 slot (0.010 inch) screen with a bottom cap will be installed. The final determination for the length of the screen will be decided in the field based on the thickness of the upper portion of the Castle Hayne formation. The screen will be connected to threaded, flush-joint, PVC riser. The riser will extend 2 to 3 feet above the ground surface. A PVC slip-cap, vented to the atmosphere, will be placed at the top of the riser.

- The annular space around the screen will be backfilled with a well-graded medium to course sand (No. 1 or No. 2 Silica Sand) as the hollow-stem augers are being withdrawn from the borehole. Sand shall be placed from the bottom of the soil boring to approximately two feet above the top of the screened interval.

- A bentonite seal at least 24-inches thick will be placed above the sand pack. The bentonite shall be allowed to hydrate for at least 8 hours before further completion of the intermediate monitoring well.

- The annular space above the bentonite seal will be backfilled with a cement-bentonite grout consisting of either two parts sand per one part of cement and water, or three to four percent bentonite powder (by dry weight) and seven gallons of potable water per 94 pound bag of Portland cement. The bentonite seal shall be installed using a tremie pipe, if applicable depths are anticipated (i.e., greater than 25 feet).

- The depth intervals of all backfilled materials shall be measured with a weighted measuring tape to the nearest 0.1 foot and recorded in the field logbook.

- For aboveground completion of intermediate monitoring wells, the top of each monitoring well will be protected with the installation of four, 3-inch diameter, 5-foot long steel pipes which will be installed around the outside of the concrete apron. The steel pipes shall be embedded to a minimum depth of 2.5 feet in 3,000 psi concrete. Each pipe shall also be filled with concrete. A concrete pad shall be placed at the same time the pipes are installed. The pad will be a minimum of 4-feet by 4-feet by 6-inches, extending two feet below the ground surface in the annular space and set two inches into the ground elsewhere. If water table conditions prevent having a 24-inch bentonite seal and the concrete pad as specified, the concrete pad depth should be decreased. Two weep holes will be drilled into opposite sides of the protective casing just above the concrete pad. The protective casing and steel pipes will be painted with day-glow yellow paint, or equivalent.

- Most intermediate and deep monitoring wells at Site 88 will be completed at the ground surface or "flush-mounted". This is necessary in high-traffic areas. The monitoring well shall be completed at the surface using a "flush" man-hole type cover. If the monitoring well is installed through a paved surface, concrete surface, or high traffic area, the annular space shall be grouted to a depth of at least 2.5-feet and the monitoring well shall be finished with a concrete collar. The concrete shall be crowned to meet the finished grade of the surrounding pavement, as required. If appropriate, the vault around the buried wellhead will have a water drain to the surrounding soil and a watertight cover.

- All monitoring wells will have a locking cap connected to the protective casing. Each monitoring well will be tagged which will contain general monitoring well construction information and marked as "Test Well - Not For Consumptive Use."

Figure 6-2 depicts a typical Type II intermediate monitoring well construction diagram, while Figure 6-3 illustrates a typical Type III deep monitoring well.

6.4 Well Development

All permanent monitoring wells which are to be sampled will be developed as specified in the ECBSOPQAM. The purpose of monitoring well development is to stabilize and increase the permeability of the filter pack around the well screen, to restore the permeability of the formation which may have been reduced by the drilling operations, and to remove fine-grained materials that may have entered the monitoring well or filter pack during installation. The selection of the monitoring well development method typically is based on drilling methods, monitoring well construction and installation details, and the characteristics of the formation.

Well development shall not be initiated until a minimum of 48 hours has elapsed subsequent to monitoring well completion. This time period will allow the cement grout to set. Shallow monitoring wells typically are developed using bailers or low-yield pumping in combination with surging using a surge block. Intermediate and deep monitoring wells are developed using compressed air (equipped with an air filter) in combination with surging. Selection of a development device will be dependent on conditions encountered during monitoring well installation.

All monitoring wells will be developed until well water runs clear of fine-grained materials. Note that the water in some monitoring wells does not clear with continued development. Typical limits placed on monitoring well development may include any one of the following:

- Clarity of water based on visual determination
- A maximum time period (typically one hour for shallow monitoring wells)
- Stability of pH, specific conductance, and temperature measurements (typically less than 10 percent variation between three successive measurements)
- Clarity based on turbidity measurements (typically less than 50 Nephelometric Turbidity Units [NTU])

A record of the monitoring well development will be completed to document the development process. Section 6.5 provides information on the use of monitoring and data collection equipment for water level measurements, pH, specific conductance, and temperature.

Usually, a minimum of one week should elapse between the end of development and the first sampling event for a monitoring well. This equilibration period allows groundwater unaffected by the installation of the monitoring well to occupy the screened interval vicinity.

6.5 Groundwater Sample Collection

Details concerning groundwater sample acquisition are contained in Appendix C. The SOPs describe items including sample equipment, calculations of well volumes, purging, sampling methods and containers, preservation of samples, volume requirements, and transportation of samples. The SOPs provide the general guidance of the sample collection, however, the following information provides site specific information regarding the collection of groundwater samples at Site 88. The items are based upon standard operating procedures but also address the site specific concerns of conditions at Building 25.

The newly installed monitoring wells at Site 88 will be sampled via low-flow methods. Low-flow is defined as a flow rate similar to the ambient flow rate in the screened formation.

A peristaltic pump will be used to purge the monitoring wells and collect the samples. VOC loss through suction degassing is expected to be insignificant due to the very slow flow rates to be used. Baker personnel report observance of minimal bubbling in the groundwater stream during recent peristaltic pump use. The procedure for collecting groundwater samples is detailed in this section, and has been assembled from ESD guidance and recently published papers and other documents.

Consistent with ECBSOPQAM, a minimum of three well volumes will be purged. The following is the low-flow purge and sampling procedure that will be used at Site 88:

1. The protective casing (for existing monitoring wells) will be unlocked, the well cap will be removed, and escaping gases will measured at the well head using a PID or flame ionization detector (FID). This will determine the need for respiratory protection.
2. The monitoring well will be allowed to equilibrate to atmospheric pressure in the event that a vent hole was not installed in the monitoring well.

3. The static water level will be measured. The total depth of the monitoring well will not be measured, as not to stir up any sediment. The total depth will be obtained from soil boring logs. The water volume in the monitoring well will then be calculated.

4. The sampling device intake (virgin, 1/4-inch ID polypropylene or polyethylene tubing) will be slowly lowered until the bottom end is 2 to 3 feet below the top of water level. Based on historical water levels, this depth will be a point within the screened interval. Next, the water level probe will be placed into the monitoring well just above the water.

5. Purging will then begin. The discharge rate will be measured using a stopwatch and calibrated container. The flow rate will be adjusted to ambient flow conditions (i.e., no drawdown is observed in the monitoring well.) Flow rates of less than 1 liter per minute (L/min) are expected.

6. The Water Quality Parameters (WQPs), including turbidity, pH, and specific conductance will be measured frequently (e.g., every 2 minutes). Temperature and Eh also will be measured.

7. Purging will be complete when a minimum of three well volumes have been removed and three successive WQP readings have stabilized within 10 percent, or there is no further discernable upward or downward trend. It is Baker's experience that at low values, certain WQPs (such as turbidity) may vary by more than 10 percent, but have reached a stable plateau.

8. Upon WQP stabilization, groundwater samples will be collected. VOA samples will be collected first, followed by semivolatiles, pesticides and PCBs, total metals, and TDS/TSS. It is recognized that the contaminants of concern at Site 88 are VOCs; however, it may be necessary to collect groundwater samples for additional laboratory analyses. As these additional parameters are not expected to be present in the groundwater, they have not been included on Table 4-1. Sample bottles will be labeled prior to sample collection and filled in the same order for all monitoring wells.

9. The following information will be recorded in the field logbook:

   - Project location, date, and time
   - Weather
   - Sample location, number, round, and identification number
   - Static water level
   - Calculation of amount of water to be purged
   - Water quality parameters during purging
   - Visual description of water (i.e., clear, cloudy, muddy, etc.)
   - Names of sampling personnel
   - Names of visitors on site
   - Purging and sampling technique, procedure and equipment used
   - Sampling remarks and observations
   - QA/QC samples collected

10. The sample jars will be stored in a cooler with ice until laboratory shipment.

11. The samples will be packed for shipping. Chain-of-Custody Forms and Sample Request Forms will be properly filled out and enclosed of attached (Section 7.0). Custody seals will be attached to the shipping package.

Sample preservation and handling procedures are outlined in Section 7.0. As mentioned above, Appendix C presents the SOP for groundwater sampling. General guidelines outlined in this SOP will be applied to groundwater sampling activities at Site 88.

6.6 Decontamination

Equipment and materials that require decontamination fall into two broad categories:

1. Field measurement, sampling, and monitoring equipment (e.g. water level meters, stainless-steel spoons, etc.)
2. Machinery, equipment, and materials (e.g. drilling rigs, backhoes, drilling equipment, monitoring well materials, etc.)

Appendices D and E detail procedures for decontaminating the two categories of equipment and materials, respectively. Decontamination of sampling and monitoring equipment will follow USEPA Region IV guidelines:

1. Clean with tap water and laboratory detergent using a brush if necessary to remove particulate matter and surface films.
2. Rinse thoroughly with tap water.
3. Rinse thoroughly with deionized water.
4. Rinse twice with pesticide grade isopropanol.
5. Rinse thoroughly with organic-free water and allow to air dry as long as possible.
6. If organic-free water is not available, allow equipment to air dry as long as possible. Do not rinse with deionized or distilled water.
7. Wrap with aluminum foil, if appropriate, to prevent contamination if equipment is going to be stored or transported.

The decontamination of large equipment such as drill rigs will involve steam-cleaning in a designated area. The procedure involves using high pressure steam-cleaner with potable water as the steam source. Once the equipment is steam-cleaned it will be allowed to air dry.

6.7 Monitoring and Data Collection Equipment

Field support activities and investigations will require the use of monitoring and data collection equipment. Turbidity, specific conductance, temperature, pH, and Eh readings will be recorded during groundwater sample collection. Appendix F, On-Site Water Quality Testing, provides specific procedures for collecting conductance, temperature, and pH readings. This SOP does not include the procedure for operation of a turbidity meter. Operation at the turbidity meter will follow the instructions applicable to the specific instrument used in the field.

Additional monitoring well information may be obtained using water level meters, water-product level meters, and well depth meters. The operation and various uses of this data collection equipment is provided in Appendix G.

Health and safety monitoring and environmental media screening will be conducted using a PID. The operation and use of the PID is described in Appendix H.

6.8 Investigation Derived Waste Handling

The following sections discuss the responsibilities, sources, containerization, sampling and analysis, and disposal of Investigation Derived Wastes (IDW). These wastes include soil from borings, groundwater from developing and purging of monitoring wells, decontamination fluids, and personal protection equipment.

6.8.1 Responsibilities

LANTDIV - Atlantic Division, Naval Facilities Engineering Command (LANTDIV) or the facility must ultimately be responsible for the final disposition of site wastes. As such, a LANTDIV or MCB Camp Lejeune representative will sign waste disposal manifests as the generator of the material, in the event off-site disposal is required. However, it may be the responsibility of Baker, depending on the contingency discussions during execution of the investigation, to provide assistance to LANTDIV in arranging for final disposition and preparing manifests.

Baker Project Manager - It is the responsibility of the Baker Project Manager to work with the LANTDIV-Technical Representative in determining the final disposition of site investigation wastes. The Baker Project Manager will relay the results and implications of the chemical analysis of waste or associated material, and advise on the regulatory requirements and prudent measures appropriate to the disposition of the material. The Baker Project Manager also is responsible for ensuring that field personnel involved in site investigation waste handling are familiar with the procedures to be implemented in the field, and that all required field documentation has been completed.

Baker Field Team Leader - The Baker Field Team Leader or Site Manager is responsible for the on site supervision of the waste handling procedures during the site investigations. The Baker Field Team Leader also is responsible for ensuring that all other field personnel are familiar with these procedures.

6.8.2 Sources of Investigation Derived Wastes

Field investigation activities often result in the generation and handling of potentially contaminated materials that must be properly managed to protect the public and the environment, as well as to meet legal requirements. These wastes may be either hazardous or nonhazardous in nature. The nature of the waste (i.e., hazardous or nonhazardous) will determine how the wastes will be handled during the field investigation.

The sources of waste material depend on the site activities planned for the project. The following types of activities or sources, typical of site investigations, may result in the generation of waste material which must be properly handled:

- Subsurface soil sampling and monitoring well construction (soil cuttings)
- Mud rotary drilling (contaminated mud)
- Monitoring well development (development water)

- Groundwater sampling (purge water)
- Heavy equipment decontamination (decontamination fluids)
- Sampling equipment decontamination (decontamination fluids)
- Personal protection equipment (health and safety disposables)

6.8.3 Designation of Potentially Hazardous and Nonhazardous Investigation Derived Wastes

Wastes generated during the field investigation can be categorized as either potentially hazardous or nonhazardous in nature. The designation of such wastes will determine how the wastes are handled. The criteria for determining the nature of the waste and the subsequent handling of the waste is described below for each type of anticipated investigative waste.

6.8.3.1 Soil Cuttings

Soil cuttings will be generated during the augering of soil borings and monitoring well borings. As the borehole is augered, collected soil samples will be monitored with an HNu PID unit for organic vapors and notes made on the physical appearance of the soil. Soil cuttings that do not indicate elevated levels of organics or have visual signs of contamination will be placed on polyethylene sheeting and backfilled into the borehole following completion of the drilling. Cuttings which, by their appearance or organic vapor readings, appear to be contaminated will be containerized in a Department of Transportation (DOT-) approved roll-off box for temporary storage on site, and subsequent treatment and/or disposal.

6.8.3.2 Monitoring Well Development and Purge Water

All development and purge water shall be containerized in one, 1,000 gallon tank. Groundwater development/purge water that exhibits elevated HNu PID readings should be kept separate from water that does not exhibit elevated levels for purposes of subsequent treatment and/or disposal.

6.8.3.3 Decontamination Fluids

Equipment and personal decontamination fluids shall be containerized in DOT-approved 55-gallon drums. The fluids shall be collected from the decontamination/wash pads.

6.8.3.4 Personal Protective Equipment

All personal protective equipment (i.e., tyveks, gloves, and other health and safety disposables) shall be placed in garbage bags and disposed of in trash dump boxes located at the Baker Field Office in Lot 203.

6.8.4 Investigation Derived Waste Sampling and Analysis

A composite sample shall be collected from the box containing soil cuttings for the site. These samples will be analyzed for full Toxicity Characteristic Leaching Procedure (TCLP) (organics and inorganics), TCL PCBs, and Resource Conservation and Recovery Act (RCRA) hazardous waste characterization (corrosivity, reactivity, and ignitability).

For each container of development/purge water, a sample shall be collected for full TCL organic and target analyte list (TAL) total metal analyses. Decontamination fluids collected during the investigation shall be sampled and analyzed for full TCL organics and TAL total metals.

6.8.5 Labeling

If DOT-approved 55-gallon drums are used to containerize soil cuttings, the containers will be numbered and labeled by the field team during the site investigation. Information shall be stenciled in paint on both the container lid and side. Container labels shall include, at a minimum:

- LANTDIV Contract Task Order (CTO) (number)
- Project name
- Drum number
- Soil boring or monitoring well number
- Date
- Source
- Contents

If laboratory analysis reveals that containerized materials are hazardous or contain PCBs above TSCA criteria (i.e., 50 ppm), additional labeling of containers may be required. The Project Manager will assist LANTDIV in additional labeling procedures for wastes exceeding TSCA criteria (i.e., 50 ppm), if necessary, after departure of the field team from the facility. These additional labeling procedures will be based upon the identification of material present; USEPA regulations applicable to labeling hazardous and PCB containing wastes are contained in 40 CFR Parts 261, 262, and 761.

6.8.6 Container Log

A container log shall be maintained in the site logbook. The container log shall contain the same information as the container label plus any additional remarks or information. Such additional information may include the identification number of a representative laboratory sample.

6.8.7 Container Storage

Containers of site investigative wastes shall be stored on site or in a specially designated secure area that is managed by the MCB Camp Lejeune Environmental Management Division (EMD) until disposition is determined. All containers shall be covered with plastic sheeting to provide protection from the weather.

If the laboratory analysis reveals that the containers contain hazardous or PCB wastes, additionally required storage security may be implemented; in the absence of the investigative team, these will be the responsibility of LANTDIV or the facility, as confirmed by the contingency discussions.

Baker will assist LANTDIV in devising the storage requirements, which may include the drums being staged on wooden pallets or other structures to prevent contact with the ground and being staged to provide easy access. Weekly inspections by facility personnel of the temporary storage area also may be required. These inspections may assess the structural integrity of the containers and proper container labeling. Also, precipitation that may accumulate in the storage area may need to be removed. These weekly inspections and whatever precipitation removal is necessary shall be recorded in the site logbook.

6.8.8 Container Disposition

The disposition of the containers of site investigation generated wastes shall be determined by LANTDIV, with the assistance of Baker, as necessary. Container disposition shall be based on quantity of materials, types of materials, and analytical results. If necessary, specific samples of contained materials may be collected to identify further characteristics which may affect disposition. Typically, container disposition will not be addressed until after receipt of applicable analytical results; these results are usually not available until long after completion of the field investigation at the facility.

6.8.9 Disposal of Contaminated Materials

Actual disposal methods for IDW will be determined following receipt of chemical analyses. The usual course will be a contractor specialist retained to conduct the disposal. However, regardless of the mechanism used, all applicable Federal, state, and local regulations shall be observed. USEPA regulations applicable to generating, storing, and transporting PCB or hazardous wastes are contained in 40 CFR Parts 262, 263, and 761.

Another consideration in selecting the method of disposal of contaminated materials is whether the disposal can be incorporated into subsequent site cleanup activities. For example, if construction of a suitable on-site disposal or treatment structure is expected, contaminated materials generated during the site investigation may be stored at the site for treatment/disposal with other site materials. In this case, the initial containment (i.e., drums or other containers) shall be evaluated for use as long-term storage. Also, other site conditions, such as drainage control, security, and soil types must be considered in order to provide proper storage.

At Site 88, any soil determined to be nonhazardous will be placed at Lot 203. Soil determined to be hazardous will be taken to a Treatment Storage and Disposal Facility (TSDF). All water will be taken to the Site 82 treatment plant if determined not to contain petroleum/oil/lubricant (POL) constituents.

7.0 SAMPLE HANDLING AND ANALYSIS

Field activities will be conducted in accordance with the USEPA Region IV ESD's ECBSOPQAM (February 1, 1991). Procedures for sample preservation, labeling, handling, and maintaining a field logbook are detailed in SOPs. Because these procedures are not specific to this project, they are provided as appendices, rather than detailed herein. Major components of sample handling and analysis are discussed in the following subsections.

The number of samples, analytical methods, data quality objectives, and laboratory turnaround times are presented in Table 4-1.

7.1 Sample Preservation and Handling

Sample preservation, sample bottle packing and shipping are important components to maintaining the integrity of the samples. Preservation and handling procedures to be used in this investigation are detailed in Appendix I and Section 6.1 of the Quality Assurance Project Plan (QAPP). The SOP provides information on sample containers, preservation techniques, and sample holding times. In addition, the handling and transportation of the samples are discussed.

7.2 Chain-of-Custody

Chain-of-custody is another important component to maintaining sample integrity. Chain-of-custody procedures to be followed during this investigation are detailed in Appendix J. The chain-of-custody documents sample identification, sample labeling, field custody procedures, transfer of custody and shipment and quality assurance.

Chain-of-custody procedures ensure a documented, traceable link between measurement results and the sample or parameter they represent. These procedures are intended to provide a legally acceptable record of sample collection, identification, preparation, storage, shipping, and analysis.

7.3 Field Logbook

Field logbooks will be used to record sampling activities and information. Entries will include general and specific sampling information so that site activities may be reconstructed. In addition to the logbook, field forms, such as boring and monitoring well development logs, will be completed as support documentation for the logbook. Appendix K describes a general format for the field logbook.

Each field person will have and maintain a logbook. Logbooks will be copied daily and stored at the field trailer as back-up in case the original is lost or destroyed. Additionally, copies of completed logbooks will be filed in the project files.

The logbooks contain detailed information concerning project number, location, name, important phone numbers and addresses, daily entries concerning site activities, equipment used, field measurements, field notes, sketches, photograph logs, and sample information.

8.0 SITE MANAGEMENT

This section outlines the responsibilities and reporting requirements of on-site personnel.

8.1 Field Team Responsibilities

The field investigation portion of this project will consist of one Field Team. All field activities will be coordinated by a Site Manager. The Site Manager will ensure that all field activities are conducted in accordance with the project plans (the Work Plan, this FSAP, the QAPP, and the Health and Safety Plan).

The Field Team will employ one or more drill rigs for soil boring and monitoring well installation during Phase II of the field investigation. The drill rig will be supervised by a Baker geologist. Two sampling technicians will be assigned to the field team for groundwater sampling. One of the sampling technicians will serve as the Site Health and Safety Officer.

8.2 Reporting Requirements

The Site Manager will report a summary of each day's field activities to the Project Manager or his/her designee. This may be done by telephone, telefax or electronic mail. The Site Manager will include, at a minimum, the following in his/her daily report:

- Baker personnel on site
- Other personnel on site
- Major activities of the day
- Subcontractor quantities (e.g., drilling footages)
- Samples collected
- Problems encountered
- Planned activities

The Site Manager will receive direction from the Project Manager regarding changes in scope of the investigation. All changes in scope will be discussed and agreed upon by LANTDIV, Camp Lejeune EMD, USEPA Region IV, and the North Carolina Department of Environment, Health, and Natural Resources (DEHNR).

9.0 REFERENCES

Barcelona, M.J., Wehrmann, H.A., Varljen, M.D. Reproducible Well-Purging Procedures and VOC Stabilization Criteria for Groundwater Sampling. Ground Water Vol. 32, No. 1. January-February, 1994.

Environmental Science and Engineering, Inc. (ESE), 1990. Final Site Summary Report, Marine Corps Base Camp Lejeune, North Carolina. Prepared for Naval Facilities Engineering Command Atlantic Division. ESE Project No. 49-02036. September 1990.

U.S. Environmental Protection Agency (USEPA), 1992. RCRA Groundwater Monitoring: Draft Technical Guidance. Office of Solid Waste. EPA/530/R-93/001. November, 1992.

U.S. Department of the Navy (DON), 1992. Navy/Marine Corps Installation Restoration Manual. February 1992.

U.S. Environmental Protection Agency, 1987. Data Quality Objectives for Remedial Response Activities. OSWER Directive 9355.0-7B. EPA/540/G-87/003. March 1987.

U.S. Environmental Protection Agency (USEPA), Region IV, 1991. Environmental Compliance Branch Standard Operating Procedures and Quality Assurance Manual. February 1991.

U.S. Environmental Protection Agency (USEPA), 1988. Guidance for Conducting Remedial Investigations and Feasibility Studies Under CERCLA. Interim Final. Office of Emergency and Remedial Response, OSWER Directive 9344.3-01. EPA/540/G-89-004.

Puls, R.W. and Paul, C.J. Low-Flow Purging and Sampling of Groundwater Monitoring Wells with Dedicated Systems. Groundwater Monitoring and Remediation. Winter, 1995.

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

TABLES

TABLE 4-1

SUMMARY OF SAMPLING AND ANALYTICAL PROGRAM
OPERABLE UNIT NO. 15 (SITE 88)
SITE EVALUATION PROJECT PLANS - CTO 0356
MARINE CORPS BASE, CAMP LEJEUNE, NORTH CAROLINA

Study Area	Investigation	Baseline Number Of Samples[1]	Analysis	Analytical Method		
Site 88 - Phase II	Soil	13 soil borings/monitoring wells ● 2 soil samples from above the water table ● 1 soil sample if depth to groundwater exceeds 10 ft. bgs 6 soil borings ● 2 soil samples from above the water table ● 1 soil sample if depth to groundwater exceeds 10 ft. bgs 5 soil borings for evaluation of remedial alternatives (3)	TCL VOCs - Mobile Laboratory[2] TCL VOCs - Fixed Base laboratory TOC bulk density permeability grain size	CLP/SOW CLP/SOW EPA 415.1 ASTM D1587-14 ASTM D2434-18 ASTM D 1140	III IV IV IV IV IV	NA Routine Routine Routine Routine Routine
	Groundwater	Temporary monitoring wells ● 7 shallow ● 7 intermediate	TCL VOCs - Mobil laboratory[2] TCL VOCs - Fixed base laboratory	CLP/SOW CLP/SOW	III IV	NA Routine
		Permanent monitoring wells at perimeter of contaminant plume ● 3 shallow (Type II) ● 3 intermediate (Type II) Permanent monitoring wells placed within contaminant plume ● 6 shallow (Type II) ● 5 intermediate (Type III) ● 4 deep (Type III) Permanent monitoring wells for evaluating remedial alternatives ● 5 (Type II or Type III)	TCL VOCs - Mobil Laboratory[2] TCL VOCs - Fixed base laboratory Dissolved oxygen Nitrate Nitrite Iron Sulfate Sulfide Methane Oxygen Reduction Potential pH Temperature Chloride Total Suspended Solids Total Dissolved Solids	CLP/SOW CLP/SOW Dissolved oxygen meter EPA 353.3 EPA 354.1 EPA 7380A EPA 375.4 EPA 376.2 SW 3810 modified A2580B pH meter temperature meter EPA 325.2 EPA 160.2 EPA 160.1	III IV	NA Routine

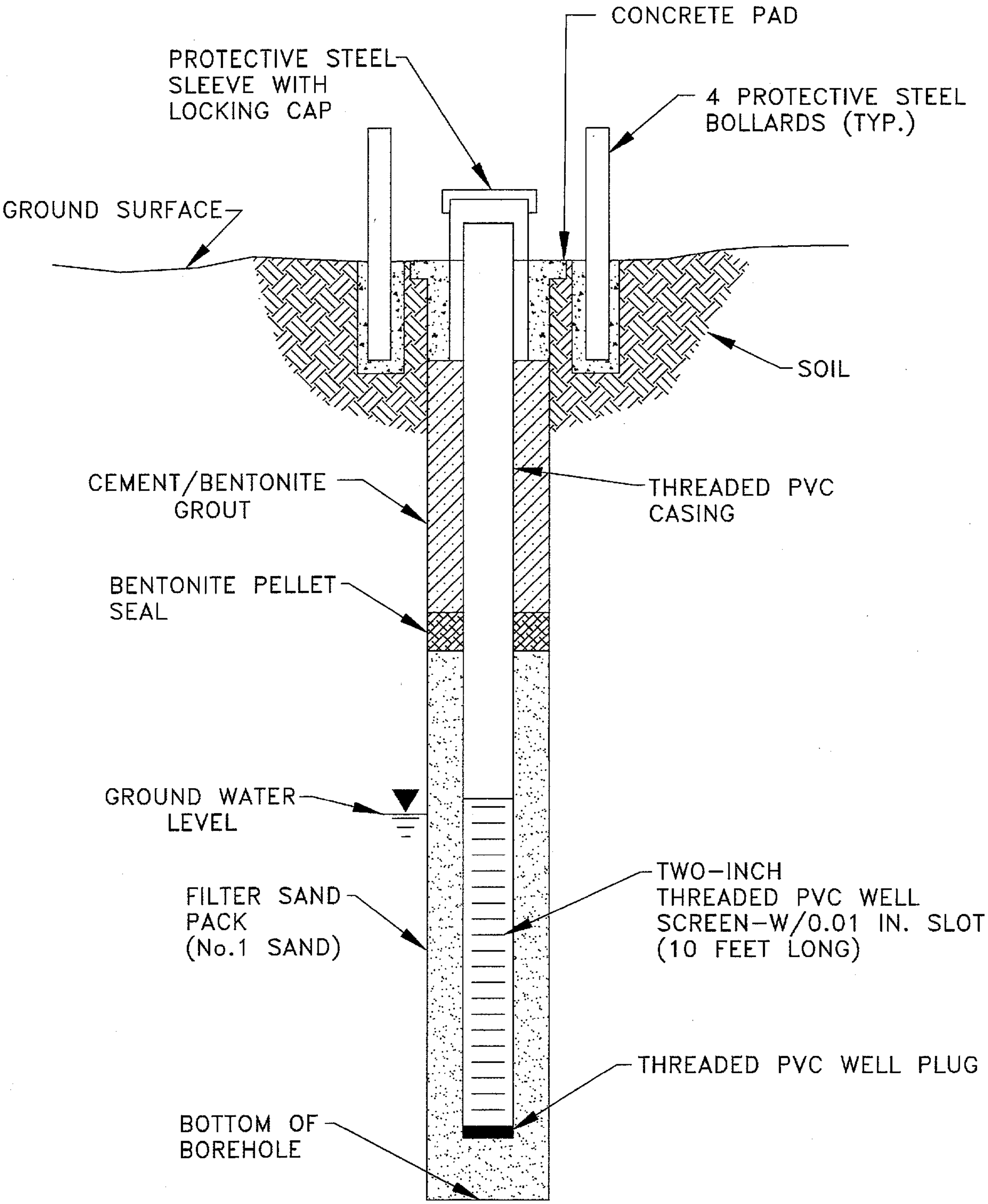
TABLE 4-1 (continued)

SUMMARY OF SAMPLING AND ANALYTICAL OBJECTIVES
OPERABLE UNIT NO. 16 (SITES 89 AND 93)
REMEDIAL INVESTIGATION/FEASIBILITY STUDY PROJECT PLANS - CTO 0344
MARINE CORPS BASE, CAMP LEJEUNE, NORTH CAROLINA

Notes:

(1) Baseline Number of samples does not include QA/QC.
(2) Ten percent of all on-site laboratory samples will be analyzed for TCL VOC at a fixed base analytical laboratory.
(3) Selected samples from areas of the site demonstrating high, medium, and low contaminant concentrations (5 samples total)

FIGURES

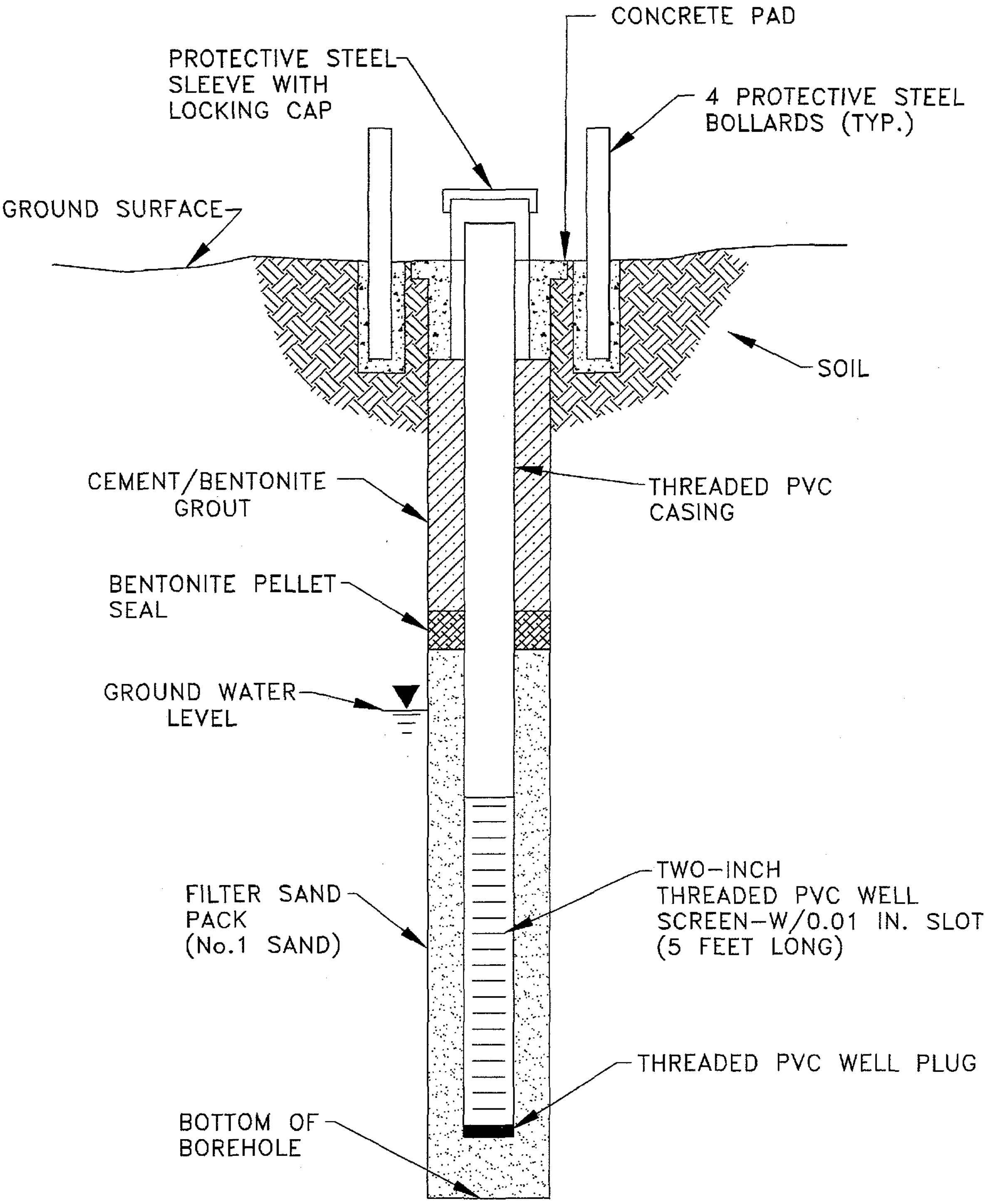


N.T.S.

Baker
Baker Environmental, Inc.

FIGURE 6-1
TYPICAL TYPE II SHALLOW GROUNDWATER
MONITORING WELL CONSTRUCTION DIAGRAM
CTO-0356

MARINE CORPS BASE, CAMP LEJEUNE
NORTH CAROLINA

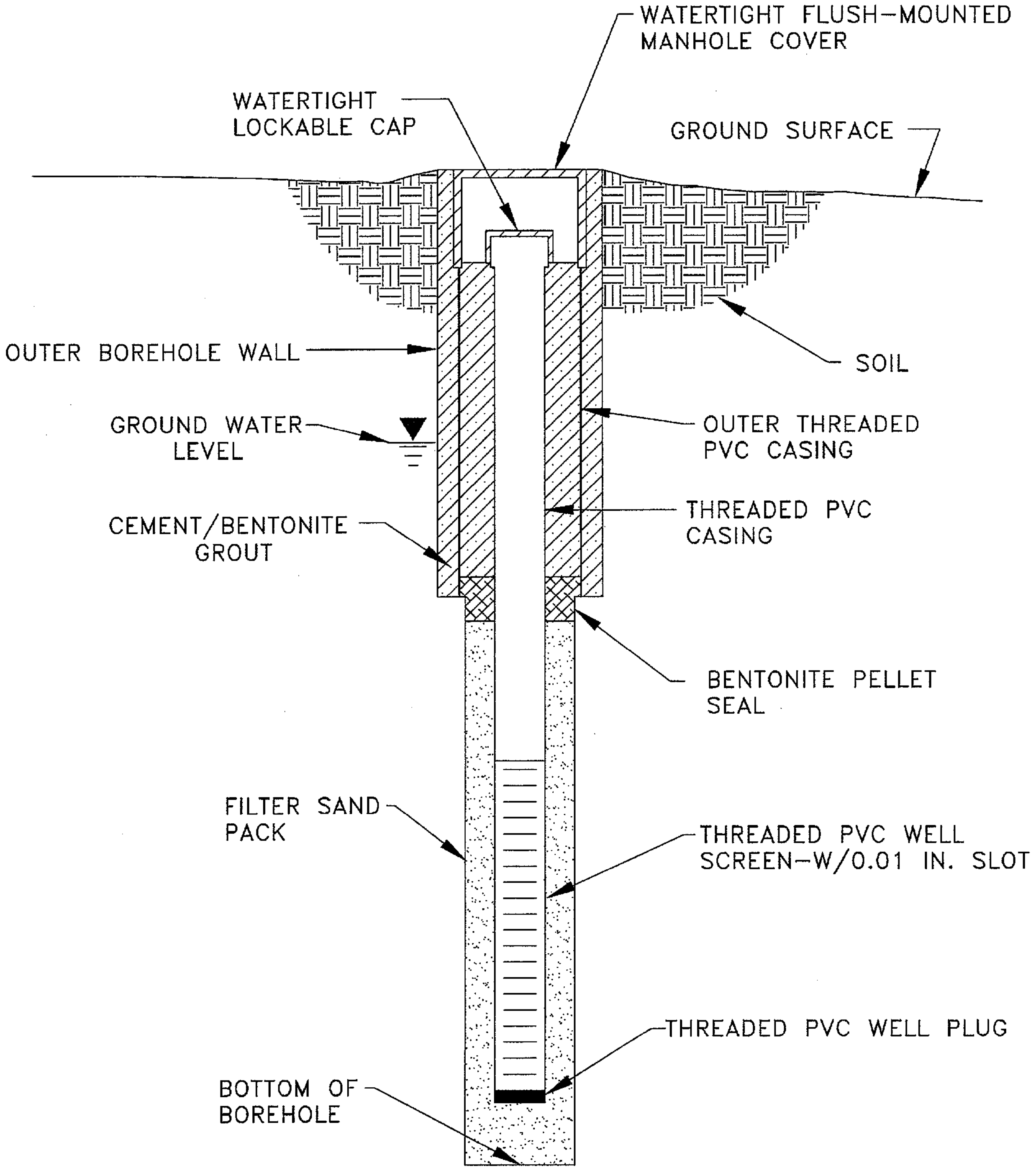


N.T.S.

Baker
Baker Environmental, Inc.

FIGURE 6-2
TYPICAL TYPE II INTERMEDIATE GROUNDWATER MONITORING WELL CONSTRUCTION DIAGRAM
CTO-0356

MARINE CORPS BASE, CAMP LEJEUNE
NORTH CAROLINA



N.T.S.

Baker
Baker Environmental, Inc.

FIGURE 6-3
TYPICAL TYPE III DEEP GROUNDWATER
MONITORING WELL CONSTRUCTION DIAGRAM
CTO-0356

MARINE CORPS BASE, CAMP LEJEUNE
NORTH CAROLINA

APPENDIX A
SOIL SAMPLE ACQUISTITION

SOIL AND ROCK SAMPLE ACQUISITION
TABLE OF CONTENTS

1.0 PURPOSE

2.0 SCOPE

3.0 DEFINITIONS

4.0 RESPONSIBILITIES

5.0 PROCEDURES
- 5.1 Rock Cores
- 5.2 Subsurface Soil Samples
  - 5.2.1 Split-Barrel (Split-Spoon) Samples
  - 5.2.2 Thin-Wall (Shelby Tube) Sampling
  - 5.2.3 Bucket (Hand) Auger Sampling
- 5.3 Surface Soil Samples

6.0 QUALITY ASSURANCE RECORDS

7.0 REFERENCES

SOIL AND ROCK SAMPLE ACQUISITION

1.0 PURPOSE

The purpose of this procedure is to describe the handling of rock cores and subsurface soil samples collected during drilling operations. Surface soil sampling also is described.

2.0 SCOPE

The methods described in this SOP are applicable for the recovery of subsurface soil and rock samples acquired by coring operations or soil sampling techniques such as split-barrel sampling and thin-walled tube sampling. Procedures for the collection of surface soil samples also are discussed. This SOP does not discuss drilling techniques or well installation procedures. ASTM procedures for "Penetration Test and Split-Barrel Sampling of Soils," "Thin-Walled Tube Sampling of Soils," and "Diamond Core Drilling for Site Investigation" have been included as Attachments A through C, respectively.

3.0 DEFINITIONS

Thin-Walled Tube Sampler - A thin-walled metal tube (also called Shelby tube) used to recover relatively undisturbed soil samples. These tubes are available in various sizes, ranging from 2 to 5 inches outer diameter (O.D.) and 18 to 54 inches length. A stationary piston device is included in the sampler to reduce sample disturbance and increase recovery.

Split-Barrel Sampler - A steel tube, split in half lengthwise, with the halves held together by threaded collars at either end of the tube. Also called a split-spoon sampler, this device can be driven into unconsolidated materials using a drive weight mounted on the drilling string. A standard split-spoon sampler (used for performing Standard Penetration Tests) is two inches O.D. and 1-3/8-inches inner diameter (I.D.). This standard spoon is available in two common lengths providing either 20-inch or 26-inch internal longitudinal clearance for obtaining 18-inch or 24-inch long samples, respectively.

Grab Sample - An individual sample collected from a single location at a specific time or period of time generally not exceeding 15 minutes. Grab samples are associated with surface water, groundwater, wastewater, waste, contaminated surfaces, soil, and sediment sampling. Grab samples are typically used to characterize the media at a particular instant in time.

Composite Samples - A sample collected over time that typically consists of a series of discrete samples which are combined or "composited". Two types of composite samples are listed below:

- Areal Composite: A sample collected from individual grab samples collected on an areal or cross-sectional basis. Areal composites shall be made up of equal volumes of grab samples. Each grab sample shall be collected in an identical manner. Examples include sediment composites from quarter-point sampling of streams and soil samples from grid points.

- Vertical Composite: A sample collected from individual grab samples collected from a vertical cross section. Vertical composites shall be made up of equal volumes of grab samples. Each grab sample shall be collected in an identical manner. Examples include vertical profiles of soil/sediment columns, lakes and estuaries.

4.0 RESPONSIBILITIES

Project Manager - The Project Manager is responsible for ensuring that, where applicable, project-specific plans are in accordance with these procedures, or that other approved procedures are developed. Furthermore, the Project Manager is responsible for development of documentation of procedures which deviate from those presented herein.

Field Team Leader - The Field Team Leader is responsible for selecting and detailing the specific sampling techniques and equipment to be used, and documenting these in the Sampling and Analysis Plan. It is the responsibility of the Field Team Leader to ensure that these procedures are implemented in the field and to ensure that personnel performing sampling activities have been briefed and trained to execute these procedures.

Drilling Inspector - It is the responsibility of the drilling inspector to follow these procedures, or to follow documented, project-specific procedures as directed by the Field Team Leader and/or the Project Manager. The Drilling Inspector is responsible for the proper acquisition of rock cores and subsurface soil samples.

Sampling Personnel - It is the responsibility of the field sampling personnel to follow these procedures, or to follow documented, project-specific procedures as directed by the Field Team Leader and/or the Project Manager. The sampling personnel are responsible for the proper acquisition of samples.

5.0 PROCEDURES

Subsurface soil and rock samples are used to characterize the three-dimensional subsurface stratigraphy. This characterization can indicate the potential for migration of contaminants from various sites. In addition, definition of the actual migration of contaminants can be obtained through chemical analysis of subsurface soil samples. Where the remedial activities may include in-situ treatment, or the excavation and removal of the contaminated soil, the depth and areal extent of contamination must be known as accurately as possible.

Surface soil samples serve to characterize the extent of surface contamination at various sites. These samples may be collected during initial site screening to determine gross contamination levels and levels of personal protection required as part of more intensive field sampling activities, to gather more detailed site data during design, or to determine the need for, or success of, cleanup actions.

Site construction activities may require that the engineering and physical properties of soil and rock be determined. Soil types, bearing strength, compressibility, permeability, plasticity, and moisture content are some of the geotechnical characteristics that may be determined by laboratory tests of soil samples. Rock quality, strength, stratigraphy, structure, etc. often are needed to design and construct deep foundations or remedial components.

5.1 Subsurface Soil Samples

This section discusses three methods for collecting subsurface soil samples: (1) split-spoon sampling; (2) shelby tube sampling; and, (3) bucket auger sampling. All three methods yield samples suitable for laboratory analysis. Copies of the ASTM procedures for split-spoon sampling and shelby-tube sampling are provided in Attachments A and B, respectively.

5.1.1 Split-Barrel (Split-Spoon) Sampling

The following procedures are to be used for split-spoon, geotechnical soil sampling:

1. Clean out the borehole to the desired sampling depth using equipment that will ensure that the material to be sampled is not disturbed by the operation.

2. Side-discharge bits are permissible. A bottom-discharge bit should not be used. The process of jetting through the sampler and then sampling when the desired depth is reached shall not be permitted. Where casing is used, it may not be driven below the sampling elevation.

3. The two-inch O.D. split-barrel (not for geotech) sampler should be driven with blows from a 140-pound hammer falling 30 inches in accordance with ASTM D1586-84, Standard Penetration Test.

4. Repeat this operation at intervals not longer than 5 feet in homogeneous strata, or as specified in the Sampling and Analysis Plan.

5. Record on the Field Test Boring Record or field logbook the number of blows required to effect each six inches of penetration or fraction thereof. The first six inches is considered to be a seating drive. The sum of the number of blows required for the second and third six inches of penetration is termed the penetration resistance, N. If the sampler is driven less than 18 inches, the penetration resistance is that for the last one foot of penetration. (If less than one foot is penetrated, the

logs shall state the number of blows and the fraction of one foot penetrated.) In cases where samples are driven 24 inches, the sum of second and third six-inch increments will be used to calculate the penetration resistance. (Refusal of the SPT will be noted as 50 blows over an interval equal to or less than 6 inches; the interval driven will be noted with the blow count.)

6. Bring the sampler to the surface and remove both ends and one half of the split-spoon such that the soil recovered rests in the remaining half of the barrel. Describe carefully the recovery (length), composition, structure, consistency, color, condition, etc. of the recovered soil according to SOP F101; then put into jars without ramming. Jars with samples not taken for chemical analysis should be tightly closed, to prevent evaporation of the soil moisture. Affix labels to the jar and complete Chain-of-Custody and other required sample data forms (see SOP F302). Protect samples against extreme temperature changes and breakage by placing them in appropriate cartons stored in a protected area.

In addition to collecting soils for geotechnical purposes, split-spoon sampling can be employed to obtain samples for environmental analytical analysis. The following procedures are to be used for split-spoon, environmental soil sampling:

1. Follow sample collection procedures 1 through 6 as outlined in Section 5.2.1.

2. After sample collection, remove the soil from the split-spoon sampler. Prior to filling laboratory containers, the soil sample should be mixed thoroughly as possible to ensure that the sample is as representative as possible of the sample interval. Soil samples for volatile organic compounds should <u>not</u> be mixed. Further, sample containers for volatile organic compounds analyses should be filled completely without head space remaining in the container to minimize volatilization.

3. Record all pertinent sampling information such as soil description, sample depth, sample number, sample location, and time of sample collection in the Field Test

Boring Record or field logbook. In addition, label, tag, and number the sample bottle(s).

4. Pack the samples for shipping (see SOP F300). Attach seal to the shipping package. Make sure that Chain-of-Custody Forms and Sample Request Forms are properly filled out and enclosed or attached (see SOP F301).

5. Decontaminate the split-spoon sample as described in SOP F501. Replace disposable latex gloves between sample stations to prevent cross-contaminating samples.

For obtaining composite soil samples (see Definitions), a slightly modified approach is employed. Each individual discrete soil sample from the desired sample interval will be placed into a stainless-steel, decontaminated bowl (or other appropriate container) prior to filling the laboratory sample containers. Special care should be taken to cover the bowl between samples with aluminum foil to minimize volatilization. Immediately after obtaining soils from the desired sampling interval, the sample to be analyzed for Volatile Organic Compounds (VOCs) should be collected. In the event that a composite sample is required, care should be taken to obtain a representative sampling of each sample interval. The remaining soils should be thoroughly mixed. Adequate mixing can be achieved by stirring in a circular fashion and occasionally turning the soils over. Once the remaining soils have been thoroughly combined, samples for analyses other than VOCs should be placed into the appropriate sampling containers.

5.1.2 Thin-Wall (Shelby Tube) Sampling

When it is desired to take undisturbed samples of soil for physical laboratory testing, thin-walled seamless tube samplers (Shelby tubes) will be used. The following method applies:

1. Clean out the hole to the sampling elevation, being careful to minimize the chance for disturbance or contamination of the material to be sampled.

2. The use of bottom discharge bits or jetting through an open-tube sampler to clean out the hole shall not be allowed. Any side discharge bits are permitted.

3. The sampler must be of a stationary piston-type, to limit sample disturbance and aid in retaining the sample. Either the hydraulically operated or control rod activated-type of stationary piston sampler may be used. Prior to inserting the tube sampler in the hole, check to ensure that the sampler head contains a check valve. The check valve is necessary to keep water in the rods from pushing the sample out of the tube sampler during sample withdrawal and to maintain a suction within the tube to help retain the sample.

4. With the sampling tube resting on the bottom of the hole and the water level in the boring at the natural groundwater level or above, push the tube into the soil by a continuous and rapid motion, without impacting or twisting. In no case shall the tube be pushed further than the length provided for the soil sample. Allow a free space in the tube for cuttings and sludge.

5. After pushing the tube, the sample should sit 5 to 15 minutes prior to removal. Immediately before removal, the sample must be sheared by rotating the rods with a pipe wrench a minimum of two revolutions.

6. Upon removal of the sampler tube from the hole, measure the length of sample in the tube and also the length penetrated. Remove disturbed material in the upper end of the tube and measure the length of sample again. After removing at least an inch of soil, from the lower end and after inserting an impervious disk, seal both ends of the tube with at least a 1/2-inch thickness of wax applied in a way that will prevent the wax from entering the sample. Newspaper or other types of filler must be placed in voids at either end of the sampler prior to sealing with wax. Place plastic caps on the ends of the sampler, tape them into place and then dip the ends in wax to seal them.

7. Affix labels to the tubes and record sample number, depth, penetration, and recovery length on the label. Mark the same information and "up" direction on the tube with indelible ink, and indicate the top of the sample. Complete chain-of-custody and other required forms (see SOP F302). Do not allow tubes to freeze, and store the samples vertically (with the same orientation they had in the ground, i.e., top of sample is up) in a cool place out of the sun at all times. Ship samples protected with suitable resilient packing material to reduce shock, vibration, and disturbance.

8. From soil removed from the ends of the tube, make a careful description using the methods presented in SOP F101.

9. When thin-wall tube samplers are used to collect soil for certain chemical analyses, it may be necessary to avoid using wax, newspaper, or other fillers. The SAP for each site should address specific materials allowed dependent on analytes being tested.

Thin-walled undisturbed tube samplers are restricted in their usage by the consistency of the soil to be sampled. Often very loose and/or wet samples cannot be retrieved by the samplers, and soils with a consistency in excess of very stiff cannot be penetrated by the sampler. Devices such as Dension or Pitcher cores can be used in conjunction with the tube samplers to obtain undisturbed samples of stiff soils. Using these devices normally increases sampling costs and, therefore, their use should be weighed against the increased cost and the need for an undisturbed sample. In any case, if a sample cannot be obtained with a tube sampler, an attempt should be made with a split-spoon sampler at the same depth so that at least one sample can be obtained for classification purposes.

5.1.3 Bucket (Hand) Auger Sampling

Hand augering is the most common manual method used to collect subsurface samples. Typically, 4-inch auger buckets with cutting heads are pushed and twisted into the ground and removed as the buckets are filled. The auger holes are advanced one bucket at a time. The practical depth of investigation using a hand auger is related to the material being sampled. In sands, augering is usually easily accomplished, but the depth of investigation is controlled by the depth at which sands begin to cave. At this point, auger holes usually begin to collapse and cannot practically be advanced to lower depths, and further samples, if required, must be collected using some type of pushed or driven device. Hand augering may also become difficult in tight clays or cemented sands. At depths approaching 20 feet, torquing of hand auger extensions becomes so severe that in resistant materials, powered methods must be used if deeper samples are required.

When a vertical sampling interval has been established, one auger bucket is used to advance the auger hole to the first desired sampling depth. If the sample at this location is to be a vertical composite of all intervals, the same bucket may be used to advance the hole, as well collect subsequent samples in the same hole. However, if discrete grab samples are to be collected to characterize each depth, a decontaminated bucket must be placed on the end of the auger extension immediately prior to collecting the next sample. The top several inches of soil should be removed from the bucket to minimize the chances of cross-contamination of the sample from fall-in of material from the upper portions of the hole. The bucket auger should be decontaminated between samples as outlined in SOP F502.

In addition to hand augering, powered augers can be used to advance a boring for subsurface soil collection. However, this type of equipment is technically a sampling aid and not a sampling device, and 20 to 25 feet is the typical lower depth range for this equipment. It is used to advance a hole to the required sample depth, at which point a hand auger is usually used to collect the sample.

5.2 Surface Soil Samples

Surface soils are generally classified as soils between the ground surface and 6 to 12 inches below ground surface. For loosely packed surface soils, stainless steel (organic analyses) or plastic (inorganic analyses) scoops or trowels, can be used to collect representative samples. For densely packed soils or deeper soil samples, a hand or power soil auger may be used.

The following methods are to be used:

1. Use a soil auger for deep samples (greater than 12 inches) or a scoop or trowel for surface samples. Remove debris, rocks, twigs, and vegetation before collecting the sample.

2. Immediately transfer the sample to the appropriate sample container. Attach a label and identification tag. Record all required information in the field logbook and on the sample log sheet, chain-of-custody record, and other required forms.

3. Classify and record a description of the sample, as discussed in SOP F101. Descriptions for surface soil samples should be recorded in the field logbook; descriptions for soil samples collected with power or hand augers shall be recorded on a Field Test Boring Record.

4. Store the sampling utensil in a plastic bag until decontamination or disposal. Use a new or freshly-decontaminated sampling utensil for each sample taken.

5. Pack and ship as described in SOP F304.

6. Mark the location with a numbered stake if possible and locate sample points on a sketch of the site or on a sketch in the field logbook.

7. When a representative composited sample is to be prepared (e.g., samples taken from a gridded area or from several different depths), it is best to composite individual samples in the laboratory where they can be more precisely composited on a weight or volume basis. If this is not possible, the individual samples (all of equal volume, i.e., the sample bottles should be full) should be placed in a stainless steel bucket (or other appropriate container), mixed thoroughly using a decontaminated stainless steel spatula or trowel, and a composite sample collected. In some cases, as delineated in project-specific sampling and analysis plans, laboratory compositing of the samples may be more appropriate than field compositing. Samples to be analyzed for parameters sensitive to volatilization

should be composited and placed into the appropriate sample bottles immediately upon collection.

5.3 Rock Cores

Once rock coring has been completed and the core recovered, the rock core must be carefully removed from the barrel, placed in a core tray (previously labeled "top" and "bottom" to avoid confusion), classified, and measured for percentage of recovery, as well as the rock quality designation (RQD) (see SOP F101). If split-barrels are used, the core may be measured and classified in the split barrel after opening and then transferred to a core box.

Each core shall be described and classified on a Field Test Boring Record using a uniform system as presented in SOP F101. If moisture content will be determined or if it is desirable to prevent drying (e.g., to prevent shrinkage of hydrated formations) or oxidation of the core, the core must be wrapped in plastic sleeves immediately after logging. Each plastic sleeve shall be labeled with indelible ink. The boring number, run number and the footage represented in each sleeve shall be included, as well as the top and bottom of the core run.

After sampling, rock cores must be placed in the sequence of recovery in wooden or plastic core boxes provided by the drilling contractor. Rock cores from different borings shall not be placed in the same core box. The core boxes should be constructed to accommodate 10 to 20 linear feet of core and should be constructed with hinged tops secured with screws, and a latch (usually a hook and eye) to keep the top securely fastened. Wood partitions shall be placed at the end of each core run and between rows. The depth from the surface of the boring to the top and bottom of the drill run and the run number shall be marked on the wooden partitions with indelible ink. The order of placing cores shall be the same in all core boxes. The top of each core obtained should be clearly and permanently marked on each box. The width of each row must be compatible with the core diameter to prevent lateral movement of the core in the box. Similarly, any empty space in a row shall be filled with an appropriate filler material or spacers to prevent longitudinal movement of the core in the box.

The inside and outside of the core-box lid shall be marked by indelible ink to show all pertinent data pertaining to the box's contents. At a minimum, the following information must be included:

- Project name
- Date
- CTO number
- Boring number
- Footage (depths)
- Run number(s)
- Recovery
- Rock Quality Designation (RQD)
- Box number (x of x)

It is also useful to draw a large diagram of the core in the box, on the inside of the box top. This provides more room for elevations, run numbers, recoveries, comments, etc., than could be entered on the upper edges of partitions or spaces in the core box.

For easy retrieval when core boxes are stacked, the sides and ends of the box should also be labeled and include CTO number, boring number, top and bottom depths of core and box number.

Due to the weight of the core, a filled core box should always be handled by two people. Core boxes stored on site should be protected from the weather. The core boxes should be removed from the site in a careful manner as soon as possible. Exposure to extreme heat or cold should be avoided whenever possible. Arrangements should be made to dispose of or return the core samples to the client for completion of the project.

6.0 QUALITY ASSURANCE RECORDS

Where applicable, Field Test Boring Records and Test Boring Records will serve as the quality assurance records for subsurface soil samples, rock cores and near surface soil samples collected with a hand or power auger. Observations shall be recorded in the Field Logbook as described in SOP F303. Chain-of-Custody records shall be completed for samples collected for laboratory analysis as described in SOP F101 and SOP F302.

7.0 REFERENCES

1. American Society for Testing and Materials, 1987. Standard Method for Penetration Test and Split-Barrel Sampling of Soils. ASTM Method D1586-84, Annual Book of Standards, ASTM, Philadelphia, Pennsylvania.

2. American Society for Testing and Materials, 1987. Standard Practice for Thin-Walled Tube Sampling of Soils. Method D1587-83, Annual Book of Standards, ASTM, Philadelphia, Pennsylvania.

3. American Society for Testing and Materials, 1987. Standard Practice for Diamond Core Drilling for Site Investigation. Method D2113-83 (1987), Annual Book of Standards ASTM, Philadelphia, Pennsylvania.

4. U. S. EPA, 1991. Standard Operating Procedures and Quality Assurance Manual. Environmental Compliance Branch, U. S. EPA, Environmental Services Division, Athens, Georgia.

APPENDIX B
JUSTIFICATION CRITERIA FOR USE OF PVC WELL CASING AND SCREEN MATERIAL

The following is USEPA Region IV minimum seven point information requirements to justify the use of PVC as an alternate casing material for groundwater monitoring wells. If requested, justification of the use of PVC should be developed by addressing each of the following items:

1. **The DQOs for the groundwater samples to be collected.**

   Level IV DQOs will be used for analyses of groundwater samples collected during this project. Analytical parameters have been selected to characterize the presence or absence of contamination and to assess any associated risks to human health or the environment.

2. **The anticipated (organic) compounds.**

Well Site 88	Constituent	Maximum Groundwater Concentration (μg/L)
25-TW03	(total) 1,2 dichloroethene	10,000
	Trichloroethylene	2,750
	Bis(2-ethylhexyl)phthalate	0.624
	Napthalene	0.53
25-TW04	Perchloroethylene	29,200

   The concentrations listed above represent maximums at the site.

   There are two primary concerns regarding sample bias associated with use of PVC well casing under these conditions. One is that organic contaminants will leach from the PVC well casing. The other is that organic contaminants that may be present in the groundwater would adsorb onto the PVC. Either of these could result in biased analytical results.

3. **The anticipated residence time of the sample in the well and the aquifer's productivity.**

   It is important to note that all stagnant water from inside the well casing is purged immediately before sample collection. The time required to do this is expected to be much less than that required for groundwater sampling bias phenomena (adsorbing/leaching) to develop.

   Samples collected immediately after purging (i.e., "fresh" from the aquifer).

   Aquifer productivity: Subsurface soil samples are mostly fine sand.

   The wells should recharge (enough to sample) before any sorbing/leaching of organics can occur.

4. **The reasons for not using other casing materials.**

   Costs associated with use of stainless steel and teflon casing materials are prohibitive.

PVC strength will be sufficient for this investigation. Existing groundwater quality data indicate that leaching/sorbing of organic materials from/onto the PVC will not be extensive enough to bias future groundwater analysis. PVC is lighter and more flexible than stainless steel.

5. **Literature on the adsorption characteristics of the compounds and elements of interest.**

   The following was originally presented in National Water Well Association (NWWA, 1989):

   Miller (1982) conducted a study to determine if PVC exhibited any tendency to sorb potential contaminants from solution. Trichloroethene and 1,1,2-trichloroethane did not sorb to PVC. Reynolds and Gillham (1985) found that 1,1,2,2-tetrachloroethane could sorb to PVC. The sorption was slow enough that groundwater sampling bias would not be significant if well development (purging the well of stagnant water) and sampling were to take place in the same day. No data was available for the other organic compounds listed in Item #2.

6. **Whether the wall thickness of the PVC casing would require a larger annular space when compared to other well construction materials.**

   It will not. The 8" diameter borehole will be of sufficient diameter for installation of the 2" PVC casing and screen.

7. **The type of PVC to be used and, if available, the manufacturers specifications, and an assurance that the PVC to be used does not leach, mask, react or otherwise interfere with the contaminants being monitored within the limits of the DQOs.**

   Baker will request the appropriate manufacturers specifications and assurances regarding this requirement. This material will be supplied to Baker by the drilling subcontractor.

References for Appendix B:

National Water Well Association, 1989, Handbook of Suggested Practices for the Design and Installation of Ground-Water Monitoring Wells, Dublin, Ohio, 398 pp.

Miller, G.D., 1982, Uptake of lead, chromium and trace level volatile organics exposed to synthetic well casings. Proceedings of the Second National Symposium on Aquifer Restoration and Ground-Water Monitoring, National Water Well Association, Dublin, Ohio, pp. 236-245.

Reynolds, G.W. and Robert W. Gillham, 1985, Absorption of halogenated organic compounds by polymer materials commonly used in ground-water monitors. Proceedings of the Second Canadian/American Conference on Hydrogeology, National Water Well Association, Dublin, Ohio, pp. 125-132.

APPENDIX C
GROUNDWATER SAMPLE ACQUISITION

GROUNDWATER SAMPLE ACQUISITION
TABLE OF CONTENTS

1.0 PURPOSE

2.0 SCOPE

3.0 DEFINITIONS

4.0 RESPONSIBILITIES

5.0 PROCEDURES
- 5.1 Sampling, Monitoring, and Evaluation Equipment
- 5.2 Calculations of Well Volume
- 5.3 Evacuation of Static Water (Purging)
  - 5.3.1 Evacuation Devices
- 5.4 Sampling
  - 5.4.1 Sampling Methods
  - 5.4.2 Sample Containers
  - 5.4.3 Preservation of Samples and Sample Volume Requirements
  - 5.4.4 Field Filtration
  - 5.4.5 Handling and Transportation Samples
  - 5.4.6 Sample Holding Times

6.0 QUALITY ASSURANCE RECORDS

7.0 REFERENCES

GROUNDWATER SAMPLE ACQUISITION

1.0 PURPOSE

The purpose of this guideline is to provide general reference information on the sampling of groundwater wells. The methods and equipment described are for the collection of water samples from the saturated zone of the subsurface.

2.0 SCOPE

This guideline provides information on proper sampling equipment and techniques for groundwater sampling. Review of the information contained herein will facilitate planning of the field sampling effort by describing standard sampling techniques. The techniques described should be followed whenever applicable, noting that site-specific conditions or project-specific plans may require adjustments in methods.

3.0 DEFINITIONS

None.

4.0 RESPONSIBILITIES

Project Manager - The Project Manager is responsible for ensuring that project-specific plans are in accordance with these procedures, where applicable, or that other, approved procedures are developed. The Project Manager is responsible for development of documentation of procedures which deviate from those presented herein.

Field Team Leader - The Field Team Leader is responsible for selecting and detailing the specific groundwater sampling techniques and equipment to be used, and documenting these in the Sampling and Analysis Plan. It is the responsibility of the Field Team Leader to ensure that these procedures are implemented in the field and that personnel performing sampling activities have been briefed and trained to execute these procedures.

Sampling Personnel - It is the responsibility of the field sampling personnel to follow these procedures, or to follow documented, project-specific procedures as directed by the Field Team Leader and the Project Manager. The sampling personnel are responsible for the proper acquisition of groundwater samples.

5.0 PROCEDURES

To be useful and accurate, a groundwater sample must be representative of the particular zone being sampled. The physical, chemical, and bacteriological integrity of the sample must be maintained from the time of sampling to the time of testing in order to minimize any changes in water quality parameters.

The groundwater sampling program should be developed with reference to ASTM D4448-85A, Standard Guide for Sampling Groundwater Monitoring Wells (Attachment A). This reference is not intended as a monitoring plan or procedure for a specific application, but rather is a review of methods. Specific methods shall be stated in the Sampling and Analysis Plan (SAP).

Methods for withdrawing samples from completed wells include the use of pumps, compressed air, bailers, and various types of samplers. The primary considerations in obtaining a representative sample of the groundwater are to avoid collection of stagnant (standing) water in the well and to avoid physical or chemical alteration of the water due to sampling techniques. In a non-pumping well, there will be little or no vertical mixing of water in the well pipe or casing, and stratification will occur. The well water in the screened section will mix with the groundwater due to normal flow patterns, but the well water above the screened section will remain largely isolated and become stagnant. To safeguard against collecting non-representative stagnant water in a sample, the following approach should be followed during sample withdrawal:

1. All monitoring wells shall be pumped or bailed prior to withdrawing a sample. Evacuation of three to five volumes is recommended for a representative sample.

2. Wells that can be pumped or bailed to dryness with the sampling equipment being used, shall be evacuated and allowed to recover prior to sample withdrawal. If the recovery rate is fairly rapid and time allows, evacuation of at least three well volumes of water is preferred; otherwise, a sample will be taken when enough water is available to fill the sample containers.

Stratification of contaminants may exist in the aquifer formation. This is from concentration gradients due to dispersion and diffusion processes in a homogeneous layer, and from separation of flow streams by physical division (for example, around clay lenses) or by contrasts in permeability (for example, between a layer of silty, fine sand and a layer of medium sand).

Purging rates and volumes for non-production wells during sampling development should be moderate; pumping rates for production wells should be maintained at the rate normal for that well. Excessive pumping can dilute or increase the contaminant concentrations in the recovered sample compared to what is representative of the integrated water column at that point, thus result in the collection of a non-representative sample. Water produced during purging shall be collected, stored or treated and discharged as allowed. Disposition of purge water is usually site-specific and must be addressed in the Sampling and Analysis Plan.

5.1 Sampling, Monitoring, and Evacuation Equipment

Sample containers shall conform with EPA regulations for the appropriate contaminants and to the specific Quality Assurance Project Plan.

The following list is an example of the type of equipment that generally must be on hand when sampling groundwater wells:

1. Sample packaging and shipping equipment: Coolers for sample shipping and cooling, chemical preservatives, and appropriate packing cartons and filler, labels and chain-of-custody documents.

2. Field tools and instrumentation: PID; Thermometer; pH meter; specific conductivity meter; appropriate keys (for locked wells) or bolt-cutter; tape measure; plastic sheeting; water-level indicator; calibrated buckets and, where applicable, flow meter.

3. Pumps

    a. Shallow-well pumps: Centrifugal, Packer Pumps, pitcher, suction, or peristaltic pumps with droplines, air-lift apparatus (compressor and tubing), as applicable.

    b. Deep-well pumps: Submersible pump and electrical power generating unit, bladder pump with compressed air source, or air-lift apparatus, as applicable.

4. Tubing: Sample tubing such as teflon, polyethylene, polypropylene, or PVC. Tubing type shall be selected based on specific site requirements and must be chemically inert to the groundwater being sampled.

5. Other Sampling Equipment: Bailers, Packer Pumps, teflon-coated wire, stainless steel single strand wire, and polypropylene monofilament line (not acceptable in EPA Region I) with tripod-pulley assembly (if necessary). Bailers shall be used to obtain samples for volatile organics from shallow and deep groundwater wells.

6. Pails: Plastic, graduated.

7. Decontamination equipment and materials: discussed in SOP F501 and F502.

Ideally, sample withdrawal equipment should be completely inert, economical, easily cleaned, sterilized, and reusable, able to operate at remote sites in the absence of power sources, and capable of delivering variable rates for well purging and sample collection.

5.2 Calculations of Well Volume for Purging

The volume of the cylinder of water in a well is given by:

Where: V =volume of standing water in well (in cubic feet)

r=well radius (in feet)
h=standing water in well (in feet)

To insure that the proper volume of water has been removed from the well prior to sampling, it is first necessary to determine the volume of standing water in the well pipe or casing. The volume can be easily calculated by the following method. Calculations shall be entered in the field logbook:

1. Obtain all available information on well construction (location, casing, screens, etc.).

2. Determine well or casing diameter (D).

3. Measure and record static water level (DW-depth to water below ground level or top of casing reference point), using one of the methods described in Section 5.1 of SOP F202.

4. Determine the depth of the well (TD) to the nearest 0.01-foot by sounding using a clean, decontaminated weighted tape measure, referenced to the top of PVC casing or ground surface.

5. Calculate number of linear feet of static water (total well depth minus the depth to static water level).

6. Calculate the volume of water in the casing:

$$V_{gal} = V_W \times 7.48 \text{ gallons/ft}^3$$

$$V_{purge} = Vgal\ (\#\ \text{Well Vol})$$

Where:

V_W = Volume of water standing in well in cubic feet (i.e., one well volume)
π = pi, 3.14
r = Well radius in feet
TD = Total depth of well in feet (below ground surface or top of casing)
DW = Depth to water in feet (below ground surface or top of casing)
V_{gal} = Volume of water in well in gallons
V_{purge} = Volume of water to be purged from well in gallons
Well Vol. =Number of well volumes of water to be purged from the well (typically three to five)

7. Determine the minimum number of gallons to be evacuated before sampling. (Note: V_{purge} should be rounded to the next highest whole gallon. For example, 7.2 gallons should be rounded to 8 gallons.)

Table 5-1 lists gallons and cubic feet of water per standing foot of water for a variety of well diameters.

TABLE 5-1
WELL VOLUMES

Diameter of Casing or Hole (in.)	Gallons per Foot of Depth	Cubic Feet per Foot of Depth
1	0.041	0.0055
2	0.163	0.0218
4	0.653	0.0873
6	1.469	0.1963
8	2.611	0.3491
10	4.080	0.5454

5.3 Evacuation of Static Water (Purging)

The amount of purging a well should receive prior to sample collection will depend on the intent of the monitoring program and the hydrogeologic conditions. Programs to determine overall quality of water resources may require long pumping periods to obtain a sample that is representative of a large volume of that aquifer. The pumped volume may be specified prior to sampling so that the sample can be a composite of a known volume of the aquifer.

For defining a contaminant plume, a representative sample of only a small volume of the aquifer is required. These circumstances require that the well be pumped enough to remove the stagnant water but not enough to induce significant groundwater flow from a wide area. Generally, three to five well volumes are considered effective for purging a well.

An alternative method of purging a well, and one accepted in EPA Regions I and IV, is to purge a well continuously (usually using a low volume, low flow pump) while monitoring specific conductance, pH, and water temperature until the values stabilize. The well is considered properly purged when the values have stabilized.

If a well is dewatered before the required volume is purged, the sample should be collected from the well once as a sufficient volume of water has entered the well. In order to avoid stagnation, the well should not be allowed to fully recharge before the sample is collected. The field parameters (pH, conductance, and temperature) should be recorded when the well was dewatered.

The Project Manager shall define the objectives of the groundwater sampling program in the Sampling and Analysis Plan, and provide appropriate criteria and guidance to the sampling personnel on the proper methods and volumes of well purging.

5.3.1 Evacuation Devices

The following discussion is limited to those devices which are commonly used at hazardous waste sites. Note that all of these techniques involve equipment which is portable and readily available.

Bailers - Bailers are the simplest evacuation devices used and have many advantages. They generally consist of a length of pipe with a sealed bottom (bucket-type bailer) or, as is more useful and favored, with a ball check-valve at the bottom. An inert line (e.g., Teflon-coated) is used to lower the bailer and retrieve the sample.

Advantages of bailers include:

- Few limitations on size and materials used for bailers.
- No external power source needed.
- Inexpensive.
- Minimal outgassing of volatile organics while the sample is in the bailer.
- Relatively easy to decontaminate and use.

Limitations on the use of bailers include the following:

- Limited volume of sample.
- Time consuming to remove stagnant water using a bailer.
- Collection and transfer of sample may cause aeration.
- Use of bailers is physically demanding, especially in warm temperatures at protection levels above Level D.
- Unable to collect depth-discrete sample.

Suction Pumps - There are many different types of inexpensive suction pumps including centrifugal, diaphragm, peristaltic, and pitcher pumps. Centrifugal and diaphragm pumps can be used for well evacuation at a fast pumping rate and for sampling at a low pumping rate. The peristaltic pump is a low volume pump (generally not suitable for well purging) that uses rollers to squeeze a flexible tubing, thereby creating suction. This tubing can be dedicated to a well to prevent cross contamination. The pitcher pump is a common farm hand-pump.

These pumps are all portable, inexpensive and readily available. However, because they are based on suction, their use is restricted to areas with water levels within 10 to 25 feet of the ground surface. A significant limitation is that the vacuum created by these pumps will cause significant loss of dissolved gases, including volatile organics. In addition, the complex internal components of these pumps may be difficult to decontaminate.

Gas-Lift Samples - This group of samplers uses gas pressure either in the annulus of the well or in a venturi to force the water up a sampling tube. These pumps are also relatively inexpensive. Gas lift pumps are more suitable for well development than for sampling because the samples may be aerated, leading to pH changes and subsequent trace metal precipitation or loss of volatile organics. An inert gas such as nitrogen is generally used as a gas source.

Submersible Pumps - Submersible pumps take in water and push the sample up a sample tube to the surface. The power sources for these samplers may be compressed air or electricity. The operation principles vary and the displacement of the sample can be by an inflatable bladder, sliding piston, gas bubble, or impeller. Pumps are available for two-inch diameter wells and larger. These pumps can lift water from considerable depths (several hundred feet).

Limitations of this class of pumps include:

- Potentially low delivery rates.
- Many models of these pumps are expensive.
- Compressed gas or electric power is needed.
- Sediment in water may cause clogging of the valves or eroding the impellers with some of these pumps.
- Decontamination of internal components is difficult and time-consuming.

5.4 Sampling

The sampling approach consisting of the following, should be developed as part of the Sampling and Analysis Plan prior to the field work:

1. Background and objectives of sampling.

2. Brief description of area and waste characterization.

3. Identification of sampling locations, with map or sketch, and applicable well construction data (well size, depth, screened interval, reference elevation).

4. Sampling equipment to be used.

5. Intended number, sequence volumes, and types of samples. If the relative degrees of contamination between wells is unknown or insignificant, a sampling sequence which facilitates sampling logistics may be followed. Where some wells are known or strongly suspected of being highly contaminated, these should be sampled last to reduce the risk of cross-contamination between wells as a result of the sampling procedures.

6. Sample preservation requirements.

7. Schedule.

8. List of team members.

9. Other information, such as the necessity for a warrant or permission of entry, requirement for split samples, access problems, location of keys, etc.

5.4.1 Sampling Methods

The collection of a groundwater sample includes the following steps:

1. First open the well cap and use volatile organic detection equipment (HNu or OVA) on the escaping gases at the well head to determine the need for respiratory protection. This task is usually performed by the Field Team Leader, Health and Safety Officer, or other designee.

2. When proper respiratory protection has been donned, measure the total depth and water level (with decontaminated equipment) and record these data in the field logbook. Calculate the fluid volume in the well according to Section 5.2 of this SOP.

3. Lower purging equipment or intake into the well to a distance just below the water level and begin water removal. Collect the purged water and dispose of it in an acceptable manner (e.g., DOT-approved 55-gallon drum).

4. Measure the rate of discharge frequently. A bucket and stopwatch are most commonly used; other techniques include using pipe trajectory methods, weir boxes or flow meters. Record the method of discharge measurement.

5. Observe peristaltic pump intake for degassing "bubbles" and all pump discharge lines. If bubbles are abundant and the intake is fully submerged, this pump is not suitable for collecting samples for volatile organics. The preferred method for collecting volatile organic samples and the accepted method by EPA Regions I through IV is with a bailer.

6. Purge a minimum of three to five well volumes before sampling. In low permeability strata (i.e., if the well is pumped to dryness), one volume will suffice. Allow the well to recharge as necessary, but preferably to 70 percent of the static water level, and then sample.

7. Record measurements of specific conductance, temperature, and pH during purging to ensure that the groundwater level has stabilized. Generally, these measurements are made after the removal of three, four, and five well volumes.

8. If sampling using a pump, lower the pump intake to midscreen or the middle of the open section in uncased wells and collect the sample. If sampling with a bailer, lower the bailer to the sampling level before filling (this requires use of other than a "bucket-type" bailer). Purged water should be collected in a designated container and disposed of in an acceptable manner.

9. (For pump and packer assembly only). Lower assembly into well so that packer is positioned just above the screen or open section and inflate. Purge a volume equal to at least twice the screened interval or unscreened open section volume below the packer before sampling. Packers should always be tested in a casing section above ground to determine proper inflation pressures for good sealing.

10. In the event that groundwater recovery time is very slow (e.g., 24 hours), sample collection can be delayed until the following day. However, it is preferred that such a well be bailed early in the morning so that sufficient volume of water may be standing in the well by the day's end to permit sample collection. If the well is incapable of producing a sufficient volume of sample at any time, take the largest quantity available and record in the logbook.

11. Add preservative if required (see SOP F301). Label, tag, and number the sample bottle(s).

12. Volatile organics septum vials (40 ml) should be completely filled to prevent volatilization and extreme caution should be exercised when filling a vial to avoid turbulence which could also produce volatilization. The sample should be carefully poured down the side of the vial to minimize turbulence. As a rule, it is best to gently pour the last few drops into the vial so that surface tension holds the water in a "convex meniscus." The cap is then applied and some overflow is lost, but air space in the bottle is eliminated. After capping, turn the bottle over and tap it to check for bubbles; if any are present, repeat the procedure. If the second attempt still produces air bubbles, note on Chain-of-Custody form and in field notebook and submit sample to the laboratory.

    Fill the remaining sample containers in order of decreasing volatilability (semi-volatiles next, then pesticides, PCBs, inorganics, etc.).

13. Replace the well cap. Make sure the well is readily identifiable as the source of the samples.

14. Pack the samples for shipping (see SOP F301). Attach custody seals to the shipping container. Make sure that Chain-of-Custody forms and Sample Analysis Request forms are properly filled out and enclosed or attached (see SOP F302).

15. Decontaminate all equipment.

5.4.2 Sample Containers

For most samples and analytical parameters, either glass or plastic containers are satisfactory. SOP F301 describes the required sampling containers for various analytes at various concentrations. Container requirements shall follow those given in NEESA 20.2 047B.

5.4.3 Preservation of Samples and Sample Volume Requirements

Sample preservation techniques and volume requirements depend on the type and concentration of the contaminant and on the type of analysis to be performed. SOP F301 describes the sample preservation and volume requirements for most of the chemicals that will be encountered during hazardous waste site investigations. Sample volume and preservation requirements shall follow those given in NEESA 20.2-047B.

5.4.4 Field Filtration

In general, preparation and preservation of water samples for dissolved inorganics involve some form of filtration. All filtration must occur in the field immediately upon collection. The recommended method is through the use of a disposable in-line filtration module (0.45 micron filter) utilizing the pressure provided by the upstream pumping device for its operation.

In Region I, all inorganics are to be collected and preserved in the filtered form, including metals. In Region II, metals samples are to be analyzed as "total metals" and preserved unfiltered. In Regions III and IV, samples collected for metals analysis are also to be unfiltered. However, if metals analysis of groundwater is required, then both an unfiltered and filtered sample are to be collected, regardless of regulatory requirements. Filtration and preservation are to occur immediately in the field with the sample aliquot passing through a 0.45 micron filter. Samples for organic analyses shall never be filtered. Filters must be prerinsed with organic-free, deionized water.

5.4.5 Handling and Transporting Samples

After collection, samples should be handled as little as possible. It is preferable to use self-contained "chemical" ice (e.g., "blue ice") to reduce the risk of contamination. If water ice is used, it should be double-bagged and steps taken to ensure that the melted ice does not cause sample containers to be submerged, and thus possibly become cross-contaminated. All sample containers should be enclosed in plastic bags or cans to prevent cross-contamination. Samples should be secured in the ice chest to prevent movement of sample containers and possible breakage. Sample packing and transportation requirements are described in SOP F301.

5.4.6 Sample Holding Times

Holding times (i.e., allowed time between sample collection and analysis) for routine samples are given in NEESA 20.2-047B.

6.0 QUALITY ASSURANCE RECORDS

Quality assurance records will be maintained for each sample that is collected. The following information will be recorded in the Field Logbook:

- Sample identification (site name, location, project no.; sample name/number and location; sample type and matrix; time and date; sampler's identity).
- Sample source and source description.
- Field observations and measurements (appearance; volatile screening; field chemistry; sampling method; volume of water purged prior to sampling; number of well volumes purged).
- Sample disposition (preservatives added; lab sent to; date and time).
- Additional remarks, as appropriate.

Proper chain-of-custody procedures play a crucial role in data gathering. SOP F302 describes the requirements for correctly completing a chain-of-custody form. Chain-of-custody forms (and sample analysis request forms) are considered quality assurance records.

7.0 REFERENCES

American Society of Testing and Materials. 1987. Standard Guide for Sampling Groundwater Monitoring Wells. Method D4448-85A, Annual Book of Standards, ASTM, Philadelphia, Pennsylvania.

U. S. EPA, 1991. Standard Operating Procedures and Quality Assurance Manual. Environmental Compliance Branch, U. S. EPA, Environmental Services Division, Athens, Georgia.

APPENDIX D
DECONTAMINATION OF SAMPLING AND MONITORING EQUIPMENT

DECONTAMINATION OF SAMPLING AND MONITORING EQUIPMENT

TABLE OF CONTENTS

1.0 PURPOSE

2.0 SCOPE

3.0 DEFINITIONS

4.0 RESPONSIBILITIES

5.0 PROCEDURES
- 5.1 Sampling Equipment Decontamination Procedures
- 5.2 Field Analytical Equipment Decontamination

6.0 QUALITY ASSURANCE RECORDS

7.0 REFERENCES

DECONTAMINATION OF SAMPLING AND MONITORING EQUIPMENT

1.0 PURPOSE

The purpose of this SOP is to provide a general methodology and protocol, and to reference information for the proper decontamination of field chemical sampling and analytical equipment.

2.0 SCOPE

This procedure applies to all field sampling equipment including, but not limited to, split-barrel soil samplers (split-spoons), bailers, beakers, trowels, filtering apparatus, and pumps. This procedure should be consulted when decontamination procedures are being developed as part of project-specific plans. Additionally, current USEPA regional procedures and decontamination guidance as well as state guidance should be reviewed.

3.0 DEFINITIONS

Decontamination - Decontamination is the process of removing or neutralizing contaminants which may have accumulated on field equipment. This process ensures protection of personnel from penetrating substances, reduces or eliminates transfer of contaminants to clean areas, prevents mixing of incompatible substances, and minimizes the likelihood of sample cross-contamination.

4.0 RESPONSIBILITIES

Project Manager - It is the responsibility of the Project Manager to ensure that project-specific plans are in accordance with these procedures. Documentation should be developed for areas where project plans deviate from these procedures.

Field Team Leader - It is the responsibility of the Field Team Leader to ensure that these procedures are implemented in the field. The Field Team Leader is responsible for ensuring field personnel performing decontamination activities have been briefed and trained to execute these procedures.

Sampling Personnel - It is the responsibility of field sampling personnel to follow these procedures, or to follow documented, project-specific procedures as directed by the Field Team Leader.

5.0 PROCEDURES

In order to ensure that chemical analysis results reflect actual concentrations present at sampling locations, sampling equipment must be properly decontaminated prior to the field effort, during the sampling program (i.e., between sampling locations) and at the conclusion of the sampling program. This will minimize the potential for cross-contamination between sampling locations and the transfer of contamination off site.

Preferably, sampling equipment should be dedicated to a given sampling location. If this is not possible, equipment must be decontaminated between sampling locations. Sampling personnel also must use disposable gloves and change them between sampling locations.

5.1 Sampling Equipment Decontamination Procedures

Soil and sediment sampling equipment including, but not limited to trowels, beakers, dredges, etc., shall be decontaminated using the following USEPA Region procedures.

The following sections summarize decontamination procedures for USEPA Regions I through IV for overall comparison. Each region should be contacted prior to initiation of sampling activities to assure that the most recent, accepted decontamination procedures are used.

USEPA Region I

Prior to use, all sampling equipment should be carefully cleaned using the following procedure:

1. A dilute hydrochloric acid rinse
2. Deionized water rinse
3. Methanol or acetone rinse; and,
4. Distilled, organic-free water rinse.

For badly contaminated equipment, a hot water detergent wash may be needed prior to the rinse procedure. Additionally, a hexane rinse also may be needed, prior to the final distilled water rinse, when sampling for low-level organic pollutants.

USEPA Region II

Prior to use, all sampling equipment will be decontaminated using the following procedure:

1. Low-phosphate detergent wash (i.e., Alconox or Liquinox)
2. Tap water rinse
3. 10 percent nitric acid solution rinse
4. Tap water rinse
5. Methanol followed by a hexane or an acetone rinse
6. Analyte-free deionized water rinse
7. Air dry
8. Wrap in aluminum foil, shiny side out, for storage or transport

If the samples will not be analyzed for metals, then steps 3 and 4 may be omitted; if samples will not be analyzed for organics, then step 5 may be omitted. All solvents must be pesticide-grade.

USEPA Region III

Prior to use, all sampling equipment will be decontaminated using the following procedure:

1. Potable water rinse
2. Alconox or Liquinox detergent wash
3. Scrubbing, as necessary
4. Potable water rinse
5. 10 percent nitric acid rinse
6. Distilled-deionized water rinse
7. Methanol or hexane rinse
8. Distilled-deionized water rinse
9. Air dry

USEPA Region IV

Prior to use, all sampling equipment will be decontaminated using the following procedures:

1. Clean with tap water and laboratory detergent using a brush if necessary to remove particulate matter and surface films.
2. Rinse thoroughly with tap water.
3. Rinse thoroughly with deionized water.
4. Rinse twice with pesticide grade isopropanol.
5. Rinse thoroughly with organic-free water and allow to air dry as long as possible.
6. If organic-free water is not available, allow equipment to air dry as long as possible. Do not rinse with deionized or distilled water.
7. Wrap with aluminum foil, if appropriate, to prevent contamination if equipment is going to be stored or transported.

* Portable power augers (such as the Little Beaver®) or large soil boring/drill rigs should be cleaned before boring or drilling operations.

5.2 Field Analytical Equipment Decontamination

Field analytical equipment which may come in direct contact with the sample or sample media, including, but not limited to water level meters, water/product level meters, pH or specific ion probes, specific conductivity probes, thermometers, and/or borehole geophysical probes must be decontaminated before and after use, according to the procedures outlined in Section 5.1, unless manufacturers instructions indicate otherwise. Probes that contact water samples not used for laboratory analyses may be rinsed with distilled water. Probes which make no direct contact (e.g. HNu or OVA probes) will be wiped clean with clean paper towels or an alcohol-saturated cloth.

6.0 QUALITY ASSURANCE RECORDS

Decontamination procedures are monitored through the collection of equipment rinsate samples and field blanks. Collection of these samples shall be specified in the project-specific Sampling and Analysis and Quality Assurance Plans following the requirements of NEESA 20.2-047B. Documentation recorded in the field logbook also shall serve as a quality assurance record.

7.0 REFERENCES

NEESA 20.2-047B. Sampling and Chemical Analysis Quality Assurance Requirements for the Navy Installation Restoration Program. Naval Energy and Environmental Support Activity. Port Hueneme, CA. June 1988.

U. S. EPA Office of Waste Program Enforcement. RCRA Ground Water Monitoring Technical Enforcement Guidance Document (TEGD). OSWER Directive 9950.1. 1986.

U. S. EPA. Standard Operating Procedures and Quality Assurance Manual. Environmental Compliance Branch, U. S. EPA Environmental Services Division, Athens, Georgia. 1991.

Micham, J. T., R. Bellandi, E. C. Tifft, Jr. "Equipment Decontamination Procedures for Ground Water and Vadose Zone Monitoring Programs: Status and Prospects." in Ground Water Monitoring Review. Spring 1989.

APPENDIX E
DECONTAMINATION OF DRILL RIGS AND MONITORING WELL MATERIALS

DECONTAMINATION OF DRILLING RIGS AND MONITORING WELL MATERIALS

TABLE OF CONTENTS

1.0 PURPOSE

2.0 SCOPE

3.0 DEFINITIONS

4.0 RESPONSIBILITIES

5.0 PROCEDURES
- 5.1 Equipment
- 5.2 Decontamination Procedures

6.0 QUALITY ASSURANCE RECORDS

7.0 REFERENCES

DECONTAMINATION OF DRILLING RIGS AND MONITORING WELL MATERIALS

1.0 PURPOSE

The purpose of this SOP is to provide a general reference regarding the proper decontamination of drilling rigs and monitoring well materials used in the performance of field investigations.

2.0 SCOPE

This procedure addresses drilling equipment, test pit equipment (i.e. backhoe) and monitoring well material decontamination and should be consulted during the preparation of project-specific plans. This procedure does not pertain to personnel decontamination, or to chemical sampling or field analytical equipment decontamination.

3.0 DEFINITIONS

Decontamination - Decontamination is the process of removing or neutralizing contaminants which may have accumulated on field equipment. This process ensures protection of personnel from penetrating substances, reduces or eliminates transfer of contaminants to clean areas, prevents mixing of incompatible substances, and minimizes the likelihood of sample cross-contamination.

4.0 RESPONSIBILITIES

Project Manager - It is the responsibility of the Project Manager to ensure that project-specific plans are in accordance with these procedures. Documentation should be developed for areas where project plans deviate from these procedures.

Field Team Leader - It is the responsibility of the Field Team Leader to ensure that these procedures are implemented in the field. The Field Team Leader is responsible for ensuring the field personnel overseeing decontamination activities, and personnel conducting the activities have been briefed and trained to execute these procedures.

Drilling Inspector (Site Geologist, Rig Geologist etc.) - It is the responsibility of the drilling inspector to ensure that the drilling subcontractor follows these, or other project-specific procedures as directed by the Field Team Leader.

5.0 PROCEDURE

The various drilling equipment and materials involved with test boring, test pit excavation, subsurface soil sampling, and monitoring well construction must be properly decontaminated to ensure that chemical analysis results reflect actual concentrations present at sampling locations. These procedures will minimize the potential for cross contamination between sampling locations and the transfer of contamination off site.

5.1 Equipment

All drilling equipment involved in field sampling activities shall be decontaminated prior to drilling, excavation, or sampling activities. Such equipment includes drilling rigs, backhoes, augers, downhole tools, well casings, and screens. Split-spoon soil samplers and other similar soil sampling devices shall be decontaminated according to the procedures given in SOP F502.

5.2 Decontamination Procedures

Prior to drilling, or leaving the site, large equipment not directly utilized for sampling will be decontaminated by steam-cleaning in a designated area. The decontamination procedure consists of steam-cleaning the equipment, using potable water as the steam source, to remove visible signs of soils or wastes, and allowing the equipment to air dry. If necessary, the equipment may be cleaned with a scrub brush and alconox/liquinox-water solution prior to steam cleaning to remove visible signs of contamination.

The steam cleaning area will be designed to contain decontamination wastes and waste waters, and can be a lined, excavated pit or a bermed concrete or asphalt pad. For the latter, a floor-drain must be provided which is connected to a holding tank. A shallow, above-surface tank may be used or a pumping system with discharge to a waste tank may be installed.

At certain sites, due to the type of contaminants or proximity to residences, concerns may exist about air emissions from steam cleaning operations. These concerns can be alleviated by utilizing one or more of the following practices:

- Locate the steam cleaning area on site to minimize potential impacts.
- Enclose steam cleaning operations. For example, augers and drilling rods can be steam cleaned in drums. Tarpaulins also can be placed around the steam cleaning area to control emissions.

For a given project, the location of the steam cleaning area will be identified in the Sampling and Analysis Plan.

Decontamination wastes will be collected and contained unless otherwise directed by LANTDIV. The eventual disposition of these wastes will be determined on a project-specific basis, but may include on-site treatment and/or transport off site to an approved treatment/disposal facility.

6.0 QUALITY ASSURANCE RECORDS

Rinsate samples may be collected from steam-cleaned equipment as quality assurance records. The frequency of rinsate samples from either drilling tools or well casings/screens shall be specified in the Sampling and Analysis and Quality Assurance Project Plans for a given project, as appropriate.

Documentation in the field logbook also shall serve as a quality assurance record of decontamination activities.

7.0 REFERENCES

None.

APPENDIX F
ON-SITE WATER QUALITY TESTING

ON-SITE WATER QUALITY TESTING
TABLE OF CONTENTS

1.0 PURPOSE

2.0 SCOPE

3.0 DEFINITIONS

4.0 RESPONSIBILITIES

5.0 PROCEDURES
- 5.1 Measurement of pH
- 5.2 Measurement of Specific Conductance/Salinity
- 5.3 Measurement of Temperature
- 5.4 Measurement of Dissolved Oxygen Concentration
- 5.5 Turbidity (Secchi Disc)

6.0 QUALITY ASSURANCE RECORDS

7.0 REFERENCES

ON-SITE WATER QUALITY TESTING (FIELD PARAMETERS)

1.0 PURPOSE

This SOP describes the procedures and equipment required to measure the following parameters of an aqueous sample in the field:

- pH
- Specific Conductance (Sc)/Salinity
- Temperature (T)
- Dissolved Oxygen Concentration (DO)
- Turbidity (Secchi Disc)

The first three are the usual field parameters; dissolved oxygen may be used in particular applications according to project requirements.

2.0 SCOPE

These procedures are applicable for use in an on-site water quality monitoring program to be conducted during a Remedial Investigation or Site Investigation at a hazardous or nonhazardous site. The procedures and equipment described are applicable to nearly all aqueous samples, including potable well water, monitoring well water, surface water, leachate and drummed water, etc.

This procedure provides generic information for measuring the parameters listed above with instruments and techniques in common use. Since instruments from different manufacturers may vary, review of the manufacturer's literature pertaining to the use of a specific instrument is required before use.

3.0 DEFINITIONS

Conductance - A measurement of water's capacity for conveying electrical current and is directly related to the concentrations of ionized substances in the water. The units of measurement for conductance (mhos) are the inverse of ohms, the unit commonly used to express resistance. Conductivity and specific conductance are used synonymously.

Electrolytic Cell - An electrochemical cell in which electrical energy is supplied from an external source. This cell functions in much the same way as a galvanic cell, only in the opposite direction due to the external source of applied voltage.

Galvanic Cell - An electrochemical cell in which chemical energy is spontaneously converted to electrical energy. The electrical energy produced is supplied to an external circuit.

Oxidation - The process in which an atom or group of atoms loses electrons to achieve an increasing positive charge.

pH - The negative logarithm (base 10) of the hydrogen ion activity. The hydrogen ion activity is related to the hydrogen ion concentration, and, in a relatively weak solution, the two are nearly equal. Thus, for all practical purposes, pH is a measure of the hydrogen ion concentration. The range of pH is 0 to 14 standard units.

Resistance - A measure of the solution's ability to oppose the passage of electrical current. For metals and solutions, resistance is defined by Ohm's Law, $E = IR$, where E is the potential difference (in units of volts), I is the current (in units of Amperes), and R is the resistance (in units of ohms).

Secchi disc - A metal disc having four quadrants, two opposing ones painted black and the other two either white or unpainted. The Secchi disc is used to measure turbidity based on the depth of light penetration.

Turbidity - An optical property of water that causes light to be scattered or absorbed in the water, resulting in decrease in water transparency. It is a function of at least three variables: 1) dissolved chemicals, such as tannins, acids, or salts; 2) suspended particles, such as silt, clay, and organic matter; and, 3) density of microbial and planktonic life.

Salinity refers to the total amount of soluble salts in water, either naturally or added to the environment as pollutants.

4.0 RESPONSIBILITIES

Project Manager - The Project Manager is responsible for ensuring that project-specific plans are in accordance with these procedures, where applicable, or that other, approved procedures are developed. The Project Manager is responsible for determining which on-site water quality measurements shall be made, the data quality objectives (DQOs) for these measurements, and for ensuring that these measurements are made in accordance with project-specific plans.

Field Team Leader - The Field Team Leader is responsible for determining that these water quality measurement procedures are implemented in the field in accordance with this SOP, or in accordance with project-specific plans, and to ensure that personnel performing sampling activities have been briefed and trained to execute these procedures.

Sampling Personnel - It is the responsibility of the field sampling personnel to follow these procedures for collecting on-site water quality measurements including instrument calibration, quality control and recording of results, as well as care and maintenance of the instruments in the field.

5.0 PROCEDURES

The following sections provide general procedures for collecting pH, specific conductance/salinity, temperature, dissolved oxygen concentration and turbidity measurements.

5.1 Measurement of pH

Measurement of pH is one of the most important and frequently used tests in water chemistry. Practically every phase of water supply and wastewater treatment, such as acid-base neutralization, water softening, and corrosion control, is pH dependent. Likewise, the pH of leachate can be correlated with other chemical analyses to determine the probable source of contamination. It is therefore important that reasonably accurate pH measurements be taken.

Measurements of pH also can be used to check the quality and corrosivity of soil and solid waste samples. However, these samples must be immersed in water prior to analysis; specific measurement techniques for solids are not described here.

Two methods are given for pH measurement: the pH meter and pH indicator paper. The indicator paper is used when only a rough estimate of the pH is required; the pH meter is used when a more accurate measurement is needed. The response of a pH meter can be affected to a slight degree by high levels of colloidal or suspended solids, but the effect is usually small and generally of little significance. Consequently, specific methods to overcome this interference are not described. The response of pH paper is unaffected by solution interferences from color, turbidity, colloidal or suspended materials unless extremely high levels capable of coating or masking the paper are encountered. In most cases, use of a pH meter will be required.

5.1.1 Principles of Equipment Operation

Use of pH papers for pH measurement relies on a chemical reaction caused by the acidity or alkalinity of the solution with the indicator compound on the paper. Depending on the indicator and the pH range of interest, a variety of different colors can be used. Typical indicators are weak acids or bases, or both. Process chemistry and molecular transformations leading to the color change are variable and complex.

Use of a pH meter relies on the same principle as other ion-specific electrodes. Measurement relies on the establishment of a potential difference across a glass or other type of membrane. The membrane is conductive to ionic species and, in combination with a standard or reference electrode, a potential difference proportional to hydrogen ion concentration can be generated and measured.

5.1.2 Equipment

The following equipment and reagents are needed for taking pH measurements:

- Portable pH meter, or pH indicator paper, such as Mydrion or Alkacid, to cover the pH range 2 through 12.

- Laboratory-prepared buffer solutions of pH 4, 7 and 10, or other buffers which bracket the expected pH range.

5.1.3 Measurement Techniques for Field Determination of pH

A. pH Meter

Standardization, calibration, and operation and maintenance shall be performed according to the manufacturers instructions. The following procedure is used for measuring pH with a pH meter:

1. The batteries and instrument shall be checked and calibrated prior to initiation of the field effort.

2. The accuracy of the buffer solutions used for field and laboratory calibration shall be checked. Buffer solutions need to be changed often due to degradation upon exposure to the atmosphere.

3. Immerse the tip of the electrodes in water overnight. If this is not possible due to field conditions, immerse the electrode tip in water for at least an hour before use. The electrode tip may be immersed in a rubber or plastic sack containing buffer solution for field transport or storage. This is not applicable for all electrodes as some must be stored dry.

4. Make sure all electrolyte solutions within the electrode(s) are at their proper levels and that no air bubbles are present within the electrode(s).

5. Immerse the electrode(s) in a pH-7 buffer solution.

6. Adjust the temperature compensator to the proper temperature (on models with automatic temperature adjustment, immerse the temperature probe into the buffer solution). It is best to maintain the buffer solution at or near expected sample temperature before calibration, if possible.

7. Adjust the pH meter to read 7.0.

8. Remove the electrode(s) from the buffer and rinse well with distilled-deionized water. Immerse the electrode(s) in pH-4 or 10 buffer solution (depending on the expected pH of the sample) and adjust the slope control to read the appropriate pH. For best results, the standardization and slope adjustments shall be repeated at least once.

9. Immerse the electrode(s) in the unknown solution, slowly stirring the probe until the pH stabilizes. Stabilization may take several seconds to minutes. If the pH continues to drift, the sample temperature may not be stable, a chemical reaction (e.g., degassing) may be taking place in the sample, or the meter or electrode may be malfunctioning. This must be clearly noted in the logbook.

10. After adjusting the temperature compensator to the sample temperature, read and record the pH of the solution. The pH value shall be recorded to the nearest 0.1 pH unit. Also record the sample temperature. All measurements shall be recorded in the Field Logbook.

11. Upon completion of measurement and removal of the electrode from the sample, the electrode shall be thoroughly rinsed with deionized water.

12. The electrode(s) shall remain immersed in deionized water when not in use.

The sample used for pH measurement shall never be saved for subsequent conductivity or chemical analysis. All pH electrodes leak small quantities of electrolytes (e.g., sodium or potassium chloride) into the solution. Precipitation of saturated electrolyte solution within the electrode, especially at colder temperatures, or in cold water, may result in slow electrode response. Any visual observation of conditions which may interfere with pH measurement, such as oily materials, or turbidity, shall be noted in the Field Logbook.

B. pH Paper

Use of pH paper is very simple and requires no sample preparation, standardization, etc. pH paper is available in several ranges, including wide-range (indicating approximately pH 1 to 12), mid-range (approximately pH 0 to 6, 6 to 9, or 8 to 14) and narrow-range (many available, with ranges as narrow as 1.5 pH units). The appropriate range of pH paper shall be selected. If the pH is unknown the investigation shall start with wide-range paper.

5.2 <u>Measurement of Specific Conductance/Salinity</u>

Conductance provides a measure of dissolved ionic species in water and can be used to suggest the direction and extent of migration of contaminants in groundwater or surface water. Salinity refers to the total amount of soluble salts in water, either naturally or added to the environment as pollutants. One basic measure of salinity is the ability of water to conduct electric current, and, therefore, a measurement of specific conductance provides a measurement of salinity and the same instrument can be used. Salinity measurements are important in ecological field investigations because flora and fauna can be limited in their distribution based on the salinity of the sampled waters.

Conductivity is a numerical expression of the ability of a water sample to carry an electric current. This value depends on the total concentration of the ionized substances dissolved in the water and the temperature at which the measurement is made. The mobility of each of the various dissolved ions, their valences, and their actual and relative concentrations affect conductivity.

It is important to obtain a specific conductance and salinity measurement soon after taking a sample, since temperature changes, precipitation reactions, and absorption of carbon dioxide from the air all affect the specific conductance.

5.2.1 Principles of Equipment Operation

An aqueous system containing ions will conduct an electric current. In a direct-current field, the positive ions (cations) migrate toward the negative electrode (cathode), while the negatively charged ions (anions) migrate toward the positive electrode (anode). Most inorganic acids, bases and salts (such as hydrochloric acid, sodium carbonate, or sodium chloride, respectively) are relatively good conductors. Conversely, organic compounds such as sucrose or benzene, which do not disassociate in aqueous solution, conduct a current very poorly, if at all.

A conductance cell and a Wheatstone Bridge (for the measurement of potential difference) may be used for measurement of electrical resistance. The ratio of current applied to voltage across the cell also may be used as a measure of conductance. The core element of the apparatus is the conductivity cell containing the solution of interest. Depending on ionic strength of the aqueous solution to be tested, a potential difference is developed across the cell which can be converted directly or indirectly (depending on instrument type) to a measurement of specific conductance.

5.2.2 Equipment

A portable conductivity meter, probe and thermometer are needed for taking specific conductance and salinity measurements. A variety of conductivity meters are available which also may be used to monitor salinity and temperatures. Probe types and cable lengths vary, so equipment may be obtained to meet the specific requirements of the sampling program.

5.2.3 Measurement Techniques for Specific Conductance/Salinity

Standardization, calibration, and operation and maintenance shall be performed according to manufacturers instructions. The steps involved in taking specific conductance and salinity measurements are listed below.

1. Check batteries and calibrate instrument before going into the field.
2. Calibrate the instrument daily when used. Potassium chloride solutions with a specific conductance closest to the values expected in the field shall be used. Calibration information shall be recorded in the field logbook.

3. Rinse the cell with one or more portions of the sample to be tested or with deionized water.

4. Immerse the electrode in the sample and measure the conductivity and salinity. If specified, adjust the temperature setting to the sample temperature.

5. Read and record the results on the Calibration Form (in the absence of the Calibration Form, the Field Logbook will be used).

6. If the meter does not compensate for temperature variations, the corrections given in Attachment A shall be applied.

7. On some meters, specific conductivity and salinity measurements may need to be reported with the associated temperature measurement. If the conductivity and salinity has been corrected, the measurements shall be reported as "corrected to 25°C." (See Attachment A)

    a. Do not take readings if the sample temperature is less than 10° C, because the calibration curve no longer follows a straight line below this temperature. If necessary, heat the sample in your vehicle to at least 10° C.

    b. Measure the sample temperature to the nearest 0.1° C to comply with SW-846.

    c. Only report results to the nearest two significant digits for the most circumstances, because of the inherent inacurracy in the test and conversion procedure.

        examples:

        - a calculated reading of 2353 umhos/cm @ 25° C should be reported as 2400 umhos/cm @ 25° C
        - a calculated reading of 2325 should be reported as 2300
        - a calculated reading of 337 should be reported as 340
        - etc.

5.3 Measurement of Temperature

In combination with other parameters, temperature can be a useful indicator of the likelihood of biological action in a water sample. It can also be used to trace the flow direction of contaminated groundwater. Temperature measurements shall be taken in-situ, or as quickly as possible in the field prior to sample collection. Collected water samples may rapidly equilibrate with the temperature of their surroundings.

5.3.1 Equipment

Temperature measurements may be taken with Thermistor, alcohol-toluene, mercury or bimetal thermometers. In addition, various meters such as specific conductance or dissolved oxygen meters, which have temperature measurement capabilities, may also be used. Using such instrumentation along with suitable probes and cables, in-situ measurements of temperature can be performed.

5.3.2 Measurement Techniques for Water Temperature

If a thermometer is used on a collected water sample:

- Immerse the thermometer in the sample until temperature equilibrium is obtained (1-3 minutes). To avoid the possibility of contamination, the thermometer shall not be inserted into samples which will undergo subsequent chemical analysis.

- Record values in a Field Logbook to the nearest 0.5 or 0.1°C, depending on the measurement device used.

If a temperature meter or probe is to be used, the instrument shall be calibrated according to the manufacturer's recommendations with an approved thermometer.

5.4 Measurement of Dissolved Oxygen Concentration

Dissolved oxygen (DO) levels in natural water and wastewater depend on the physical, chemical and biochemical activities in the water body. Conversely, the growth of many aquatic organisms, as well as the rate of corrosivity, are dependent on the dissolved oxygen concentration. Thus, analysis for dissolved oxygen is a key test in water pollution and waste treatment process control. If at all possible, DO measurements shall be taken in-situ, since concentration may show a large change in a short time, if the sample is not adequately preserved.

The method discussed here is limited to the use of dissolved oxygen meters only. Chemical methods of analysis (i.e., Winkler methods) are available, but require more equipment and greater sample manipulation. Furthermore, DO meters, using a membrane electrode, are suitable for highly polluted waters, because the probe is completely submersible. DO meters also are free from interference caused by color, turbidity, colloidal material or suspended matter.

5.4.1 Principles of Equipment Operation

Dissolved oxygen probes normally are electrochemical cells that have two solid metal electrodes of different potential immersed in an electrolyte. The electrolyte is retained by an oxygen-permeable membrane. The metal of higher nobility (the cathode) is positioned at the membrane. When a suitable potential exists between the two metals, reduction of oxygen to hydroxide ion (OH) occurs at the cathode surface. An electrical current is developed directly proportional to the rate of arrival of oxygen molecules at the cathode.

Since the current produced in the probe is directly proportional to the rate of arrival of oxygen at the cathode, it is important that a fresh supply of sample always be in contact with the membrane. Otherwise, the oxygen in the aqueous layer along the membrane is quickly depleted and false low readings are obtained. It is therefore necessary to stir the sample (or the probe) constantly to maintain fresh solution near the membrane interface. Stirring, however, shall not be so vigorous that additional oxygen is introduced through the air-water interface at the sample surface. To avoid this possibility, some probes are equipped with stirrers to agitate the solution near the probe, but to leave the surface of the solution undisturbed.

Dissolved oxygen probes are relatively free of interferences. Interferences that can occur are reactions with oxidizing gases (such as chlorine) or with gases such as hydrogen sulfide which are not easily depolarized from the indicating electrode. If gaseous interference is suspected, it shall be noted in the Field Logbook and checked if possible. Temperature variations also can cause interference because probes exhibit temperature sensitivity. Automatic temperature compensation normally is provided by the manufacturer. Attachment B presents variations of DO in water as a fraction of temperature and salinity.

5.4.2 Equipment

The following, similar or equivalent, equipment is needed to measure dissolved oxygen concentration:

- YSI Model 56 dissolved oxygen monitor (or equivalent).
- Dissolved oxygen/temperature probe.
- Sufficient cable to allow the probe to contact the sample.

5.4.3 Measurement Techniques for Dissolved Oxygen Determination

Probes differ as to specifics of use. Follow the manufacturer's instructions to obtain an accurate reading. The following general steps shall be used to measure the dissolved oxygen concentration.

1. Calibrate equipment and check batteries in the laboratory before going to the field.

2. The probe shall be conditioned in a water sample for as long as practical before use in the field. Long periods of dry storage followed by short periods of use in the field may result in inaccurate readings.

3. The instrument shall be calibrated in the field before each measurement or group of closely spaced measurements by placing the probe in a water sample of known dissolved oxygen concentration (i.e., determined by Winkler method) or in a freshly air-saturated water sample of known temperature. Dissolved oxygen values for air-saturated water can be determined by consulting a table listing oxygen solubilities as a function of temperature and salinity (see Attachment B).

4. Immerse the probe in the sample. Be sure to provide for sufficient flow past the membrane, either by stirring the sample, or placing the probe in a flowing stream. Probes without stirrers which are placed in wells should be moved up and down.

5. Record the dissolved oxygen content and temperature of the sample in a Field Logbook.

6. Recalibrate the probe when the membrane is replaced, or following similar maintenance, or as needed. Follow the manufacturer's instructions.

Note that in-situ placement of the probe is preferable, since sample handling is not involved. This, however, may not always be practical. Be sure to record whether the liquid was analyzed in-situ, or whether a sample was taken.

Special care shall be taken during sample collection to avoid turbulence which can lead to increased oxygen dissolution and positive test interferences.

5.5 Measurement of Turbidity Using a Secchi Disc

In combination with other parameters, turbidity can be a useful indicator of the likelihood of biological action in a water body. It can be used to determine the depth of light penetration of surface water and the distribution and intensity of photosynthesis in the body of water. Turbidity measurements shall be taken in-situ with a Secchi disc.

5.5.1 Equipment

Turbidity measurements may be taken with a Secchi disc. In addition, turbidity may be measured using a colimeter or a spectrophotometer. These are ex-situ measurements conducted in a laboratory environment.

5.5.2 Measurement Techniques for Turbidity

Observations must be made through a shaded area of water surface.

- Standard conditions for the use of the Secchi disc are: 1) clear sky; (2) sun directly overhead; 3) shaded, protected side of boat or under a sun shade; 4) minimal waves or ripples; and, 5) any departure from these conditions should be specifically stated on field sheets.

- Rope accurately graduated in meters with 0.1 meter graduations for the first meter and 0.5 meters thereafter.

- Observer's eye should be 1 meter above the surface of the water.

- Observations should be made during the middle of the day.

- Lower the disc into the water, noting the depth at which it disappears, then lift the disc and note the depth at which it reappears. The average of the two readings is considered to be the limit of visibility and is recorded in a Field Logbook to the nearest 0.1 meter (first meter) or 0.5 meter, depending on the depth of visibility.

6.0 QUALITY ASSURANCE RECORDS

Quality assurance records for on-site water quality management consists principally of observations and measurements recorded in the Field Logbook. Records of instrument calibration, malfunction, repair, etc., shall be maintained in an Equipment Logbook as described in the Navy CLEAN Contractor Quality Control Plan.

7.0 REFERENCES

American Public Health Association, 1980. Standard Methods for the Examination of Water and Wastewater, 15th Edition, APHA, Washington, D.C.

U.S. EPA, 1979. Methods for Chemical Analysis of Water and Wastes. EPA-600/4-79-020.

U.S. Geological Survey, 1984. National Handbook of Recommended Methods for Water Data Acquisition, Chapter 5: Chemical and Physical Quality of Water and Sediment. U.S. Department of the Interior, Reston, Virginia.

ATTACHMENT A

SPECIFIC CONDUCTANCE CONVERSION TABLE

ATTACHMENT A
SPECIFIC CONDUCTANCE CONVERSION TABLE

Temperature Degrees C	Calculated Multiplier	Temperature Degrees C	Calculated Multiplier	Temperature Degrees C	Calculated Multiplier	Temperature Degrees C	Calculated Multiplier	Temperature Degrees C	Calculated Multiplier
10	1.402	12	1.330	14	1.266	16	1.208	20	1.106
10.1	1.398	12.1	1.327	14.1	1.263	16.1	1.205	20.1	1.103
10.2	1.394	12.2	1.324	14.2	1.260	16.2	1.202	20.2	1.101
10.3	1.390	12.3	1.320	14.3	1.257	16.3	1.199	20.3	1.099
10.4	1.387	12.4	1.317	14.4	1.254	16.4	1.197	20.4	1.096
10.5	1.383	12.5	1.314	14.5	1.251	16.5	1.194	20.5	1.094
10.6	1.379	12.6	1.310	14.6	1.248	16.6	1.191	20.6	1.092
10.7	1.376	12.7	1.307	14.7	1.245	16.7	1.188	20.7	1.089
10.8	1.372	12.8	1.304	14.8	1.242	16.8	1.186	20.8	1.087
10.9	1.369	12.9	1.301	14.9	1.239	16.9	1.183	20.9	1.085
11	1.365	13	1.297	15	1.236	17	1.180	21	1.083
11.1	1.361	13.1	1.294	15.1	1.233	17.1	1.178	21.1	1.080
11.2	1.358	13.2	1.291	15.2	1.230	17.2	1.175	21.2	1.078
11.3	1.354	13.3	1.288	15.3	1.227	17.3	1.172	21.3	1.076
11.4	1.351	13.4	1.285	15.4	1.225	17.4	1.170	21.4	1.074
11.5	1.347	13.5	1.281	15.5	1.222	17.5	1.167	21.5	1.072
11.6	1.344	13.6	1.278	15.6	1.219	17.6	1.165	21.6	1.069
11.7	1.341	13.7	1.275	15.7	1.216	17.7	1.162	21.7	1.067
11.8	1.337	13.8	1.272	15.8	1.213	17.8	1.159	21.8	1.065
11.9	1.334	13.9	1.269	15.9	1.210	17.9	1.157	21.9	1.063
22	1.061	24	1.019	26	0.981	28	0.946	30	0.913
22.1	1.059	24.1	1.017	26.1	0.979	28.1	0.944	30.1	0.911
22.2	1.057	24.2	1.016	26.2	0.978	28.2	0.942	30.2	0.910
22.3	1.054	24.3	1.014	26.3	0.976	28.3	0.941	30.3	0.908
22.4	1.052	24.4	1.012	26.4	0.974	28.4	0.939	30.4	0.907
22.5	1.050	24.5	1.010	26.5	0.972	28.5	0.937	30.5	0.905
22.6	1.048	24.6	1.008	26.6	0.970	28.6	0.936	30.6	0.903
22.7	1.046	24.7	1.006	26.7	0.969	28.7	0.934	30.7	0.902
22.8	1.044	24.8	1.004	26.8	0.967	28.8	0.932	30.8	0.900

ATTACHMENT A (Continued)
SPECIFIC CONDUCTANCE CONVERSION TABLE

Temperature Degrees C	Calculated Multiplier	Temperature Degrees C	Calculated Multiplier	Temperature Degrees C	Calculated Multiplier	Temperature Degrees C	Calculated Multiplier	Temperature Degrees C	Calculated Multiplier
22.9	1.042	24.9	1.002	26.9	0.965	28.9	0.931	30.9	0.899
23	1.040	25	1.000	27	0.963	29	0.929	31	0.897
23.1	1.038	25.1	0.998	27.1	0.961	29.1	0.927	31.1	0.896
23.2	1.036	25.2	0.996	27.2	0.960	29.2	0.926	31.2	0.894
23.3	1.034	25.3	0.994	27.3	0.958	29.3	0.924	31.3	0.893
23.4	1.032	25.4	0.992	27.4	0.956	29.4	0.922	31.4	0.891
23.5	1.029	25.5	0.991	27.5	0.954	29.5	0.921	31.5	0.890
23.6	1.027	25.6	0.989	27.6	0.953	29.6	0.919	31.6	0.888
23.7	1.025	25.7	0.987	27.7	0.951	29.7	0.918	31.7	0.887
23.8	1.023	25.8	0.985	27.8	0.949	29.8	0.916	31.8	0.885
23.9	1.021	25.9	0.983	27.9	0.948	29.9	0.914	31.9	0.884

Notes:

- Do not make specific conductance measurements at temperatures below 10° C.
- Measure temperature to the nearest 0.1° C.
- Report all conductivities at 25° C, to two significant digits.
- This conversion table is based on a temperature coefficient of 0.0191 (as per SW-846) and a cell constant of 1, where the ratio of conductivity at 25 C to the conductivity at temperature t° C equals 1/(1+0.0191[t-25]).
- The temperature coefficient and cell constants are only approximate, actual values may differ.
- The more the temperature deviates from 25° C, the greater the uncertainty in applying the temperature correction.

ATTACHMENT B

VARIATION OF DISSOLVED OXYGEN CONCENTRATION IN WATER AS A FUNCTION OF TEMPERATURE AND SALINITY

Temperature °C	2.Dissolved Oxygen mg/l 2.1.Chloride Concentration in Water 2.1.1.0 2.1.2.5,000 2.1.3.10,000 2.1.4.15,000 2.1.5.20,000 2.2.Difference/ 100 mg chloride					
0	14.6	13.8	13.0	12.1	11.3	0.017
1	14.2	13.4	12.6	11.8	11.0	0.106
2	13.8	13.1	12.3	11.5	10.8	0.015
3	13.5	12.7	12.0	11.2	10.5	0.015
4	13.1	12.4	11.7	11.0	10.3	0.014
5	12.8	12.1	11.4	10.7	10.0	0.014
6	12.5	11.8	11.1	10.5	9.8	0.014
7	12.2	11.5	10.9	10.2	9.6	0.013
8	11.9	11.2	10.6	10.0	9.4	0.013
9	11.6	11.0	10.4	9.8	9.2	0.012
10	11.3	10.7	10.1	9.6	9.0	0.012
11	11.1	10.5	9.9	9.4	8.8	0.011
12	10.8	10.3	9.7	9.2	8.6	0.011
13	10.6	10.1	9.5	9.0	8.5	0.011
14	10.4	9.9	9.3	8.8	8.3	0.010

Temperature °C	2.Dissolved Oxygen mg/l 2.1.Chloride Concentration in Water 2.1.1.0 2.1.2.5,000 2.1.3.10,000 2.1.4.15,000 2.1.5.20,000 2.2.Difference/ 100 mg chloride					
15	10.2	9.7	9.1	8.6	8.1	0.010
16	10.0	9.5	9.0	8.5	8.0	0.010
17	9.7	9.3	8.8	8.3	7.8	0.010
18	9.5	9.1	8.6	8.2	7.7	0.009
19	9.4	8.9	8.5	8.0	7.6	0.009
20	9.2	8.7	8.3	7.9	7.4	0.009
21	9.0	8.6	8.1	7.7	7.3	0.009
22	8.8	8.4	8.0	7.6	7.1	0.008
23	8.7	8.3	7.9	7.4	7.0	0.008
24	8.5	8.1	7.7	7.3	6.9	0.008
25	8.4	8.0	7.6	7.2	6.7	0.008
26	8.2	7.8	7.4	7.0	6.6	0.008
27	8.1	7.7	7.3	6.9	6.5	0.008
28	7.9	7.5	7.1	6.8	6.4	0.008
29	7.8	7.4	7.0	6.6	6.3	0.008
30	7.6	7.3	6.9	6.5	6.1	0.008

APPENDIX G
WATER LEVEL, WATER-PRODUCT LEVEL MEASUREMENTS AND WELL DEPTH MEASUREMENTS

WATER LEVEL, WATER-PRODUCT LEVEL MEASUREMENTS, AND WELL DEPTH MEASUREMENTS

TABLE OF CONTENTS

1.0 PURPOSE

2.0 SCOPE

3.0 DEFINITIONS

4.0 RESPONSIBILITIES

5.0 PROCEDURES
- 5.1 Water Level Measurement
- 5.2 Groundwater-Product Interface Level Measurement
- 5.3 Well Depth Measurements
- 5.4 Decontamination of Measuring Devices

6.0 QUALITY ASSURANCE RECORDS

WATER LEVEL, WATER-PRODUCT LEVEL MEASUREMENTS, AND WELL DEPTH MEASUREMENTS

1.0 PURPOSE

The purpose of this procedure is to describe the method of determining various down-hole measurements: groundwater levels and product (or non-aqueous phase liquid, NAPL) levels, if present, and total depth of groundwater monitoring wells and piezometers.

2.0 SCOPE

The methods described in this SOP generally are applicable to the measurement of groundwater levels, product or NAPL levels, and well depths in monitoring wells and piezometers.

3.0 DEFINITIONS

None.

4.0 RESPONSIBILITIES

Project Manager - The Project Manager is responsible for ensuring that project-specific plans are in accordance with these procedures, where applicable, or that other approved procedures are developed.

Field Team Leader - The Field Team Leader is responsible for ensuring that these procedures are implemented in the field, and for ensuring that personnel performing these activities have been briefed and trained to execute these procedures.

Sampling Personnel - It is the responsibility of the sampling personnel to follow these procedures or to follow documented, project-specific procedures as directed by the Field Team Leader and/or the Project Manager. The sampling personnel are responsible for the proper acquisition of down-hole measurements.

5.0 PROCEDURES

Calculations of groundwater elevations and product or NAPL interface level measurements collected from a monitoring well give an indication of:

- The horizontal hydraulic gradient and the direction of groundwater flow.
- The vertical hydraulic gradient, if well nests are used (i.e., the direction of groundwater flow in the vertical plane).

- Floating or sinking product thicknesses which are also known as Light Non-Aqueous Phase Liquids (LNAPLS) and Dense Non-Aqueous Phase Liquids (DNAPLS), respectively.

This information, when combined with other site specific information such as hydraulic conductivity or transmissivity, extent of contamination, and product density, may be used to estimate the rate of contaminant movement or source areas, etc.

Well depth is one of the factors used to determine the zone that a well monitors. Well depth also is used in the calculation of purge volumes as discussed in SOP F104, Groundwater Sample Acquisition.

The following sections briefly discuss the procedures for measuring groundwater levels, product or NAPL levels, and well depth. For all of the procedures discussed, it is assumed that the measurement will be taken from the top of the PVC or stainless steel casing (though other measuring points can be used), and that horizontal and vertical control is available for each well through a site survey, such that measurements may be converted to elevations above Mean Sea Level (MSL) or some other consistent datum. A permanent notch, placed on the inner PVC or stainless steel casing by the surveyor will facilitate consistent water level measurements.

The manufacturer's instructions for all equipment referenced herein should be read by the equipment operator(s) and accompany the equipment to the field.

5.1 Water Level Measurement

Water levels in groundwater monitoring wells shall be measured from the permanent point indicated at the top of the inner casing (the surveyed elevation point, as marked by the surveyor), unless otherwise specified in the project plans, using an electronic water level measuring device (water level indicator). The point of measurement will be documented in the field logbook if different from the top of the inner casing. The reason for deviating from the measurement point should also be noted.

Water levels are measured by lowering the probe into the well until the device indicates that water has been encountered, usually with either a constant buzz, or a light, or both. The water level is recorded to the nearest foot (0.01) using the graduated markings on the water level indicator cord. This measurement, when subtracted from the measuring point elevation, yields the groundwater elevation.

Groundwater levels shall always be measured to the nearest 0.01 foot. However, reporting of water level elevations depends on the accuracy of the vertical control (typically either 0.1 or 0.01 foot).

5.2 Product or NAPL Level Measurements

The procedure for product or NAPL level measurement is nearly identical to that for groundwater elevation measurements. The only differences are the use of an interface probe that detects both NAPLs and water, and the indication signal given by the measurement device. Typically, encountering NAPLs in a monitoring well is indicated by a constant sound. When water is encountered, the signal becomes an alternating on/off beeping sound. This allows for the collection of measurements for both the top of the NAPL layer in a well and the water/NAPL interface.

The apparent water table elevation below the product level will be determined by subtracting the "depth to water" from the measuring point elevation. The corrected water table elevation will then be calculated using the following equation:

$$WTE_c = WTE_a + (\text{Free Product Thickness} \times 0.80)$$

Where:

WTE_c = Corrected water table elevation
WTE_a = Apparent water table elevation
0.80 = Average value for the density of petroleum hydrocarbons. Site-specific data will be used where available.

5.3 Well Depth Measurements

Well depths typically are measured using a weighted measuring tape. A water level meter may also be used. The tape is lowered down the well until resistance is no longer felt, indicating that the weight has touched the bottom of the well. The weight should be moved in an up and down motion a few times so that obstructions, if present, may be bypassed. The slack in the tape then is collected until the tape is taut. The well depth measurement is read directly off of the measuring tape, at the top of the PVC or stainless steel casing, to the nearest 0.01-foot and recorded in the Field Logbook. If a water level indicator is used, add the distance from the bottom of the probe to the point where water levels are measured.

5.4 Decontamination of Measuring Devices

Water level indicators, interface probes and weighted measuring tapes that come in contact with groundwater must be decontaminated using the following steps after use in each well:

- Rinse with potable water
- Rinse with deionized water
- Rinse with Methanol or Isopropanol

- Rinse with deionized water

Portions of the water level indicators or other similar equipment that do not come into contact with groundwater, but may encounter incidental contact during use, need only undergo potable water and deionized water rinses.

6.0 QUALITY ASSURANCE RECORDS

The Field Logbook shall serve as the quality assurance record for water, product level or well depth measurements.

APPENDIX H
PHOTOIONIZATION DETECTOR (PID)
HNU MODELS PI 101 AND DL 101

PHOTOIONIZATION DETECTOR (PID)
TABLE OF CONTENTS

1.0 PURPOSE

2.0 SCOPE

3.0 DEFINITIONS

4.0 RESPONSIBILITIES

5.0 PROCEDURES
- 5.1 Calibration
- 5.2 Operation
- 5.3 Interferences and Potential Problems
- 5.4 Maintenance

6.0 QUALITY ASSURANCE RECORDS

7.0 REFERENCES

PHOTOIONIZATION DETECTOR (PID)
HNu MODELS PI 101 and DL 101

1.0 PURPOSE

The purpose of this SOP is to provide general reference information for using the HNu Model PI 101 or DL 101 photoionization detector (PID), or an equivalent or similar instrument, in the field. Calibration and operation, along with field maintenance will be included in this SOP.

2.0 SCOPE

This procedure provides information on the field operation and general maintenance of the HNu (PID). Application of the information contained herein will ensure that this type of field monitoring equipment will be used properly. Review of the manufacturer's instruction manual is necessary for more complete information.

These procedures refer only to monitoring for health and safety. The methods are not directly applicable to surveillance of air quality for analytical purposes.

3.0 DEFINITIONS

Ionization Potential - In this case, a numeric equivalent that expresses the amount of energy needed to replace an electron with a photon. This energy is further defined in terms of electron volts (eV).

PID - Photoionization Detector

ppm - parts per million: parts of vapor or gas per million parts of air (directly proportional to calibration gas).

4.0 RESPONSIBILITIES

Project Manager - The Project Manager is responsible for ensuring that project-specific plans are in accordance with these procedures, where applicable, or that other approved procedures are developed. The Project Manager is responsible for selecting qualified individuals for the monitoring activities.

Project Health and Safety Officer (PHSO) - The Project Health and Safety Officer is responsible for developing a site-specific Health and Safety Plan (HASP) which specifies air monitoring requirements.

Field Team Leader - It is the responsibility of the Field Team Leader to implement these procedures in the field, and to ensure that the Field Investigation Personnel performing air monitoring activities, have been briefed and trained to execute these procedures before the start of site operations.

Site Health and Safety Officer (SHSO) - The SHSO is responsible for ensuring that the specified air monitoring equipment is on site, calibrated, and used correctly by the Field Personnel. The SHSO will coordinate these activities with the Field Team Leader.

Field Investigation Personnel - It is the responsibility of the Field Investigation Personnel to follow these procedures or to follow documented project-specific procedures as directed by the Field Team Leader/Site Health and Safety Officer. The Field Investigation Personnel are responsible for documenting all air monitoring results in both the Field Logbook and the daily Realtime Air Monitoring Log during each field investigation.

5.0 PROCEDURES

The HNu utilizes the principle of photoionization whereby contaminant molecules enter the ion chamber and electrons are displaced by ultraviolet photons producing positive ions. These displaced positive ions are in turn collected on a special electrode. As the positive ions collect on the electrode, they create an electrical current which is amplified and displayed on the meter as a concentration in parts per million (ppm).

The HNu is only effective for contaminants that have ionization potentials (IP) of less than or equal to the electron volt (eV) capacity of the lamp (i.e., methane, having an IP of 12.98 eV, will not be detected at a lamp potential of 11.7 eV). The standard lamp is 10.2 eV with optional lamps of 9.5 eV and 11.7 eV, respectively. For the PI 101 the span settings should be as follows: 1.0 for 9.5 eV lamps; 9.8 for 10.2 eV lamps; and 5.0 for 11.7 eV lamps. During calibration, these span settings will be adjusted as necessary, using the span control knob.

The following subsections will discuss HNu calibration, operation, and maintenance. These sections, however, should not be used as a substitute for the manufacturer's instruction manual.

5.1 Calibration

For calibration purposes, the following items will be needed:

- *Gas cylinder containing 95 to 100 parts per million (ppm) of isobutylene, balance in air.
- A 0.30 liters per minute regulator.
- Connector tubing.
- Screwdriver set.
- Calibration Gas Humidifier (for high humidity environments).
- Photoionization Detector (PID) Calibration Form.

*Note: Do not rely on accuracy of rated cylinder concentration when content drops to <200 psi.

Prior to each use, make sure that the battery is fully charged, the ultraviolet lamp is working, and that the fan is operating and drawing air into the probe (fan operates at approximately 100-200 cc/minute for the PI 101 and 225 cc/minute for the DL 101). Procedures for completing these preliminary activities are given in the manufacturer's instruction manual.

PI 101

To calibrate the HNu PI 101, the steps provided below should be followed. For an itemized description of the calibration process, refer to Section 3-5 in the manufacturer's instruction manual. The HNu PI 101 should be calibrated on a daily basis.

- Turn the function control switch to the standby position and zero the instrument by turning the zero adjustment knob to align the indicator needle with zero on the readout meter.

- Set the range on the HNu and allow the instrument to warm up a few minutes before calibrating. Choices for range are 0-20, 0-200, and 0-2,000 ppm, respectively. Range choice must take into account the concentration of the calibration gas. For example, if you are using a concentration of 100 ppm isobutylene as the calibration gas, your range should be set on the 0-200 scale. If you have to zero the instrument in the desired range, record background if present.

- Attach tubing to the regulator (use the Calibration Gas Humidifier in high humidity environments).

- Attach the free end of the tubing to the probe and turn on the calibration gas.

- Calibrate the PID to benzene equivalents. Using the 10.2 eV (lamp) probe and 100 ppm isobutylene, the meter should read 56 units. Using the 11.7 eV (lamp) probe and 100 ppm isobutylene, the meter should read 65 units. If the reading on the meter is not ±5 percent of the concentration of the calibration gas, adjust the span setting knob until the meter reads accordingly. If after adjusting the span setting knob the readout meter is still not responding, refer to the manufacturer's instruction manual. Also, when the HNu is calibrated it should respond to a minimum of 90 percent of the concentration of the calibration gas within three seconds after introduction of that gas. If proper calibration cannot be obtained, internal calibration may be required. Note, only qualified personnel should perform internal calibrations.

- Record the calibration on the "Photoionization Detector (PID) Calibration Form".

DL 101

To calibrate the HNu DL 101, the steps provided below should be followed. For an itemized description of the calibration process, refer to Section 4.4 in the manufacturer's instruction manual.

- Press and release the POWER button on the keypad and wait for the screen to stabilize then press the CALIBRATE key until "Calibrate?" appears. At this point press the ENTER key until "Elec_Zero? Yes" appears on the screen in which case you will press the ENTER key, again, to confirm the electronic zero.

- The display will now read "CE/ENT/EXIT Conc = ____ ppm" which requires the concentration of the calibration gas (noted on the side of the calibration gas bottle) to be entered on the keypad. The display will prompt you to "Attach gas to probe and /ENTER/" so attach tubing to probe (use the calibration gas humidifier in high humidity environments), open valve, and press ENTER key. Press ENTER again when "Press ENTER when Ready: xxx ppm" appears on screen. This will cause "Calibrating...Please Wait" to appear on screen.

Note: This calibration is effective when the instrument is in the Survey Mode, which is the default mode. For calibrations other the one described, or if proper calibration cannot be obtained, refer to the manufacturer's instruction manual.

- For calibrations using an alternate gas or span values, refer to Section 4.5 of the manufacturer's instruction manual.

- Record the calibration on the "Photoionization Detector (PID) Calibration Form" which accompanies each HNu.

5.2 Operation

PI 101

Note: IMPORTANT - The HNu should be "zeroed" in a fresh air environment if at all possible. If there is a background concentration, it must be documented and then zeroed out.

- Prior to each use of the HNu, check that the battery is fully charged by turning the dial to BATT and making sure that it is within range. Also make sure that the ultraviolet lamp and the fan are working properly.

- Select your desired range. HNu ranges consists of a 0-20, 0-200, and 0-2,000 ppm, respectively. Consult with the Field Team Leader for more information when choosing the appropriate range, however, in most instances the range will be set initially at 0-20.

- When HNu is used intermittently, turn knob to STANDBY to help in extending the life of the UV lamp when operating in a low humidity environment. Otherwise, leave the knob set to the range desired so that the UV lamp will "burn off" any accumulated moisture.

Note: When using the PI 101 HNu, make sure that the probe does not contact water or soil during sampling. This will cause erroneous readings and will possibly damage the instrument.

DL 101

The DL 101 is designed to default to the survey mode when initially powered up, therefore once the calibration has been completed, the instrument is ready to go. Within the survey mode several options are available, briefly these options include:

1. The Site Function

The Site function assigns a number to a site that is being analyzed. Press the Site Key on the keypad to enter a specific site number, or press the gray button on the rear of the probe to increment a site number.

2. Logging Data

The Log function stores data in memory. To log data, press the Log key on the keypad or the Log button on the back of the probe. "Log" will appear in the upper right corner of the display when activated and disappears when not activated. To turn logging off, press either the Log key on the keypad or the red Log button on the rear of the probe.

- The DL 101 allows for the interchanging of different voltage lamps, however, refer to the manufacturer's instructions before attempting to change the lamp.

- The DL 101 also offers three other modes of operation, the Hazardous Waste Mode, the Industrial Hygiene Mode, and the Leak Detection Mode. Each of these modes increases the range of capabilities for this instrument which is covered in detail in the manufacturer's instruction manual.

Note: When using the DL 101 HNu, make sure that the probe does not contact water or soil during sampling. This will cause erroneous readings and will possibly damage the instrument.

5.3 Interferences and Potential Problems

A number of factors can affect the response of the PI 101 HNu and DL 101 HNu.

- High humidity can cause lamp fogging and decreased sensitivity. This can be significant when soil moisture levels are high, or when monitoring a soil gas well that is accessible to groundwater.

- High concentrations of methane can cause a downscale deflection of the meter.

- High and low temperature, electrical fields, FM radio transmission, and naturally occurring compounds, such as terpines in wooded areas, will also affect instrument response.

5.4 Maintenance

The best way to keep an HNu operating properly is to keep it as clean as possible. HNu's should be decontaminated or wiped down daily or after each use, as appropriate.

Corrective Maintenance

- The ultraviolet lamp should be periodically cleaned using a special compound supplied by HNu Systems, Inc. for the 10.2 eV lamp, and a chlorinated solvent such as 1,1,1-trichloroethane for the 11.7eV lamp. Consult the manufacturer's instruction manual for specific cleaning instructions.

- The ionization chamber can be periodically cleaned with methyl alcohol and a swab.

Note: UV lamp and ion chamber cleaning is accomplished by following the procedures outlined in Section 5.2, however, this should only be performed by trained personnel.

- Documenting the HNu's observed symptoms and then referring to the manufacturer's instruction manual section on troubleshooting (Section 6.0) also can be employed. If this does not work, the Field Team Leader should be consulted for an appropriate course of action.

Repair and Warranty Repair - HNu's have different warranties for different parts, so documenting the problem and sending it into the manufacturer assists in expediting repair time and obtaining appropriate warranty service.

5.5 Shipping and Handling

Following is information regarding the transport of the HNu meter and calibration gas.

- If HNu is to be carried on in aircraft, the calibration gas must be removed from the carrying case as cylinders of compressed gas are not permitted on passenger aircraft. The calibration gas should either be shipped to the site of its intended use, or purchased locally.

- Shipping of the calibration gas requires the completion of a form (specified by the shipping company) that identifies the package as a compressed gas. Compressed gas stickers must be affixed to the package.

6.0 QUALITY ASSURANCE RECORDS

Quality assurance records will be maintained for each air monitoring event. The following information shall be recorded in the Field Logbook.

- Identification - Site name, location, CTO number, activity monitored, (surface water sampling, soil sampling, etc.) serial number, time, resulting concentration, comments and identity of air monitoring personnel.
- Field observations - Appearance of sampled media (if definable).
- Additional remarks (e.g., the HNu meter had wide range fluctuations during air monitoring activities).

7.0 REFERENCES

HNu Systems, Inc. Instruction Manual. Model PI 101, 1986.
HNu Systems, Inc. Operator's Manual. Model DL 101, 1991.

APPENDIX I
SAMPLE PRESERVATION AND HANDLING

SAMPLE PRESERVATION AND HANDLING
TABLE OF CONTENTS

1.0 PURPOSE

2.0 SCOPE

3.0 DEFINITIONS

4.0 RESPONSIBILITIES

5.0 PROCEDURES
  5.1 Sample Containers
  5.2 Preservation Techniques
  5.3 Sample Holding Times

6.0 SAMPLE HANDLING AND TRANSPORTATION

7.0 REFERENCES

SAMPLE PRESERVATION AND HANDLING

1.0 PURPOSE

This SOP describes the appropriate containers for samples of particular matrices, and the steps necessary to preserve those samples when shipped off site for chemical analysis. It also identifies the qualifications for individuals responsible for the transportation of hazardous materials and samples and the regulations set forth by the Department of Transportation regarding the same.

2.0 SCOPE

Some chemicals react with sample containers made of certain materials; for example, trace metals adsorb more strongly to glass than to plastic, while many organic chemicals may dissolve various types of plastic containers. It is therefore critical to select the correct container in order to maintain the integrity of the sample prior to analysis.

Many water and soil samples are unstable and may change in chemical character during shipment. Therefore, preservation of the sample may be necessary when the time interval between field collection and laboratory analysis is long enough to produce changes in either the concentration or the physical condition of the constituent(s). While complete and irreversible preservation of samples is not possible, preservation does retard the chemical and biological changes that may occur after the sample is collected.

Preservation techniques are usually limited to pH control, chemical addition(s), and refrigeration/freezing. Their purposes are to (1) retard biological activity, (2) retard hydrolysis of chemical compounds/complexes, (3) reduce constituent volatility, and (4) reduce adsorption effects.

Typical sample container and preservation requirements for the CLEAN Program are referenced in NEESA 20.2-047B and are provided in Attachment A of this SOP. Note that sample container requirements (i.e., volumes) may vary by laboratory.

The Department of Transportation, Code of Federal Regulations (CFR) Title 49 establishes regulations for all materials offered for transportation. The transportation of environmental samples for analysis is regulated by Code of Federal Regulations Title 40 (Protection of the Environment), along with 49 CFR Part 172 Subpart H. The transportation of chemicals used as preservatives and samples identified as hazardous (as defined by 49 CFR Part 171.8) are regulated by 49 CFR Part 172.

3.0 DEFINITIONS

HCl - Hydrochloric Acid
H_2SO_4- Sulfuric Acid
HNO_3 - Nitric Acid
$NaOH$ - Sodium Hydroxide

Normality (N) - Concentration of a solution expressed as equivalents per liter, where an equivalent is the amount of a substance containing one mole of replaceable hydrogen or its equivalent. Thus, a one molar solution of HCl, containing one mole of H, is "one-normal," while a one molar solution of H_2SO_4 containing two moles of H, is "two-normal."

4.0 RESPONSIBILITIES

Project Manager - The Project Manager is responsible for ensuring that project-specific plans are in accordance with these procedures, where applicable, or that other, approved procedures are developed. The Project Manager is responsible for development of documentation of procedures which deviate from those presented herein. The Project Manager is also responsible for proper certification of individuals responsible for transportation of samples of hazardous substances.

Field Team Leader - It is the responsibility of the Field Team Leader to ensure that these procedures are implemented in the field and to ensure that personnel performing sampling activities have been briefed and trained to execute these procedures. The Field Team Leader is responsible to ensure all samples and/or hazardous substances are properly identified, labeled, and packaged prior to transportation.

Sampling Personnel - It is the responsibility of the field sampling personnel to initiate sample preservation and handling. It is also the responsibility of the field sampling personnel to understand and adhere to the requirements for proper transportation of samples and/or hazardous substances.

5.0 PROCEDURES

The following procedures discuss sample containerization and preservation techniques that are to be followed when collecting environmental samples for laboratory analysis.

5.1 Sample Containers

For most samples and analytical parameters either glass or plastic containers are satisfactory. In general, if the analyte(s) to be measured is organic in nature, the container shall be made of glass. If the analyte(s) is inorganic, then glass or plastic containers may be used. Containers shall be kept out of direct sunlight (to minimize biological or photo-oxidation/photolysis of constituents) until they reach the analytical laboratory. The sample container shall have approximately five to ten percent air space ("ullage") to allow for expansion/vaporization if the sample is heated during transport (one liter of water at 4°C expands by 15 milliliters if heated to 130°F/55°C); however, head space for volatile organic analyses shall be omitted.

The analytical laboratory shall provide sample containers that have been certified clean according to USEPA procedures. Shipping containers for samples, consisting of sturdy ice chests, are to be provided by the laboratory.

Once opened, the sample container must be used at once for storage of a particular sample. Unused, but opened, containers are to be considered contaminated and must be discarded. Because of the potential for introduction of contamination, they cannot be reclosed and saved for later use. Likewise, any unused containers which appear contaminated upon receipt, or which are found to have loose caps or missing liners (if required for the container) shall be discarded.

General sample container, preservative, and holding time requirements are listed in Attachment A.

5.2 Preservation Techniques

The preservation techniques to be used for various analytes are listed in Attachment A. Reagents required for sample preservation will either be added to the sample containers by the laboratory prior to their shipment to the field or added in the field using laboratory supplied preservatives. Some of the more commonly used sample preservation techniques include storage of sample at a temperature of 4°C, acidification of water samples, and storage of samples in dark (i.e. amber) containers to prevent the samples from being exposed to light.

All samples shall be stored at a temperature of 4°C. Additional preservation techniques shall be applied to water samples as follows:

- Water samples to be analyzed for volatile organics shall be acidified.
- Water samples to be analyzed for semivolatile organics shall be stored in dark containers.
- Water samples to be analyzed for pesticides/PCBs shall be stored in dark containers.
- Water samples to be analyzed for inorganic compounds shall be acidified.

These preservation techniques generally apply to samples of low-level contamination. The preservation techniques utilized for samples may vary. However, unless documented otherwise in the project plans, all samples shall be considered low concentration. All samples preserved with chemicals shall be clearly identified by indicating on the sample label that the sample is preserved.

5.3 Sample Holding Times

The elapsed time between sample collection and initiation of laboratory analyses is considered the holding time and must be within a prescribed time frame for each individual analysis to be performed. Sample holding times for routine sample collection are provided in Attachment A.

6.0 SAMPLE HANDLING AND TRANSPORTATION

After collection, the outside of all sample containers will be wiped clean with a damp paper towel; however sample handling should be minimized. Personnel should use extreme care to ensure that samples are not contaminated. If samples are placed in an ice chest, personnel should ensure that melted ice cannot cause sample containers to become submerged, as this may result in sample cross-contamination and loss of sample labels. Sealable plastic bags, (zipper-type bags), should be used when glass sample containers are placed in ice chests to prevent cross-contamination, if breakage should occur.

Samples may be hand delivered to the laboratory or they may be shipped by common carrier. Relevant regulations for the storage and shipping of samples are contained in 40 CFR 261.4(d). Parallel state regulations may also be relevant. Shipment of dangerous goods by air cargo is also regulated by the United Nations/International Civil Aviation Organization (UN/ICAO). The Dangerous Goods Regulations promulgated by the International Air Transport Association (IATA) meet or exceed DOT and UN/ICAO requirements and should be used for shipment of dangerous goods via air cargo. Standard procedure for shipping environmental samples are given in Attachment B.

7.0 REFERENCES

American Public Health Association, 1981. Standard Methods for the Examination of Water and Wastewater. 15th Edition. APHA, Washington, D.C.

USEPA, 1984. "Guidelines Establishing Test Procedures for the Analysis of Pollutants under Clean Water Act." Federal Register, Volume 49 (209), October 26, 1984, p. 43234.

USEPA, 1979. Methods for Chemical Analysis of Water and Wastes. EPA-600/4-79-020. USEPA EMSL, Cincinnati, Ohio.

USEPA, Region IV, 1991. Environmental Compliance Branch Standard Operating Procedures and Quality Assurance Manual. Athens, Georgia.

Protection of the Environment, Code of Federal Regulation, Title 40, Parts 260 to 299.

Transportation, Code of Federal Regulation, Title 49, Parts 100 to 177.

ATTACHMENT A

REQUIRED CONTAINER, PRESERVATION TECHNIQUES AND HOLDING TIMES

ATTACHMENT A

SUMMARY OF CONTAINERS, PRESERVATION, AND HOLDING TIMES FOR AQUEOUS SAMPLES

Parameter	Bottle Requirements	Preservation Requirements	Holding Time [1]	Analytical Method	Bottle Volume
Volatile Organic Compounds (VOA)	glass teflon lined cap	Cool to 4°C 1:1 HCl pH <2	10 days	CLP	2 x 40 ml
Semivolatile Organic Compounds (SVOA)	glass teflon lined cap	Cool to 4°C Dark	Extraction within 5 days Analyze 40 days	CLP	2 x 1 liter
PCB/Pesticides	glass teflon lined cap	Cool to 4°C Dark	Extraction within 5 days Analyze 40 days	CLP	2 x 1 liter
Cyanide	plastic/glass	NaOH to pH>12 Cool to 4°C	14 days	CLP EPA 335.2	1 x 1 liter
Metals (TAL)	plastic/glass	HNO_3 to pH <2	180 days except Mercury is 26 days	CLP	1 x 1 liter
Total Organic Carbon	glass, teflon lined cap	Cool to 4°C H_2SO_4 to pH <2	28 days	EPA 415.1	2 x 40 ml
Total Organic Halogen	plastic/glass	Cool to 4°C H_2SO_4 to pH <2	28 days	EPA 450.1	250 ml
Chloride	plastic/glass	none required	28 days	EPA 325.2/325.3	250 ml
Sulfate	plastic/glass	Cool to 4°C	28 days	EPA 375.4	250 ml
Alkalinity	plastic/glass	Cool to 4°C	14 days	EPA 310.1/310.2	250 ml
Gross alpha/gross beta	plastic/glass	HNO_3 to pH <2	6 months	9310	1 gallon
Chlorinated herbicides	glass, teflon lined cap	Cool to 4°C	14/28 days	EPA 515.1	1000 ml
Hardness	plastic/glass	HNO_3 to pH <2	6 months	EPA 130.2	150 ml

(1) Holding times for CLP methods are based on Validated Time of Sample Receipt as stated in CLP statement of work of February, 1991. Holding times for Non-CLP methods are based on time of sample collection.

Note: Verify this information with the laboratory that will perform the analyses.

ATTACHMENT A (Continued)

SUMMARY OF CONTAINERS, PRESERVATION, AND HOLDING TIMES FOR SOIL SAMPLES

Parameter	Bottle Requirements	Preservation Requirements	Holding Time [1]	Analytical Method	Bottle Volume
Volatile Organic Compounds (VOA)	glass teflon lined cap	Cool to 4°C	10 days	CLP	1 x 50 gm
Semivolatile Organic Compounds (SVOA)	glass teflon lined cap	Cool to 4°C	Extraction within 10 days Analyze 40 days	CLP	1 x 250 gm
PCB/Pesticides	glass teflon lined cap	Cool to 4°C	Extraction within 10 days Analyze 40 days	CLP	1 x 50 gm
Metals (TAL)	plastic/glass	Cool to 4°C	Mercury is 26 days 180 days	CLP	1 x 50 gm
Cyanide	plastic/glass	Cool to 4°C	14 days	CLP EPA 335.2M	1 x 50 gm

[1] Holding times for CLP methods are based on Validated Time of Sample Receipt as stated in CLP statement of work of February, 1991. Holding times for Non-CLP methods are based on time of sample collection.

Note: Verify this information with the laboratory that will perform the analyses.

ATTACHMENT B

SAMPLE SHIPPING PROCEDURES

ATTACHMENT B

SAMPLE SHIPPING PROCEDURES

Introduction

Samples collected during field investigations or in response to a hazardous materials incident must be classified by the project leader, prior to shipping by air, as either environmental or hazardous substances. The guidance for complying with U.S. DOT regulations in shipping environmental laboratory samples is given in the "National Guidance Package for Compliance with Department of Transportation Regulations in the Shipment of Environmental Laboratory Samples."

Pertinent regulations for the shipping of environmental samples is given in 40 CFR 261.4(d). Samples collected from process wastewater streams, drums, bulk storage tanks, soil, sediment, or water samples from areas suspected of being highly contaminated may require shipment as dangerous goods/hazardous substance. Regulations for packing, marking, labeling, and shipping of dangerous goods by air transport are promulgated by the United Nations International Civil Aviation Organization (UN/ICAO),which is equivalent to IATA.

Individuals responsible for transportation of environmental samples or dangerous goods/hazardous substances must be tested and certified by their employer. This is required by 49 CFR Part 172 Subpart H Docket HM-126 to assure the required qualifications for individuals offering materials for transportation.

Environmental samples shall be packed prior to shipment by commercial air carrier using the following procedures:

1. Select a sturdy cooler in good repair. Secure and tape the drain plug (inside and outside) with fiber or duct tape. Line the cooler with a large heavy duty plastic bag. This practice keeps the inside of the cooler clean and minimizes cleanup at the laboratory after samples are removed.
2. Allow sufficient headspace (ullage) in all bottles (except VOAs) to compensate for any pressure and temperature changes (approximately 10 percent of the volume of the container).

3. Be sure the lids on all bottles are tight (will not leak). In many regions custody seals are also applied to sample container lids. The reason for this practice is two-fold: to maintain integrity of samples and keep lid on the container should the lid loosen during shipment. Check with the appropriate regional procedures prior to field work. In many cases, the laboratory manager of the analytical lot to be used on a particular project can also provide this information.

4. It is good practice to wrap all glass containers in bubblewrap or other suitable packing material prior to placing in plastic bags.

5. Place all bottles in separate and appropriately sized polyethylene bags and seal the bags with tape (preferably plastic electrical tape, unless the bag is a zipper-type bag). Up to three VOA bottles, separately wrapped in bubblewrap, may be packed in one plastic bag.

6. Optionally, place three to six VOA vials in a quart metal can and then fill the can with vermiculite.

7. Place two to four inches of vermiculite (ground corn cob, or other inert packing material) in the bottom of the cooler and then place the bottles and cans in the cooler with sufficient space to allow for the addition of more vermiculite between the bottles and cans.

8. Put frozen "blue ice" (or ice that has been placed in properly sealed, double-bagged, heavy duty polyethylene bags) on top of and between the samples. Fill all remaining space between the bottles or cans with packing material. Fold and securely fasten the top of the large heavy duty plastic bag with tape (preferably electrical or duct).

9. Place the Chain-of-Custody Record and the Request for Analysis Form (if applicable) into a plastic bag, tape the bag to the inner side of the cooler lid, and then close the cooler and securely tape (preferably with fiber tape) the top of the cooler unit. Wrap the tape three to four times around each side of the cooler unit. Chain-of-custody seals should be affixed to the top and sides of the cooler within the securing tape so that the cooler cannot be opened without breaking the seal.

10. Each cooler (if multiple coolers) should have its own Chain-of-Custody Record reflecting the samples shipped in that cooler.

11. Label according to 40 CFR 261.4(d). The shipping containers should be marked "THIS END UP," and arrow labels which indicate the proper upward position of the container should be affixed to the container. A label containing the name and address of the shipper and laboratory shall be placed on the outside of the container. It is good practice to secure this label with clear plastic tape to prevent removal during shipment by blurring of important information should the label become wet. The commercial carrier is not required to sign the COC record as long as the custody seals remain intact and the COC record stays in the cooler. The only other documentation required is the completed airbill, which is secured to the top of the shipping container. Please note several coolers/shipping containers may be shipped under one airbill. However, each cooler must be labeled as "Cooler 1 of 3, Cooler 2 of 3, etc.", prior to shipping. Additionally it is good practice to label each COC form to correspond to each cooler (i.e., 1 of 3, 2 of 3, etc.).

APPENDIX J
CHAIN-OF-CUSTODY

CHAIN-OF-CUSTODY
TABLE OF CONTENTS

1.0 PURPOSE

2.0 SCOPE

3.0 DEFINITIONS

4.0 RESPONSIBILITIES

5.0 PROCEDURES
- 5.1 Sample Identification
- 5.2 Chain-of-Custody Procedures

6.0 QUALITY ASSURANCE RECORDS

7.0 REFERENCES

CHAIN-OF-CUSTODY

1.0 PURPOSE

The purpose of this SOP is to provide information on chain-of-custody procedures to be used to document sample handling.

2.0 SCOPE

This procedure describes the steps necessary for transferring samples through the use of Chain-of-Custody Records. A Chain-of-Custody Record is required, without exception, for the tracking and recording of samples collected for on-site or off-site analysis (chemical or geotechnical) during program activities (except wellhead samples taken for measurement of field parameters, SOP F101). Use of the Chain-of-Custody Record Form creates an accurate written record that can be used to trace the possession and handling of the sample from the moment of its collection through analysis. This procedure identifies the necessary custody records and describes their completion. This procedure does not take precedence over region-specific or site-specific requirements for chain-of-custody.

3.0 DEFINITIONS

Chain-of-Custody Record Form - A Chain-of-Custody Record Form is a printed two-part form that accompanies a sample or group of samples as custody of the sample(s) is transferred from one custodian to another custodian. One copy of the form must be retained in the project file.

Custodian - The person responsible for the custody of samples at a particular time, until custody is transferred to another person (and so documented), who then becomes custodian. A sample is under one's custody if:

- It is in one's actual possession.
- It is in one's view, after being in one's physical possession.
- It was in one's physical possession and then he/she locked it up to prevent tampering.
- It is in a designated and identified secure area.

Sample - A sample is physical evidence collected from a facility or the environment, which is representative of conditions at the point and time that it was collected.

4.0 RESPONSIBILITIES

Project Manager - The Project Manager is responsible for ensuring that project-specific plans are in accordance with these procedures, where applicable, or that other, approved procedures are developed. The Project Manager is responsible for development of documentation of procedures which deviate from those presented herein. The Project Manager is responsible for ensuring that chain-of-custody procedures are implemented. The Project Manager also is responsible for determining that custody procedures have been met by the analytical laboratory.

Field Team Leader - The Field Team Leader is responsible for determining that chain-of-custody procedures are implemented up to and including release to the shipper or laboratory. It is the responsibility of the Field Team Leader to ensure that these procedures are implemented in the field and to ensure that personnel performing sampling activities have been briefed and trained to execute these procedures.

Sampling Personnel - It is the responsibility of the field sampling personnel to initiate chain-of-custody procedures, and maintain custody of samples until they are relinquished to another custodian, the sample shipper, or to a common carrier.

5.0 PROCEDURES

The term "chain-of-custody" refers to procedures which ensure that evidence presented in a court of law is valid. The chain-of-custody procedures track the evidence from the time and place it is first obtained to the courtroom, as well as providing security for the evidence as it is moved and/or passed from the custody of one individual to another.

Chain-of-custody procedures, recordkeeping, and documentation are an important part of the management control of samples. Regulatory agencies must be able to provide the chain-of-possession and custody of any samples that are offered for evidence, or that form the basis of analytical test results introduced as evidence. Written procedures must be available and followed whenever evidence samples are collected, transferred, stored, analyzed, or destroyed.

5.1 Sample Identification

The method of identification of a sample depends on the type of measurement or analysis performed. When in-situ measurements are made, the data are recorded directly in bound logbooks or other field data records with identifying information.

Information which shall be recorded in the field logbook, when in-situ measurements or samples for laboratory analysis are collected, includes:

- Field Sampler(s)
- CTO Number
- Project Sample Number
- Sample location or sampling station number
- Date and time of sample collection and/or measurement
- Field observations
- Equipment used to collect samples and measurements
- Calibration data for equipment used

Measurements and observations shall be recorded using waterproof ink.

5.1.1 Sample Label

Samples, other than in-situ measurements, are removed and transported from the sample location to a laboratory or other location for analysis. Before removal, however, a sample is often divided into portions, depending upon the analyses to be performed. Each portion is preserved in accordance with the Sampling and Analysis Plan. Each sample container is identified by a sample label (see Attachment A). Sample labels are provided, along with sample containers, by the analytical laboratory. The information recorded on the sample label includes:

- Project or Contract Task Order (CTO) Number.
- Station Location – The unique sample number identifying this sample.
- Date – A six-digit number indicating the day, month, and year of sample collection (e.g., 12/21/85).
- Time – A four-digit number indicating the 24-hour time of collection (for example: 0954 is 9:54 am., and 1629 is 4:29 p.m.).
- Medium – Water, soil, sediment, sludge, waste, etc.
- Sample Type – Grab or composite.
- Preservation – Type and quantity of preservation added.
- Analysis – VOA, BNAs, PCBs, pesticides, metals, cyanide, other.
- Sampled By – Printed name of the sampler.
- Remarks – Any pertinent additional information.

Using only the work assignment number of the sample label maintains the anonymity of sites. This may be necessary, even to the extent of preventing the laboratory performing the analysis from knowing the identity of the site (e.g., if the laboratory is part of an organization that has performed previous work on the site).

5.2 Chain-of-Custody Procedures

After collection, separation, identification, and preservation, the sample is maintained under chain-of-custody procedures until it is in the custody of the analytical laboratory and has been stored or disposed.

5.2.1 Field Custody Procedures

- Samples are collected as described in the site Sampling and Analysis Plan. Care must be taken to record precisely the sample location and to ensure that the sample number on the label matches the Chain-of-Custody Record exactly.

- The person undertaking the actual sampling in the field is responsible for the care and custody of the samples collected until they are properly transferred or dispatched.

- When photographs are taken of the sampling as part of the documentation procedure, the name of the photographer, date, time, site location, and site description are entered sequentially in the site logbook as photos are taken. Once developed, the photographic prints shall be serially numbered, corresponding to the logbook descriptions; photographs will be stored in the project files. It is good practice to identify sample locations in photographs by including an easily read sign with the appropriate sample/location number.

- Sample labels shall be completed for each sample, using waterproof ink unless prohibited by weather conditions, e.g., a logbook notation would explain that a pencil was used to fill out the sample label if the pen would not function in freezing weather.

5.2.2 Transfer of Custody and Shipment

Samples are accompanied by a Chain-of-Custody Record Form. A Chain-of-Custody Record Form example is shown in Attachment B. When transferring the possession of samples, the individual(s) relinquishing and receiving will sign, date, and note the time on the Record. This Record documents sample custody transfer from the sampler, often through another person, to the analyst in the laboratory. The Chain-of-Custody Record is filled out as given below.

- Enter header information (CTO number, samplers, and project name).

- Enter sample specific information (sample number, media, sample analysis required and analytical method, grab or composite, number and type of sample containers, and date/time sample was collected).

- Sign, date, and enter the time under "Relinquished by" entry.

- Have the person receiving the sample sign the "Received by" entry. If shipping samples by a common carrier, print the carrier to be used in this space (i.e., Federal Express).

- If a carrier is used, enter the airbill number under "Remarks," in the bottom right corner;

- Place the original (top, signed copy) of the Chain-of-Custody Record Form in a plastic zipper-type bag or other appropriate sample shipping package. Retain the copy with field records.

- Sign and date the custody seal, a 1- by 3-inch white paper label with black lettering and an adhesive backing. Attachment C is an example of a custody seal. The custody seal is part of the chain-of-custody process and is used to prevent tampering with samples after they have been collected in the field. Custody seals shall be provided by the analytical laboratory.

- Place the seal across the shipping container opening so that it would be broken if the container was to be opened.

- Complete other carrier-required shipping papers.

The custody record is completed using waterproof ink. Any corrections are made by drawing a line through and initialing and dating the change, then entering the correct information. Erasures are not permitted.

Common carriers will usually not accept responsibility for handling Chain-of-Custody Record Forms; this necessitates packing the record in the shipping container (enclosed with other documentation in a plastic zipper-type bag). As long as custody forms are sealed inside the shipping container and the custody seals are intact, commercial carriers are not required to sign the custody form.

The laboratory representative who accepts the incoming sample shipment signs and dates the Chain-of-Custody Record, completing the sample transfer process. It is then the laboratory's responsibility to maintain internal logbooks and custody records throughout sample preparation and analysis.

6.0 QUALITY ASSURANCE RECORDS

Once samples have been packaged and shipped, the COC copy and airbill receipt becomes part of the Quality Assurance Record.

7.0 REFERENCES

1. USEPA. User's Guide to the Contract Laboratory Program. Office of Emergency and Remedial Response, Washington, D.C. (EPA/540/P-91/002), January 1991.

ATTACHMENT A

EXAMPLE SAMPLE LABEL

Note: Typically, sample labels are provided by the analytical laboratory and may be used instead of the above. However, samplers should make sure all pertinent information can be affixed to the label used.

ATTACHMENT B

EXAMPLE CHAIN-OF-CUSTODY RECORD

Baker
Baker Environmental, Inc

Baker Environmental, Inc.
Airport Office Park, Bldg. 3
420 Rouser Road
Coraopolis, PA 15108
412-269-6000
412-269-6097 (fax)

CHAIN-OF-CUSTODY RECORD

Pg. __ of __

Project Number: ______________________
Project Name: ______________________
Field Team: ______________________
SEND RESULTS TO: ______________________

Sample Number	Date	Time	Sample Location	Matrix Type (1)		Analytical Methods / Preservatives												General Comments
						Type of Container(s) (3)												
				GB (2)	COM. (2)	Number of Container(s)												Remarks

Relinquished By: ______________________ Date: __________ Time: __________
Received By: ______________________ Date: __________ Time: __________
Shipped by (check one): Hand ☐ Overnight ☐ Other ☐ ______________

Relinquished By: ______________________ Date: __________ Time: __________
Received By: ______________________ Date: __________ Time: __________
Shipped by (check one): Hand ☐ Overnight ☐ Other ☐ ______________

Relinquished By: ______________________ Date: __________ Time: __________
Received By: ______________________ Date: __________ Time: __________
Shipped by (check one): Hand ☐ Overnight ☐ Other ☐ ______________

Sample Stored at 4°C: Yes ☐ No ☐
Chain-of-custody seal on cooler: Yes ☐ Number: __________ No ☐
Analysis turnaround: Priority ☐ ________hrs. Regular ☐
See Work Order ☐
See Analysis Request Form ☐

Sample Disposal: Return to Baker ☐ Lab Disposal ☐
Archive until: ______________________ (date)

NOTES:

(1) A - Air
GW - Groundwater
S - Spring
SO - Soil
SW - Surface water
W - Waste
WP - Wipe
WW - Wastewater

(2) GB - Grab
COM - Composite

(3) P - Plastic
G - Glass

White - Return with analytical results; Yellow - Laboratory Copy; Pink - Field Copy

7/94

ATTACHMENT C

EXAMPLE CUSTODY SEAL

Baker _____/_____/_____ **Date** ____________________ **Signature** **CUSTODY SEAL**	**Baker** _____/_____/_____ **Date** ____________________ **Signature** **CUSTODY SEAL**

APPENDIX K
FIELD LOGBOOK

FIELD LOGBOOK
TABLE OF CONTENTS

1.0 PURPOSE

2.0 SCOPE

3.0 DEFINITIONS

4.0 RESPONSIBILITIES

5.0 PROCEDURES
- 5.1 Cover
- 5.2 Daily Entries
- 5.3 Photographs

6.0 QUALITY ASSURANCE RECORDS

7.0 REFERENCES

FIELD LOGBOOK

1.0 PURPOSE

This SOP describes the process for maintaining a field logbook.

2.0 SCOPE

The field logbook is a document which records all major on-site activities conducted during a field investigation. At a minimum, the following activities/events shall be recorded in the field logbook by each member of the field crew.

- Arrival/departure of site workers and visitors
- Arrival/departure of equipment
- Sample pickup (sample numbers, carrier, time)
- Sampling activities
- Start or completion of boreholes, monitoring wells, or sampling activities
- Health and safety issues

The field logbook is initiated upon arrival at the site for the start of the first on-site activity. Entries are made every day that on-site activities take place. At least one field logbook shall be maintained per site.

The field logbook becomes part of the permanent site file. Because information contained in the field logbook may be admitted as evidence in legal proceedings, it is critical that this document is properly maintained.

3.0 DEFINITIONS

Field logbook - The field logbook is a bound notebook with consecutively numbered pages. Upon entry of data, the logbook requires the signature of the responsible data/information recorder.

4.0 RESPONSIBILITIES

The Field Team Leader is responsible for maintaining a master field logbook for the duration of on-site activities. Each member of the sampling crew is responsible for maintaining a complete and accurate record of site activities for the duration of the project.

5.0 PROCEDURES

The following sections discuss some of the information which must be recorded in the field logbook. In general, a record of all events and activities, as well as other potentially important information shall be recorded by each member of the field team.

5.1 Cover

The inside cover or title page of each field logbook shall contain the following information:

- Contract Task Order Number
- Project name and location
- Name of Field Team Leader
- Baker's address and telephone number
- Start date
- If several logbooks are required, a sequential field logbook number

It is good practice to list important phone numbers and points of contact here.

5.2 Daily Entries

Daily entries into the logbook may contain a variety of information. At the beginning of each day the following information must be recorded by each team member.

- Date
- Start time
- Weather
- All field personnel present
- All visitors present
- Other pertinent information (i.e., planned activities, schedule changes, expected visitors, and equipment changes)

During the day, an ongoing record of all site activities should be written in the logbook. The master logbook kept by the field team leader need not duplicate that recorded in other field logbooks, but should summarize the information in other books and, where appropriate, reference the page numbers of other logbooks where detailed information pertaining to a subject may be found.

Some specific information which must be recorded in the logbook includes:

- Equipment used, equipment numbers, calibration, field servicing
- Field measurements
- Sample numbers, media, bottle size, preservatives, collection methods, and time
- Test boring and monitoring well construction information, including boring/well number and location
- Sketches for each sample location including appropriate measurements if required.
- Photograph log
- Drum log
- Other pertinent information

All entries should be made in indelible ink; all pages numbered consecutively; and all pages must be signed or initialed and dated by the responsible field personnel completing the log. No erasures are permitted. If an incorrect entry is made, the entry shall be crossed out with a single line, initialed, and dated.

5.3 Photographs

If photographs are permitted at a site, the record shall be maintained in the field logbook. When movies, slides or photographs are taken of any site location, they are numbered or cross-referenced to correspond to logbook entries. The name of the photographer, date, time, site location, site description, direction of view and weather conditions are entered in the logbook as the photographs are taken. Special lenses, film, or other image-enhancement techniques also must be noted in the field logbook. Once processed, photographs shall be serially numbered and labeled corresponding to the field logbook entries. Note that it may not be permitted to take photographs at all Activities; permission must be obtained from the LANTDIV EIC and the Activity responsible individual.

6.0 QUALITY ASSURANCE RECORDS

Once on-site activities have been completed, the field logbook shall be considered a quality assurance record.

7.0 REFERENCES

None.

FINAL

SITE EVALUATION
QUALITY ASSURANCE PROJECT PLAN

OPERABLE UNIT NO. 15 (SITE 88)
MCB CAMP LEJEUNE, NORTH CAROLINA

CONTRACT TASK ORDER 0356

FEBRUARY 21, 1997

Prepared for:

DEPARTMENT OF THE NAVY
ATLANTIC DIVISION
NAVAL FACILITIES
ENGINEERING COMMAND
Norfolk, Virginia

Under:

LANTDIV CLEAN Program
Contract N62470-89-D-4814

Prepared by:

BAKER ENVIRONMENTAL, INC.
Coraopolis, Pennsylvania

TABLE OF CONTENTS

Page

1.0 INTRODUCTION 1-1

2.0 SCOPE OF QUALITY ASSURANCE PROJECT PLAN 2-1

3.0 PROJECT DESCRIPTION 3-1

4.0 PROJECT ORGANIZATION 4-1

5.0 QUALITY ASSURANCE OBJECTIVES FOR DATA MEASUREMENT ... 5-1
5.1 Project Quality Assurance Objectives 5-1
5.2 Data Quality Objectives 5-2

6.0 SAMPLE AND DOCUMENT CUSTODY PROCEDURES 6-1
6.1 Sampling Handling 6-1
6.2 Chain-of-Custody Procedures 6-1
6.3 Document Custody Procedures 6-3

7.0 CALIBRATION PROCEDURES AND FREQUENCY 7-1
7.1 Field Instruments 7-1
7.2 Laboratory Instruments 7-1
7.2.1 Method Calibration 7-2
7.2.2 GC/MS System Calibration Procedure 7-2
7.2.3 Periodic Calibration 7-3

8.0 ANALYTICAL PROCEDURES 8-1
8.1 Field Analysis 8-1
8.2 Laboratory Analysis 8-1

9.0 DATA REDUCTION, VALIDATION AND REPORTING 9-1
9.1 Field Data Procedures 9-1
9.2 Laboratory Data Procedures 9-1
9.2.1 Laboratory Data Validation 9-1
9.2.2 Analytical Reports 9-2
9.3 Independent (Third Party) Data Validation 9-2

10.0 INTERNAL QUALITY CONTROL CHECKS 10-1
10.1 Field Quality Control Checks 10-1
10.2 Laboratory Quality Control Checks 10-2
10.3 Laboratory Control Limits 10-3

11.0 PERFORMANCE AND SYSTEM AUDITS 11-1

TABLE OF CONTENTS
(Continued)

Page

12.0 **PREVENTIVE MAINTENANCE** **12-1**
12.1 Field Maintenance 12-1
12.2 Laboratory Maintenance 12-1

13.0 **DATA MEASUREMENT ASSESSMENT PROCEDURES** **13-1**
13.1 Overall Project Assessment 13-1
13.2 Field Quality Assessment 13-1
13.3 Laboratory Data Quality Assessment 13-1

14.0 **CORRECTIVE ACTION** **14-1**
14.1 Limits of Operation 14-1
14.2 Corrective Action 14-1

15.0 **QUALITY ASSURANCE REPORTING PROCEDURES** **15-1**

LIST OF TABLES

5-1 Definitions of Data Quality Indicators

6-1 Summary of Containers, Preservation, and Holding Times for Aqueous Samples
6-2 Summary of Containers, Preservation, and Holding Times for Solid Samples

8-1 Organic Method Performance Limits
8-2 Engineering Parameter Method Performance Limits

10-1 QA/QC Sample Frequency

11-1 Field Site Audit Inspection Form

LIST OF FIGURES

4-1 Project Organization Chart

LIST OF ACRONYMS AND ABBREVIATIONS

ASTM	American Society of Testing and Materials
BOD	biological oxygen demand
CCC	Calibration Check Compound
CERCLA	Comprehensive Environmental Response, Compensation and Liability Act
CLEAN	Comprehensive Long-Term Environmental Action Navy
CLEJ	Camp Lejeune
CLP	Contract Laboratory Program
COC	Chain-of-Custody
COD	Chemical Oxygen Demand
DOD	Department of the Defense
DoN	Department of the Navy
DQO	Data Quality Objective
°F	degrees Fahrenheit
FSAP	Field Sampling and Analysis Plan
ft	feet
GC/MS	Gas Chromatograph/Mass Spectrometer
LANTDIV	Naval Facilities Engineering Command, Atlantic Division
µg/L	micrograms per liter
µg/kg	micrograms per kilogram
MCL	maximum contaminant level
MWR	Morale, Welfare and Recreation
NCRs	Navy Contract Representatives
NEESA	Navy Energy and Environmental Support Activity
NFESC	Naval Facilities Environmental Service Center
NTR	Navy Technical Representative
OU	operable unit
ppb	parts per billion
ppm	parts per million
QA/QC	quality assurance/quality control
QAPP	Quality Assurance Project Plan
RAC	Remediation Contractor
RRF	Relative Response Factor
SARA	Superfund Amendments and Reauthorization Act
SOP	Standard Operating Procedure

LIST OF ACRONYMS AND ABBREVIATIONS
(Continued)

TAL	Target Analyte List
TCL	Target Compound List
TCLP	Toxicity Characteristics Leaching Procedure
TDS	total dissolved solids
TOC	total organic carbon
TSS	total suspended solids
USEPA	United States Environmental Protection Agency

1.0 INTRODUCTION

This Quality Assurance Project Plan (QAPP) has been developed for the field investigation at Operable Unit (OU) No. 15, Marine Corps Base, Camp Lejeune, North Carolina. OU 15 consists of Site 88 (Building 25 - MWR Dry Cleaners).

The preparation of this QAPP, and other related project plans (Work Plan, Field Sampling and Analysis Plan, and Health and Safety Plan), is being performed under the Navy CLEAN Contract No. N62470-89-D-4814, Contract Task Order 0356. Baker Environmental, Inc. (Baker), is the prime contractor for the implementation of this project.

This QAPP addresses the quality assurance and quality control steps and procedures that will be administered for the sample collection and analysis for this Site Evaluation. Detailed information regarding sample handling and analytical methods are provided in Sections 6.0 and 9.0, respectively. Sample collection procedures are provided in the Field Sampling and Analysis Plan (FSAP).

2.0 SCOPE OF QUALITY ASSURANCE PROJECT PLAN

This Quality Assurance Project Plan (QAPP) addresses sample collection and analysis to be conducted for the field investigation at Site 88, Camp Lejeune, North Carolina. The QAPP has been developed for the Department of Navy (DoN) in accordance with U.S. Environmental Protection Agency (USEPA) guidelines. Contractors will follow QA/QC practices and procedures, including chain-of-custody procedures, while conducting all sample collection and analysis activities.

In order to provide adequate QA/QC, this investigation will require:

1. Use of a Naval Facilities Environmental Service Center (NFESC) certified analytical laboratories;

2. Use of accepted analytical methods for the samples are discussed in the FSAP. Analysis of samples for hazardous constituents parameters will be performed using the following documents:

    - "Statement of Work for Organic Analysis," USEPA, OLM03.1, September 1994

    - "Test Methods for Evaluating Solid Waste," USEPA, November 1986, 3rd Edition

    - "Hazardous Waste Management System; Identification and Listing of Hazardous Waste; Toxicity Characteristics Revisions; Final Rule," USEPA, 52 FR 26886

3. Conducting field audit(s) during initial sampling activities to verify that sampling is being performed according to the Plan.

The structure of this QAPP and the QA elements addressed are:

- Title Page
- Table of Contents
- Introduction
- QAPP Scope
- Project Description
- Project Organization
- QA Objectives for Data Measurement
- Sampling Procedures
- Sample and Document Custody
- Calibration Procedures and Frequency
- Analytical Procedures
- Data Reduction, Validation, and Reporting
- Internal QC Checks
- Performance and System Audits
- Preventive Maintenance

- Data Measurement Assessment Procedures
- Corrective Action
- QA Reports to Management

3.0 PROJECT DESCRIPTION

The site evaluation at OU No. 15 (Site 88) is being completed in two phases. Phase I of the investigation was conducted in August 1996. Results of this investigation are provided in the Draft Phase I Investigation Report (Baker, 1996). This investigation provided the framework for preparing the Phase II Study. Further details of the investigation at Site 88 including a description of the project objectives and scope are given in the Work Plan. This Work Plan discusses the objectives of the Phase II Site Investigation, and the various field sampling and analytical programs. A detailed description of the field investigations, including sample location and designation and sampling procedures and frequency, is presented in the FSAP.

4.0 PROJECT ORGANIZATION

Technical performance of the investigation at Site 88 and key personnel responsible for quality assurance throughout its duration are described in Section 5.0 of the Work Plan. The contractor will utilize subcontractors to perform laboratory analysis, data validation, drilling and monitoring well installation, and surveying. Specific subcontractors have not yet been identified. Figure 4-1 shows the project organization, lines of authority, and support personnel/organizations.

5.0 QUALITY ASSURANCE OBJECTIVES FOR DATA MEASUREMENT

The purpose of a quality assurance (QA) Program is to establish policies for the implementation of regulatory requirements and to provide an internal means for control and review so that the work performed is of the highest professional standards.

5.1 Project Quality Assurance Objectives

The following is a list of QA objectives which will be implemented at Operable Unit No. 15 (Site 88).

- Obtain scientific data of a quality sufficient to meet scientific and legal scrutiny.
- Gather/develop data in accordance with procedures appropriate for its intended use.
- Ensure that data is of acceptable precision, accuracy, completeness, representativeness, and comparability as required by the project.

The fundamental mechanisms that will be employed to achieve these quality goals can be categorized as prevention, assessment and correction where:

- Prevention of errors through planning, documented instructions and procedures, and careful selection and training of skilled, qualified personnel.
- Assessment of all quality assurance sampling reports furnished by the contract laboratory.
- Assessment of data through data validation, and of procedures through laboratory and field audits.
- Correction for prevention of reoccurrence of conditions adverse to quality.

This QAPP, prepared in direct response to these goals, describes the QA Program to be implemented and the quality control (QC) procedures to be followed by field and laboratory personnel during the course of the project. The document also presents the project organization and specifies or references technical procedures, documentation requirements, sample custody requirements, audit, and corrective action provisions to be applied to provide confidence that all activities meet the intent of the QA program. This QAPP has been prepared in accordance with USEPA guidance as presented in "Interim Guidelines and Specifications for Preparing Quality Assurance Project Plans," QAMS-005/80.

The procedures contained or referred to herein have been taken from:

- "Statement of Work for Organic Analysis," USEPA , OLM03.1, August 1991
- "Test Methods for Evaluating Solid Waste," USEPA SW846, November 1986, 3rd Edition

- "Hazardous Waste Management System; Identification and Listing of Hazardous Waste; Toxicity Characteristics Revisions; Final Rule," USEPA, 52 FR 26886

- "Interim Guidelines and Specifications for Preparing Quality Assurance Project Plans," USEPA, (QAMS 005/80).

5.2 Data Quality Objectives

Data quality objectives (DQOs) are qualitative or quantitative statements developed by the data users to specify the quality of data needed from a particular data collection activity to support a specific decision. The DQOs are expressed in terms of precision, accuracy, representativeness, completeness, and comparability. Definitions for these terms, as well as for the more general term uncertainty, are given in Table 5-1.

The Project Manager, in conjunction with the Navy Environmental Technical Representative (NTR), is responsible for defining the DQOs. The intended use of the data, analytical measurements, and the availability of resources are integral in development of DQOs. DQOs define the level of uncertainty in the data that is acceptable for each specific activity during the investigation. This uncertainty includes both field sampling error and analytical instrument error. Ideally, zero uncertainty is the goal; however, the variables associated with sampling and analysis contribute to a degree of uncertainty in any data generated. It is an overall program objective to keep the total uncertainty within an acceptable range, so as not to hinder the intended use of the data. To achieve this objective, specific data quality requirements such as detection limits, criteria for accuracy and precision, sample representativeness, data comparability, and data completeness have been specified.

The data collected will be used:

- To evaluate the presence or absence of contamination resulting from previous disposal activities.

- To assess potential contaminant migration and exposure pathways.

- To monitor health and safety conditions during field activities.

- To identify releases or suspected releases of hazardous waste and/or constituents.

- To screen from further investigation those areas which do not pose a threat to human health or environment.

All samples for characterizing the site or qualitatively assessing human health and environmental risks will be analyzed and reported by the mobile laboratory as Level III data (NFESC Level C) and fixed-based laboratory as Level IV data (NFESC Level D). All samples collected for engineering evaluation will be analyzed and reported by the laboratory as Level II (NFESC Level B). Field parameters including temperature (aqueous only) and specific conductance will be Level I (NFESC Level A) data quality.

6.0 SAMPLE AND DOCUMENT CUSTODY PROCEDURES

Descriptions of the procedures to be used for sampling the groundwater and soil at the site are provided in the FSAP. The number of samples, sampling locations, and sampling rationale by media also are presented in Section 5.0 of the FSAP.

Sample custody procedures outlined in this section have been developed from "User's Guide to the Contract Laboratory Program," December 1988, OSWER Directive No. 9240.0-01. These procedures are in accordance with "EPA NEIC Policies and Procedure Manual," May 1978, revised November 1984, EPA 330-78-001-R and "Interim Guidelines and Specifications for Preparing Quality Assurance Project Plans," December 1980, QAMS-005/80.

The purpose of this section is to outline the sample handling and sample documentation procedures to be used during implementation of the FSAP. The objective of the sample handling procedures is to deliver representative samples to the laboratories for analysis. The objectives of the sample documentation procedures are to: (1) ensure complete analysis of the requested parameters within the required turnaround times; and (2) document the sample from the point of collection to the final data report.

6.1 Sampling Handling

New polyethylene or glass bottles containing the proper preservatives will be provided by the laboratory for sample collection. In addition to the chemical preservatives, samples will be stored on ice at 4°C in a waterproof metal or sturdy plastic cooler, if required (see Tables 6-1 through 6-2 for summaries of containers, preservation, and holding times for water and solids, respectively).

6.2 Chain-of-Custody Procedures

A sample is considered to be in an individual's possession if:

- It is in the sampler's possession or it is in the sampler's view after being in his or her possession.
- It was in the sampler's possession and then locked or sealed to prevent tampering.
- It is in a secure area.

Five kinds of documentation will be used in tracking and shipping the analytical samples:

- Field log book
- Sample labels
- Chain-of-Custody (COC) records
- Custody seals
- Commercial carrier airbills

At a minimum, the label for each sample bottle will contain the following information:

- Site name
- Sample number

- Date and time of collection
- Sample type (grab or composite)
- Matrix
- Sampler's initials

The sample information, as well as the analysis to be performed on the sample, will be entered in the field log book for each sampling point. Section 6.0 of the FSAP also contains a list of information to be included in the field logbook for each media that is to be sampled. Additionally, the following items will be entered:

- Dates and times of entry
- Names of field personnel on site
- Names of visitors on site
- Field conditions
- Description of activities
- Sampling remarks and observations
- QA/QC samples collected
- List of photographs taken
- Sketch of site conditions

Custody of the samples will be maintained by field personnel from the time of sampling until the time they are forwarded to the analytical laboratory.

The sample custody is documented using COC records. Field personnel will complete a COC record, in waterproof ink, to accompany each cooler forwarded from the site to the laboratory. Chemical reagents used to preserve the samples will be recorded on the COC record. Any errors on the COC records will not be erased; instead, a line will be drawn through the error and initialed by the person completing the form. The original copy will be placed in a sealable plastic bag and put inside the appropriate cooler, secured to the cooler's lid.

If the sample cooler is to be shipped by commercial air carrier, the cooler must be secured with custody seals so that the seals would be broken if the cooler was opened. The commercial carrier is not required to sign the COC record as long as the custody seals remain intact and the COC record stays in the cooler. The only other documentation required is the completed airbill.

If the sample shipment is hand delivered to the laboratory by field personnel or retrieved by laboratory personnel at the site, then the custody seals are not necessary. The laboratory sample custodian, or his/her designee accepting the sample shipment, whether it is from the air carrier or the field personnel, signs and dates the COC record upon sample receipt. The original COC record will be returned along with the final data report. The laboratory will be responsible for maintaining internal log books and records that provide a custody record during sample preparation and analysis.

Laboratory Chain-of-Custody Procedures

Upon sample receipt the steps below will be performed.

- Samples will be received and unpacked in the laboratory where the staff checks for bottle integrity (loose caps, broken bottles, etc.).

- Samples will be verified with incoming paperwork (packing slip, etc.) by type of bottle and stabilizer. The paperwork must be either signed or initialed.

- Information concerning the sample (from the sampling record, Chain-of-Custody, and observation) will be recorded along with parameters to be analyzed, date of sampling, and date the sample is received in the laboratory.

- Samples will be placed in an appropriate secured storage area until analysis.

- When analysis is complete, samples will be stored for a 30-day period unless otherwise specified.

If collected samples arrive without Chain-of-Custody or incorrect Chain-of-Custody records, the following steps will be taken:

- The laboratory will prepare a nonconformance form stating the problem.

- The site supervisor and Project Manager will be notified.

- If the missing information cannot be provided by the field staff, the samples affected will not be analyzed.

Primary considerations for sample storage are:

- Secured storage.

- Maintain prescribed temperature, if required, which is typically four degrees Celsius.

- Extract and/or analyze samples within the prescribed holding time for the parameters of interest.

6.3 Document Custody Procedures

Project records are necessary to support the validity of the work and to furnish documentary evidence of quality. The evidentiary value of data is dependent upon the proper maintenance and retrieval of quality assurance records. Therefore, procedures will be established to assure that all documents attesting to the validity of work can be accounted for when the work is completed.

Records must be legible, filled out completely, and adequately identified as to the item or activity involved. Records will be considered valid only if initialed, signed, or otherwise authenticated and dated by authorized personnel. These records may either be originals or reproduced copies. Records submitted to the files, with the exception of correspondence, will be bound, placed in folders or binders, or otherwise secured for filing.

Following receipt of information from external sources, completion of analyses, and issuance of reports or other transmittals, associated records will be submitted to the proper file. In addition, transmitted records must be adequately protected from damage and loss during transfer (e.g, hand carrying or making copies prior to shipment).

The following documents will be transferred to the proper files during the course of the project: calculations and checkprints; reports and other data transmittals; copies of proposals, purchase orders for project services, and contracts; correspondence including incoming and outgoing letters, memoranda, and telephone records; and reference material.

All individuals on the project staff will be responsible for reporting obsolete or superseded project-related information to the Project Manager. In turn, the Project Manager will notify the project and laboratory staffs of the resulting status change in project documents, such as drawings and project procedures.

In general, outdated drawings and other documents will be marked "void." However, the Project Manager may request the copies be destroyed. One copy of void documents is maintained in the project files with the reasons, and date of voiding clearly indicated.

Documents will be marked "preliminary" to denote calculations and other material which have not been formally checked, or based on information which has not been checked, or do not contribute to final project information.

7.0 CALIBRATION PROCEDURES AND FREQUENCY

The following section describes calibration procedures and frequency.

7.1 Field Instruments

Two field instruments will be used for health and safety monitoring: the O_2/LEL meter, and the HNu System portable photoionizer. These instruments will be calibrated on site daily according to the manufacturer's instructions in addition to the factory calibration it will receive prior to the start of site sampling. The calibration standards will be recorded in the field log book.

A pH meter, conductivity meter, and a temperature probe will be used to analyze groundwater samples. Procedures from "Test Methods for Evaluating Solid Waste," USEPA, SW846, November 1986, 3rd Edition will be used to calibrate these meters. Other instruments used to measure water quality parameters include a dissolved oxygen meter and turbidity meter. These instruments will be calibrated on a daily basis according to the manufacturer's instructions. Specific procedures for the calibration of water quality instruments are presented in the FSAP.

7.2 Laboratory Instruments

The laboratory's procedures for calibration and related quality control measures will be conducted according to the protocols presented in the following documents:

- "Statement of Work for Organic Analysis," USEPA, OLM03.1, August 1991
- "Test Methods for Evaluating Solid Waste," USEPA SW846, November 1986, 3rd Edition

Formal calibration procedures will be established to ensure that instrumentation and equipment used for sample analysis are accurately calibrated and properly functioning. These procedures will apply to all instruments and equipment quantities. All calibrations will be performed by laboratory personnel or external agencies using standard reference materials.

All calibrations will be recorded on in-house calibration forms or instrument vendor forms or in dedicated bound notebooks. The following data will be recorded for all calibrations: the date, target readings, actual readings, instrument identification number, and the analyst's initials. Other data may be recorded depending upon the calibration performed.

Only properly calibrated and operating equipment and instrumentation will be used. Equipment and instrumentation not meeting the specified calibration criteria will be segregated from active equipment whenever possible. Such equipment will be repaired and recalibrated before reuse.

All equipment will be uniquely identified, either by serial number or internal calibration number, to allow traceability between equipment and calibration records. Recognized procedures (ASTM, USEPA, or manufacturer's procedures) will be used for calibration whenever available.

7.2.1 Method Calibration

Method calibration will be performed as part of the laboratory analytical procedure (calibration curves, tuning). Calibration curves will be prepared using five standards in graduated amounts across the appropriate range of analysis. New calibration curves will be prepared whenever new reagents or standards are prepared or yearly, whichever is more frequent.

7.2.2 GC/MS System Calibration Procedure

This section outlines the requirements for the calibration of GC/MS systems for the determination of organic compounds. The following operations will be performed in support of these requirements:

- Documentation of GC/MS mass calibration and abundance pattern
- Documentation of GC/MS response factor stability
- Internal standard response and retention time monitoring

Tuning and Mass Calibration

It will be necessary to establish that a given GC/MS system meets the standard mass spectral abundance criteria prior to initiating data collection. This will be accomplished through the analysis of p-bromofluorobenzene (BFB) for volatile compounds. The BFB criteria must be met before any blanks, standards, or samples are analyzed.

A GC/MS system used for organic compound analysis will be tuned to meet the criteria specified for BFB analysis (volatile compounds) for an injection of 50 nanograms (ng) of BFB. The analysis must be performed separately from standard or blank analysis. These criteria will be demonstrated every 12 hours of operation. Professional judgment must be used to determine whether background subtraction is required to eliminate column bleed or instrument background (i.e., noise). Calibration documentation will be in the form of a bar graph spectrum and a mass listing.

GC/MS System Calibration

After tuning criteria have been met and prior to sample analysis, the GC/MS system is initially calibrated at five concentrations utilizing the compounds to be analyzed to determine the linearity of response. Internal and surrogate standards will be used with each calibration standard. Standards will be analyzed under the same conditions as the samples.

- Relative Response Factor (RRF) Calculation - The USEPA specifies the internal standard to be used on a compound-by-compound basis for quantification. The RRF will be calculated for each compound at each concentration level.

- Continuing Calibration - A calibration check standard containing all semivolatile or volatile compounds and surrogates will be run every 12 hours of analysis. A system performance check will also be performed. The criteria will be the same as for the initial calibration system performance check. A calibration check will also be performed. The percent difference will be determined for each Calibration Check Compound (CCC).

The percent Difference for each CCC must be less than or equal to 25.0 percent. The system performance check and calibration check criteria must be met before sample analysis can be performed. The continuing calibration will be recorded on the continuing calibration forms.

7.2.3 Periodic Calibration

Periodic calibration must be performed on equipment required in analyses but not routinely calibrated as part of the analytical methodology. Equipment that falls within this category includes ovens, refrigerators, and balances. The calibration will be recorded either on specified forms or in bound notebooks. Discussed below are the equipment, the calibration performed, and the frequency at which the calibration must be performed.

- Balances will be calibrated weekly with class S weights.

- The pH meter will be calibrated daily with pH 4 and 7 buffer solutions and checked with pH 10 buffer solution.

- The temperatures of the refrigerators will be recorded daily.

- All liquid in glass thermometers will be calibrated annually with the N.B.S. certified thermometer. Dial thermometers will be calibrated quarterly.

- The N.B.S. Certified Thermometer will be checked annually at the ice point.

The following equipment must maintain the following temperatures:

- Sample Storage and Refrigerators - within 2 degrees of 4 degrees Celsius
- Water Bath, Mercury - within 2 degrees of 95 degrees Celsius

8.0 ANALYTICAL PROCEDURES

This next section discusses analytical procedures.

8.1 Field Analysis

A O_2/LEL and HNu PI-101 meters will be used to analyze ambient air for health and safety monitoring, as well as to screen soil during the soil sampling. The O_2/LEL meter detects explosive gases that may be present (i.e., methane). The HNu PI-101 detects total organic vapor. These instruments will be operated in accordance with the manufacturer's instructions.

The pH, temperature, and specific conductivity of aqueous samples also will be measured in the field. These analyses will be obtained in accordance with "Handbook for Sampling and Sample Preservation of Water and Wastewater," September 1982, EPA/600/4-82-029.

8.2 Laboratory Analysis

The samples that will be collected during the investigation will be analyzed for constituents listed in Tables 8-1 and 8-2. Parameters will be analyzed using USEPA methods as noted in Tables 8-1 and 8-2. Compounds and the corresponding method performance limits also are listed in Tables 8-1 and 8-2.

9.0 DATA REDUCTION, VALIDATION AND REPORTING

The following section presents data reduction, validation, and reporting procedures.

9.1 Field Data Procedures

Data validation practices as described by "Laboratory Data Validation Functional Guidelines for Evaluating Organic Analyses," USEPA, February 1994 will be followed to insure that raw data are not altered and that an audit trail is developed for those data which require reduction. The documentation of sample collection will include the use of bound field log books in which all information on sample collection will be entered in indelible ink. Appropriate information will be entered to reconstruct the sampling event, including site name (top of each page), sample identification, brief description of sample, date and time of collection, sampling methodology, field measurements and observations, and sampler's initials (bottom of each page, and dated).

A rigorous data control program will insure that all documents for the investigations are accounted for when they are completed. Accountable documents include items such as log books, field data records, correspondence, chain-of-custody records, analytical reports, data packages, photographs, computer disks, and reports. The project manager will be responsible for maintaining a project file in which all accountable documents will be inventoried. The project records will be retained for a period of three years after project close-out; then the files will be forwarded to the Navy.

All the field data, such as those generated during field measurements, observations and field instrument calibrations, will be entered directly into a bound field notebook. Each project team member will be responsible for proofing all data transfers made, and the Project Manager or his designee will proof at least ten percent of all data transfers.

9.2 Laboratory Data Procedures

The following procedures summarize the practices routinely used by laboratory staff for data reduction, validation, and reporting. Numerical analyses, including manual calculations, will be documented and subjected to quality control review. Records of numerical analyses must be legible and complete enough to permit reconstruction of the work by a qualified individual other than the originator.

9.2.1 Laboratory Data Validation

Data validation begins with data reduction and continues through to the reporting of data.

Data processing will be checked by an individual other than the analyst who performed the data processing. The person(s) checking the information will review the data for the following:

- Utilization of the proper equations
- Correctness of numerical input
- Correctness of computations
- Correct interpretation of raw data (chromatographs, strip charts, etc.)

The checking process will be sufficient thorough enough to verify the results.

All entries made in benchbooks, data sheets, computation sheets, input sheets, etc. will be made in ink. No entry will be rendered unreadable.

9.2.2 Analytical Reports

The items listed below will be required of analytical reports.

- Data will be presented in a tabular format.
- Analytical reports will be approved by appropriate laboratory personnel.
- The following information will be included on the report: client name and address, report date, sample date, analysis dates, number of samples, purchase order number, project number, and project type. All pages must be numbered.
- The sample numbers and corresponding laboratory numbers will be identified.
- The parameters analyzed, report units, and values will be identified.
- Method, trip, and field blank results will be reported.
- Matrix spike, matrix spike duplicate, and replicate recoveries will be reported.
- Calibration summaries will be reported.
- Surrogate recoveries will be reported.
- Holding times and sample analysis dates will be reported.
- The detection limit of the procedure will be identified.
- Consistent significant figures will be used.
- Referenced footnotes will be used when applicable.
- A letter of transmittal will accompany the report if any anomalies are associated with the data.

9.3 Independent (Third Party) Data Validation

Review of all pertinent analytical data will be performed by Baker personnel and an independent third party data validator.

A preliminary review will be performed by the Project Manager or designee to verify that all necessary paperwork (e.g., chain-of-custodies, traffic reports, analytical reports, and laboratory personnel signatures) and deliverables are present. A detailed and independent data validation will be performed by a data validation subcontractor to verify the qualitative and quantitative reliability of the data presented and adherence to stated analytical protocols. This review will include a detailed review and interpretation of all data generated by the laboratory for Level IV deliverables. The primary tools which will be used by experienced data validation personnel will be analytical method operating practices, statements of work (for CLP), guidance documents, established criteria, and professional judgment.

During the data review, a data support documentation package will be prepared which will provide the back-up information that will accompany all qualifying statements present in the quality assurance review.

10.0 INTERNAL QUALITY CONTROL CHECKS

The following section describes internal quality control checks.

10.1 Field Quality Control Checks

Four types of field quality assurance/quality control samples will be submitted to the laboratory: trip blanks, equipment rinsates, field blanks, and field duplicates. The results from the field quality control samples will be used by the data validator to determine the overall quality of the data. A breakdown by type of sample with which the QA/QC samples will be submitted to the laboratories is given in Table 10-1. A summary of the number of environmental and QA/QC samples to be submitted for analysis will be given in the FSAP.

Field Blanks

Field blanks consist of the source water used in decontamination, steam cleaning, and drilling. At a minimum, one field blank from each event and each source of water must be collected and analyzed for the same parameters as the related samples. Organic-free deionized water is taken to the field in sealed containers and poured into the appropriate sample containers at predesignated locations. This will be done to determine if any contaminants present in the area may have an affect on the sample integrity.

Trip Blank

Analysis of trip blanks will be performed to monitor possible contamination during shipment and collection of samples. Trip blanks are initiated in the laboratory prior to the shipping of sample packs. A corresponding trip blank will be prepared for each set of samples to be analyzed for volatile organic compounds.

Trip blank samples will be prepared by adding four drops of concentrated hydrochloric acid and then filling the container with organic-free deionized water (ASTM Type II). The trip blanks accompany the samples through shipment to the sample site, sample collection, shipment to the laboratory, and storage of the samples.

If the analyses indicate contamination of the trip blank, the sample sources may be resampled. If the extent and nature of the contamination does not warrant such actions, the data will be accepted as valid.

Field Duplicates

Duplicates for soil samples are collected, homogenized, and split. All samples except VOCs are homogenized, and split. Volatiles are not mixed, but select segments of the soil are taken from the length of the core and placed in 4-ounce glass jars. Cores may be sealed and shipped to the laboratory for subsampling if the project deems this appropriate. The duplicate for water samples should be collected simultaneously. Field duplicates should be collected at a frequency of 10% per sample matrix for Level IV. All the duplicates should be sent to the primary laboratory responsible for analysis. The same samples used for field duplicates shall be split by the laboratory and used by the laboratory as the laboratory duplicate or matrix spike. This means that for the duplicate sample, there will be analyses of the normal sample, the field duplicate, and the laboratory matrix spike/duplicate.

Equipment Rinsates

Equipment rinsates are the final organic-free deionized water rinse from equipment cleaning collected daily during a sampling event to determine if decontamination procedures were adequate. Initially, samples from every other day should be analyzed. If analytes pertinent to the project are found in the rinsate, the remaining samples must be analyzed. The results of the blanks will be used to flag or assess levels of analytes in the samples. This comparison is made during validation. The rinsates are analyzed for the same parameters as the related samples.

10.2 Laboratory Quality Control Checks

This section provides descriptions of the laboratory quality control checks.

Method Blank

Analysis of method blanks will be performed to verify that method interferences caused by contamination in reagents, glassware, solvents, etc. are minimized and known.

Method blanks will be initiated by the analyst prior to the preparation and/or analysis of the sample set. A method blank consists of a volume of organic-free deionized water equal to the sample volume which is carried through the entire analytical procedure. For solid samples to be analyzed by GC/MS, the method blank consists of a purified solid matrix approximately equal to the sample weight. A method blank will be analyzed with each set of samples or at the very least, daily. If the analytical data of the method blank indicates excessive contamination, the source of contaminant will be determined. The samples may be re-analyzed or the data may be processed "as is" depending upon the nature and extent of the contamination.

Replicate Sample Analysis

Replicate sample analysis will be performed to demonstrate the precision of an analysis. An interlaboratory replicate sample is initiated by the analyst prior to sample preparation and carried through the entire analytical procedure.

Surrogate Standards

Surrogate standard analysis will be performed to monitor the preparation and analyses of samples. All samples and blanks analyzed by GC/MS are fortified with a surrogate spiking solution prior to extraction or purging.

Internal Standards

Internal standard analyses will be performed to monitor system stability. Prior to injection or purging, internal standards are added to all blanks and samples analyzed by GC/MS (refer to Section 5.1.1.).

Matrix Spikes and Matrix Spike Duplicates

A matrix spike is an aliquot of a matrix (water or soil) fortified (spiked) with known quantities of specific compounds and subjected to the entire analytical procedure in order to indicate the appropriateness of the method for the matrix by measuring recovery. A matrix spike duplicate is a second aliquot of the same matrix as the matrix spike that is spiked in order to determine the precision of the method. A matrix spike and matrix spike duplicate will be performed at a frequency of 1 per 20 samples for organics.

10.3 Laboratory Control Limits

Control limits will be established for QC checks (spikes, duplicates, blanks, etc.). CLP control limits for surrogate standards spikes, and duplicates associated with GC/MS analyses. Control limits for spikes, duplicates, and reference samples will be determined internally through statistical analysis.

Whenever an out-of-control situation occurs, the cause is determined. Any needed corrective actions must be taken.

Method Blanks

For metals analyses, the criteria below are used for method blank analysis.

- If the concentration of the method blank is less than or equal to the detection level, no correction of sample results is performed.
- If the concentration of the blank is above the detection level for any group of samples associated with a particular blank, the concentration of the sample with the least concentrated analyte must be ten times the blank concentration. Otherwise, all samples associated with the blank and less than ten times the blank concentration must be redigested (reprepared) and reanalyzed, if possible. If the affected samples cannot be reprepared and reanalyzed within method holding times, the flagged sample result and the blank result are both to be reported. The sample value is not corrected for the blank value.

For GC/MS analyses, the criteria below are used for method blank analysis:

- A method blank for volatiles analysis must contain no greater than five times the detection limit of common laboratory solvents (common laboratory solvents are: methylene chloride, acetone, toluene, 2-butanone, and chloroform).
- For all other compounds not listed above, the method blank must contain less than the detection limit of any single compound. If a method blank exceeds the criteria, the analytical system is considered to be out of control. The source of the contamination is investigated and appropriate corrective measures are taken and documented before sample analysis proceeds. All samples processed with a method blank that is out of control (i.e., contaminated), are re-extracted/repurged and reanalyzed, when possible. If the affected samples cannot be re-extracted/repurged and reanalyzed within method holding times, the flagged sample result and the

blank result are both to be reported. The sample value is not corrected for the blank value.

Surrogate Standards

For method blank surrogate standard analysis, corrective action will be taken if any one of the conditions below exist.

- Recovery of any one surrogate compound in the volatile fraction is outside the required surrogate standard recovery limit.

Corrective action will include steps listed below:

- A check of: the calculations for errors; the internal standard and surrogate spiking solutions for degradation, contamination, etc.; and instrument performance.
- Recalculation or re-injection/repurging of the blank or extract if the above corrective actions fail to solve the problem.
- Re-extraction and reanalysis of the blank. For sample surrogate standard analysis, corrective action will be taken if any one of the following conditions exist:
    - Recovery of any one surrogate compounds in the volatile fraction is outside the surrogate spike recovery limits;

Corrective action will include the steps listed below.

- A check of: the calculations for errors; of the internal standard and surrogate spiking solutions for degradation, contamination, etc.; and of instrument performance.
- Recalculating or reanalysis the sample or extract if the above corrective action fails to solve the problem.
- Re-extraction and reanalysis of the sample if none of the above are a problem.

11.0 PERFORMANCE AND SYSTEM AUDITS

A field audit will be conducted during the field investigation to verify that sampling is being performed according to the plan. A report will be submitted within 30 calendar days of completion of the audit. Serious deficiencies will be reported within 24 hours of the time of discovery of the deficiency, including actions taken or to be taken to correct such deficiencies.

The following table (Table 11-1) is used for audits. At the appropriate time, the Project Manager or Program QA/QC designee will conduct field audits. Additionally, personnel adhere to Baker's Standard Operating Procedures which cover procedures, reporting and quality.

12.0 PREVENTIVE MAINTENANCE

The following section outlines preventative maintenance.

12.1 Field Maintenance

The O_2/LEL meter and the HNu PI-101 are to be used in site characterization and will be maintained as described by the manufacturer's instructions. The pH and specific conductance meters to be used during sampling will be maintained according to Baker's Standard Operating Procedure (SOP) F201. A full set of SOPs will be maintained in the field trailer.

12.2 Laboratory Maintenance

Preventive maintenance is an organized program of actions to prevent instruments and equipment from failing during use and to maintain proper performance of equipment and instruments. A comprehensive preventive maintenance program is implemented to increase the reliability of the measurement system. The preventive maintenance program will address the following:

- Schedules of important preventive maintenance tasks that are carried out to minimize downtime.
- Lists of critical spare parts that are available to minimize downtime.

The laboratory maintains histories, in instrument/equipment logs, of all major equipment. Trouble shooting, maintenance, and spare parts inventory will be recorded in the logs. Instruments and equipment will be maintained periodically in accordance with procedures described in individual analytical methods, manufacturer's recommendation, and/or service contracts.

The modern analytical laboratory depends heavily upon instrumentation and equipment; therefore, cleaning and preventive maintenance are primary considerations in the sustained production of satisfactory data. Specific requirements for proper care of laboratory instrumentation and equipment are contained in the manufacturer's instructions; however, some general guidelines are considered, and are listed below.

- Special precautions must be taken to avoid spillage of corrosive chemicals on or around equipment and instrumentation not only to extend the life of the item, but also to eliminate contamination.
- Where available, covers must be placed on instrumentation when not in use.
- Instrument parts must be cleaned as required (i.e., mirrors, probes, detector cells).

13.0 DATA MEASUREMENT ASSESSMENT PROCEDURES

The following section outlines data measurement assessment procedures.

13.1 Overall Project Assessment

Overall data quality will be assessed by a thorough understanding of the data quality objectives. By maintaining thorough documentation of all decisions made during each phase of sampling, performing field and laboratory audits, thoroughly reviewing the analytical data as they are generated by the laboratory, and providing appropriate feedback as problems arise in the field or at the laboratory, data accuracy, precision, and completeness will be closely monitored.

13.2 Field Quality Assessment

To assure that all field data are collected accurately and correctly, specific written instructions will be issued to all personnel involved in field data acquisition by the Project Manager. The Project Manager will perform field audit(s) during the investigation to document that the appropriate procedures are being followed with respect to sample (and blank) collection. These audits will include a thorough review of the field books used by the project personnel to insure that all tasks were performed as specified in the instructions. The field audits will necessarily enable the data quality to be assessed with regard to the field operations.

The evaluation (data review) of field blanks, and other field QC samples will provide definitive indications of the data quality. If a problem that can be isolated arises, corrective actions can be instituted for future field efforts.

13.3 Laboratory Data Quality Assessment

As part of the analytical QA/QC program, the laboratory applies precision and accuracy criteria for each parameter that is analyzed. When analysis of a sample set is completed, QC data generated will be reviewed and evaluated to ensure acceptance criteria are met. These criteria will be method and matrix specific.

QA/QC data review is based on the following criteria:

- Method Blank Evaluation - The method blank results will be evaluated for high readings characteristic of background contamination. If high blank values are observed, laboratory glassware and reagents are checked for contamination and the analysis of future samples halted until the system can be brought under control. A high background is defined as a background value sufficient to result in a difference in the sample values, if not corrected, greater than or equal to the smallest significant digit known to be valid. A method blank must contain no greater than two times the parameter detection limit for most parameters.

- Trip Blank Evaluation - Trip blank results will be evaluated for high readings similar to the method blanks described above. If high trip blank readings are encountered (i.e. a value sufficient to result in a difference in sample values, if not corrected, greater than or equal to the smallest significant digit known to be valid), procedures for sample collection, shipment, and laboratory analysis are reviewed.

If both the method and the trip blanks exhibit significant background contamination, the source of contamination is probably within the laboratory. Ambient air in the laboratory and reagents will be checked as possible sources of contamination.

- Standard Calibration Curve Verification - The calibration curve or midpoint calibration standard (check standard) will be evaluated daily to determine curve linearity through its full range and that sample values are within the range defined by the low and high standards. If the curve is not linear, sample values are corrected. If average response factors are used to calculate sample concentrations, these factors are verified on a daily basis. Verification of calibration curves and response factors will be accomplished when the evaluated response for any parameter varies from the calibrated response by less than ranges specified in Section 7.0.

- Duplicate Sample Analyses - Duplicate sample analyses will be used to determine the precision of the analytical method for the sample matrix. Two types of duplicate samples will be analyzed for this project, field, and laboratory. Duplicate results will be used to calculate precision as defined by the relative percent difference (RPD). If laboratory duplicate values exceeds the control limit, the sample set may be reanalyzed for the parameter in question. Precision limits will be updated periodically following review of data.

- Reference Sample Analyses - The results of reference sample analysis will be compared with true values, and the percent recovery of the reference sample will be calculated. If correction is required (excessive or inadequate percent recovery), the reference sample must be reanalyzed to demonstrate that the corrective action has been successful.

- Surrogate Standard Analyses - Surrogate standard determinations will be performed on all samples and blanks for GC/MS analyses. All samples and blanks are fortified with surrogate spiking compounds before purging or extraction to monitor preparation and analysis of samples. Recoveries must meet specific criteria. If acceptance criteria are not met, corrective action must be taken to correct the problem and the affected sample must be reanalyzed.

- Matrix Spike Analyses - The observed recovery of spike versus theoretical spike recovery will be used to calculate accuracy as defined by the percent recovery. If the accuracy value exceeds the control limit for the given parameter, the appropriate laboratory personnel notified and corrective action will be taken before the sample set is reanalyzed for the parameter in question.

For completeness, it is expected that the methodology proposed for chemical characterization of the samples will meet QC acceptance criteria for at least 95 percent of all sample data. To ensure this completeness goal, data that does not meet the acceptance criteria will be recollected, re-extracted, or reanalyzed, if necessary.

Data representativeness will be ensured through the use of appropriate analytical procedures, and analysis of samples performed within the allowed holding times.

Comparability is a qualitative characteristic of the data. By using standard methods for sampling and analyses, data generated in past or future investigations will be comparable with this investigation data.

14.0 CORRECTIVE ACTION

Corrective action will be taken whenever a nonconformance occurs. A nonconformance will be defined as an event which is beyond the limits established for a particular operation by the plan. Nonconformances can occur in a number of activities. Such activities include sampling procedures, sample receipt, sample storage, sample analysis, data reporting, and computations.

The following personnel will be responsible for detecting and reporting nonconformances:

- Project Staff - during testing and preparation and verification of numerical analyses.
- Laboratory Staff - during the preparation for analyses, performance of analytical procedures, calibration of equipment, and quality control activities.

14.1 Limits of Operation

The limits of operation that are used to identify nonconformances will be established by the contents of the Work Plan, QAPP, and FSAP. Interlaboratory control limits produced by statistical analyses will also be considered as limits of operation.

14.2 Corrective Action

Nonconformances will be identified and communicated to Baker to avoid delays with respect to project schedules and prevent the submission of non-valid data. Documentation will include the following:

- Personnel identifying the nonconformance(s) will be identified.
- The nonconformance(s) will be described and communicated to the Baker Project Manager.
- For serious nonconformances, the site supervisor will have the authority to initiate corrective action.
- For less serious nonconformances, corrective action will be decided upon and signatures will be obtained prior to implementation of corrective action.
- All nonconformances and corrective actions will be documented and reside with the Baker Activity Coordinator. This documentation will be available to LANTDIV.

The Baker Project Manager and Activity Coordinator will be notified of laboratory or field nonconformances and corrective actions taken if:

- A nonconformance causes a delay in work beyond the schedule completion date.
- A nonconformance affects information already reported.
- A nonconformance affects the validity of the data.

If the nonconformance(s) are serious and corrective action cannot resolve the problem(s), NFESC Navy Contract Representatives (NCRs) and the LANTDIV NTR may be notified by Baker.

15.0 QUALITY ASSURANCE REPORTING PROCEDURES

The Project Manager will be responsible for assessing the performance of measurement systems and data quality related to the field investigation. A written record will be maintained of: the results of laboratory QC reports and other periodic assessments of measurement, data accuracy, precision, and completeness; performance and system audits; and any significant QA problems and recommended solutions. Each deliverable will contain a QA/QC assessment section. Also, QA/QC assessment will be performed any time QA significant problem is identified.

The Project Manager will keep in contact with the LANTDIV NTR through informal, verbal reports during the project as well as through monthly progress reports.

TABLES

TABLE 5-1

DEFINITIONS OF DATA QUALITY INDICATORS

PRECISION - A measure of mutual agreement among individual measurements of the sample property, usually under prescribed similar conditions. Precision is expressed in terms of the standard deviation. Comparison of replicate values is best expressed as the relative percent difference (RPD). Various measures of precision exist depending upon the "prescribed similar conditions".

ACCURACY - The degree of agreement of a measurement (or an average of replicate measurements), X, with an accepted reference or true value, T, expressed as the difference between the two values, X-T. Accuracy is a measure of the bias in a system.

REPRESENTATIVENESS - Expresses the degree to which data accurately and precisely represent a characteristic of a population, parameter variations at a sampling point, a process condition, or an environmental concern.

COMPLETENESS - A measure of the amount of the valid data obtained from the measurement system compared to the amount that was expected under "normal" conditions.

COMPARABILITY - Expresses the confidence with which one data set can be compared with another.

UNCERTAINTY - The unlikelihood of all types of errors associated with a particular decision.

TABLE 6-1

SUMMARY OF CONTAINERS, PRESERVATION, AND HOLDING TIMES FOR AQUEOUS SAMPLES
OPERABLE UNIT NO. 15 (SITE 88)
CTO 0356
MCB CAMP LEJEUNE, NORTH CAROLINA

Parameter	Container	Preservation	Holding Time
TCL Volatiles	Two 40-ml vials with teflon septum caps	Cool, 4°C HCl pH <2	14 days (7 days if unpreserved)
Nitrate	Two 40-ml vials with teflon septum caps	Cool, 4°C H_2SO_4 pH <2	7 days
Nitrite	Two 40-ml vials with teflon septum caps	Cool, 4°C H_2SO_4 pH <2	7 days
Iron	100-ml in headspace free container	Cool, 4°C	7 days
Sulfate	Two 40-ml vials with teflon septum caps	Cool, 4°C	7 days
Sulfide	Two 40-ml vials with teflon septum caps	Cool, 4°C	7 days
Methane	50-ml in glass container	Cool, 4°C H_2SO_4 pH <2	7 days
Oxygen Reduction Potential	250-ml in glass container	Cool, 4°C	7 days
Chloride	100-ml in glass container	Cool, 4°C	7 days
Total Suspended Solids (TSS)	500-ml in plastic container	Cool, 4°C	7 days
Total Dissolved Solids (TDS)	500-ml in plastic container	Cool, 4°C	7 days

Notes:

TCL - Target Contaminant List
TSS - Total Suspended Solids
TDS - Total Dissolved Solids

TABLE 6-2

SUMMARY OF CONTAINERS, PRESERVATION, AND HOLDING TIMES FOR SOLID SAMPLES
OPERABLE UNIT NO. 15 (SITE 88)
CTO 0356
MCB CAMP LEJEUNE, NORTH CAROLINA

Parameter	Container	Preservation	Holding Time
TCL Volatiles	One 4-ounce wide-mouth glass jars	Cool, 4°C	10 days
TOC	One 4-ounce wide-mouth glass jar	Cool, 4°C	N/A
Bulk Density	Shelby Tube	NA	NA
Permeability/Grainsize	Shelby Tube	NA	NA

Notes:

TCL - Target Contaminant List
TOC - Total Organic Carbon

TABLE 8-1

ORGANIC METHOD PERFORMANCE LIMITS

Compound	Water CRQL$^{(1)}$ (µg/L)	Soil CRQL$^{(1)}$ (µg/kg)	Method
Volatiles Chloromethane	10	10	CLP/SOW$^{(2)}$
Bromomethane	10	10	
Vinyl Chloride	10	10	
Chloroethane	10	10	
Methylene Chloride	10	10	
Acetone	10	10	
Carbon Disulfide	10	10	
1,1 -Dichloroethene	10	10	
1,1 -Dichloroethane	10	10	
1,2 -Dichloroethene	10	10	
Chloroform	10	10	
1,2 -Dichloroethane	10	10	
2-Butanone	10	10	
1,1,1-Trichloroethane	10	10	
Carbon Tetrachloride	10	10	
Bromodichloromethane	10	10	
1,2-Dichloropropane	10	10	
cis-1,3-Dichloropropene	10	10	
Trichloroethene	10	10	
Dibromochloromethane	10	10	
1,1,2-Trichloroethane	10	10	
Benzene	10	10	
trans-1,3-Dichloropropene	10	10	
Bromoform	10	10	
4-Methyl-2-pentanone	10	10	
2-Hexanone	10	10	
Tetrachloroethene	10	10	
Toluene	10	10	
1,1,2,2-Tetrachloroethane	10	10	
Chlorobenzene	10	10	
Ethylbenzene	10	10	
Styrene	10	10	
Xylenes (total)	10	10	

Notes:

(1) Contract Required Quantitation Limit.

(2) "Statement of Work for Organic Analysis," USEPA Contract Laboratory Program, OLM03.1.

TABLE 8-2

ENGINEERING PARAMETER METHOD PERFORMANCE LIMITS

Parameter	Aqueous Performance Limit	Solid Performance Limit	Method
Engineering Parameters			
Total Organic Carbon (TOC)	N/A	N/A	EPA 415.1
Permeability	N/A	N/A	ASTM D2434-18
Grain Size	N/A	N/A	ASTM D422-63 ASTM D1140-54
Bulk Density	N/A	N/A	ASTM D1587-14
Nitrate	N/A	N/A	EPA 353.3
Nitrite	N/A	N/A	EPA 354.1
Iron	N/A	N/A	EPA 7380A
Sulfate	N/A	N/A	EPA 375.4
Sulfide	N/A	N/A	EPA 376.2
Methane	N/A	N/A	SW 3810 Method
Oxygen Reduction Potential	N/A	N/A	A2580B
Chloride	N/A	N/A	EPA 325.2
Total Suspended Solids (TSS)	N/A	N/A	EPA 160.1
Total Dissolved Solids (TDS)	N/A	N/A	EPA 160.2

Note:

N/A - Not Applicable

TABLE 10-1

QA/QC SAMPLE FREQUENCY
OPERABLE UNIT NO. 15 (SITE 88)
CTO 0356
MCB CAMP LEJEUNE, NORTH CAROLINA

Type of Sample	Metal	Organic
Trip Blank (for volatiles only)	NA(1)	One per cooler or one per shipping day
Equipment Rinsate(2)	One per day	One per day
Field Blank	One per source per event(3)	One per source per event(3)
Field Duplicate(4)	10%	10%

Notes:

(1) Not Applicable

(2) Samples are collected daily; however, only samples from every other day are analyzed. Other samples are held and analyzed only if evidence of contamination exists.

(3) Source water includes water used in decontamination, steam cleaning, and drilling.

(4) The duplicate must be taken from the sample which will become the laboratory matrix spike/matrix spike duplicate for organics.

TABLE 11-1
FIELD SITE AUDIT INSPECTION FORM

Legend
X = Yes
O = No
NA = Not Applicable

Site Name ______________________________ CTO No. ______________

Location ______________________________ Date ______________

SECTION 1 - DOCUMENTATION/SAFETY/QA/QC PROCEDURES

1. Were sampling locations adequately documented in a bound field log book using indelible ink?
Yes ______ No ______
Comments ______________________________

2. Were photos taken and a photo log maintained?
Yes ______ No ______

3. What field instruments were used during this study?
____
____

4. Were field instruments properly calibrated and calibrations recorded in a bound field log book?
Yes ______ No ______
Comments ______________________________

5. Was sampling equipment properly wrapped and protected from possible contamination prior to sample collection?
Yes ______ No ______
Comments ______________________________

6. Was sampling equipment constructed of Teflon®, glass, or stainless steel?
____

7. Were samples collected in proper order (least suspected contamination to most contaminated)?
Yes ______ No ______
Comments ______________________________

8. Were clean disposable latex or vinyl gloves worn during sampling?
Yes ______ No ______
Comments ______________________________

9. Were gloves changed for each sample station?
Yes ______ No ______
Comments ______________________________

10. Was any equipment field cleaned?
Yes ______ No ______

11. Type of equipment cleaned?
____

TABLE 11-1
FIELD SITE AUDIT INSPECTION FORM

12. Were proper field cleaning procedures used?
Yes ______ No ______
Comments ____

13. Were equipment rinse blanks collected after field cleaning?
Yes ______ No ______
Comments ____

14. Were proper sample containers used for samples?
Yes ______ No ______
Comments ____

15. Were split samples offered to the facility owner or his representative?
Yes ______ No ______
Comments ____

16. Was a receipt for samples form given to facility representative?
Yes ______ No ______

17. Were any duplicate samples collected?
Yes ______ No ______
Comments ____

18. Were samples properly field preserved?
Yes ______ No ______
Comments ____

19. Were preservative blanks utilized?
Yes ______ No ______
Comments ____

20. Were field and/or trip blanks utilized?
Yes ______ No ______
Comments ____

21. Were samples adequately identified with labels or tags?
Yes ______ No ______
Comments ____

22. Were samples sealed with custody seals after collection?
Yes ______ No ______
Comments ____

23. What security measures were taken to insure custody of the samples after collection?
____

24. Were chain-of-custody and receipt for samples forms properly completed?
Yes ______ No ______
Comments ____

25. Were any samples shipped to a laboratory?
Yes ______ No ______

TABLE 11-1
FIELD SITE AUDIT INSPECTION FORM

26. If yes to No. 25, were samples properly packed?
Yes ________ No ________
Comments ____

27. If shipped to a CLP lab, were Traffic Report Forms properly completed?
Yes ________ No ________
Comments ____

28. What safety monitoring equipment, protection, and procedures were used prior to and during sampling?

____

29. Was safety monitoring equipment properly calibrated and calibrations recorded in a bound field log book?
Yes ________ No ________
Comments ____

TABLE 11-1
FIELD SITE AUDIT INSPECTION FORM

SECTION 2 - SAMPLING - GROUNDWATER WELLS

1. Type of wells sampled (monitoring, potable, industrial, etc.)?

   ____

2. Were wells locked and protected?
   Yes ________ No ________
   Comments ________________________________

3. Were identification marks and measurement points affixed to the wells?
   Yes ________ No ________
   Comments ________________________________

4. What were the sizes and construction materials of the well casings?

   ____

5. Were the boreholes sealed with a concrete pad to prevent surface infiltration?
   Yes ________ No ________
   Comments ________________________________

6. Was there a dedicated pump in the well?
   Yes ________ No ________

7. Was clean plastic sheeting placed around the wells to prevent contamination of sampling equipment and containers?
   Yes ________ No ________

8. Were total depths and depths to water determined before purging?
   Yes ________ No ________

9. What device was used to determine depths?

   ____

10. Were measurements made to the nearest 0.01 foot?
    Yes ________ No ________

11. Was the measuring device properly cleaned between wells?
    Yes ________ No ________
    Comments ________________________________

12. Was the standing water volume in each well determined?
    Yes ________ No ________

13. How was the volume determined?

    ____

14. Was a sufficient volume purged prior to sampling?
    Yes ________ No ________
    Comments ________________________________

TABLE 11-1
FIELD SITE AUDIT INSPECTION FORM

15. How many volumes?

____

16. How was the purged volume measured?

____

17. What was the method of purging?

____

18. Were pH, conductivity, and temperature measurements taken and recorded at least once during each well volume purged?
Yes ________ No ________
Comments ____

19. Were pH, conductivity, and temperature readings stable prior to sampling?
Yes ________ No ________
Comments ____

20. How many wells were sampled? ____ Upgradient? ____ Downgradient? ____

21. How were the samples collected? Bailer ____ Pump ____ Other ____
Comments ____

22. If pump was used, what type?

____

23. If a pump was used, was it properly cleaned before and/or between wells?
Yes ________ No ________
Comments ____

24. What were the cleaning procedures?

____

25. Did bailers have Teflon® coated wire leaders to prevent rope from coming into contact with water?
Yes ________ No ________

26. Were bailers open or closed top?

____

27. Was a clean bailer and new rope used at each well?
Yes ________ No ________
Comments ____

28. Were samples properly transferred from the sampling device to the sample containers (i.e., purgeable sample first - not aerated, etc.)?
Yes ________ No ________
Comments ____

29. Was pH of preserved samples checked to insure proper preservation?
Yes ________ No ________
Comments ____

TABLE 11-1
FIELD SITE AUDIT INSPECTION FORM

30. Were sampled iced immediately after collection?
Yes ________ No ________

31. For what analyses were the samples collected?

____

32. If samples were split, what were the sample/station numbers for these?

____

____

Other comments or observations ______________________________________

____

____

TABLE 11-1
FIELD SITE AUDIT INSPECTION FORM

SECTION 3 - SAMPLING - SOIL, SEDIMENT, SLUDGE, ETC. (Non-Containerized)

1. Type of samples collected?

____

2. General description of samples?

____

3. How many samples were collected?

____

4. Were background and/or control samples collected?
Yes ______ No ______
Comments ______________________________

5. Were representative samples collected?
Yes ______ No ______
Comments ______________________________

6. Were grab or composite samples collected?

____

7. Were composite samples areal or vertical?

____

8. How many aliquots were taken for the composite sample?

____

9. What procedures and equipment were used to collect samples?

____

____

10. Were samples thoroughly mixed prior to putting them into the sample containers?
Yes ______ No ______
Comments ______________________________

11. Were samples properly placed into sample containers?
Yes ______ No ______
Comments ______________________________

12. Were samples iced immediately after collection?
Yes ______ No ______

13. For what analyses were the samples collected?

____

14. If samples were split, what were the sample/station numbers for these?

____

15. Was a drilling rig, backhoe, etc., used to collect soil samples?
Yes ______ No ______

TABLE 11-1
FIELD SITE AUDIT INSPECTION FORM

16. Were the drilling rig(s), backhoe(s), etc., properly cleaned according to the ESD SOP, Appendix B, prior to arriving on site?
Yes ______ No ______
Comments ____

17. What was the condition of the drilling and sampling equipment when it arrived on site?
____

18. Was a decontamination area located where the cleaning activities would not cross-contaminate clean and/or drying equipment?
Yes ______ No ______
Comments ____

19. Was clean equipment properly wrapped and stored in a clean area?
Yes ______ No ______
Comments ____

20. Was the drilling rig(s) properly cleaned between well borings?
Yes ______ No ______
Comments ____

21. Were the cleaning and decontamination procedures conducted in accordance with the ESD SOP?
Yes ______ No ______
Comments ____

22. Other comments or observations
____

____

TABLE 11-1
FIELD SITE AUDIT INSPECTION FORM

SECTION 4 - SAMPLING - SURFACE WATER (Pond, Stream, River, Leachate, etc.)

1. Type of samples collected?

____

2. General description of samples?

____

3. How many samples were collected?

____

4. Were background and/or control samples collected?
Yes ______ No ______
Comments ______________________________

5. Were grab or composite samples collected?

____

6. How many aliquots were taken for the composite sample?

____

7. What procedures and equipment were used to collect samples?

____

____

8. Were samples collected directly into sample containers?
Yes ______ No ______
Comments ______________________________

9. Did the sampler wade in the stream to collect the samples?
Yes ______ No ______
Comments ______________________________

10. Were the samples collected upstream from the sampler?
Yes ______ No ______
Comments ______________________________

11. Did the sampler insure that roiled sediments were not collected along with the water samples?
Yes ______ No ______
Comments ______________________________

12. Were representative samples collected?
Yes ______ No ______
Comments ______________________________

13. Was the pH of preserved samples checked to insure proper preservation?
Yes ______ No ______
Comments ______________________________

14. Were samples iced immediately after collection?
Yes ______ No ______

TABLE 11-1
FIELD SITE AUDIT INSPECTION FORM

15. For what analyses were the samples collected?

16. If samples were split, what were the sample/station numbers for these?

Other comments or observations

TABLE 11-1
FIELD SITE AUDIT INSPECTION FORM

SECTION 5 - OTHER SAMPLING - DRUMS, TANKS, BARRELS, ETC. (Containerized)

1. Type of samples collected (oil, sludge, waste)?

2. Description of containers or sources sampled?

3. How many samples were collected?

4. What type of equipment was used to collect the samples?

5. What procedures were used to collect the samples?

6. For what analyses were the samples collected?

7. If samples were split, what were the sample/station numbers for these?

8. Were any special safety measures taken during collection of the samples?

9. What level of safety protection was required for collection of the samples?

TABLE 11-1
FIELD SITE AUDIT INSPECTION FORM

Other comments or observations

TABLE 11-1
FIELD SITE AUDIT INSPECTION FORM

SECTION 6 - MONITORING WELL INSTALLATION

General

1. Were the wells installed in the proper locations in accordance with the study plan and/or project operations plan (POP)?
Yes ________ No ________
Comments ____

2. Were the wells installed starting in the least contaminated area and proceeding to the most contaminated area?
Yes ________ No ________
Comments ____

3. Were proper safety protocols employed during the well installations?
Yes ________ No ________
Comments ____

4. Were samples of the drilling mud, water, bentonite pellets, filter pack materials, etc., collected for quality control analyses?
Yes ________ No ________
Comments ____

Equipment Decontamination

5. Were the drilling rig(s), backhoe(s), etc., properly cleaned according to the ESD SOP, Appendix B, prior to arriving on site?
Yes ________ No ________
Comments ____

6. What was the condition of the drilling and sampling equipment when it arrived on site?
____

7. Was a decontamination area located where the cleaning activities could cross-contaminant clean and/or drying equipment?
Yes ________ No ________
Comments ____

8. Was clean equipment properly wrapped and stored in a clean area?
Yes ________ No ________
Comments ____

9. Was the drilling rig(s) properly cleaned between well borings?
Yes ________ No ________
Comments ____

10. Were the cleaning and decontamination procedures conducted in accordance with the ESD SOP?
Yes ________ No ________
Comments ____

TABLE 11-1
FIELD SITE AUDIT INSPECTION FORM

Drilling

11. What type of drilling method(s) was used to install the wells?

____

12. Was this drilling method(s) the same as proposed in the study plan and/or POP?
Yes ______ No ______
Comments ____________________________________

13. Were soil samples collected for logging and analyses as the wells were installed?
Yes ______ No ______

14. If yes to 13, at what intervals and by what method?

____

15. If air rotary was used:
Was an in-line organic air filter employed?
Yes ______ No ______

Was a cyclone velocity dissipator used?
Yes ______ No ______
Comments ____________________________________

16. What diameter borehole(s) were installed?

____

17. Were surface outer casings used?
Yes ______ No ______

18. If yes to 17, what size and to what depth?

____

19. Were the wells double cased?
Yes ______ No ______

20. If yes to 19, explain procedure.

____

Well Installation

21. What type of well casing(s) and screen(s) were used?

____

22. What diameter were the well casing(s)? ______ screen(s)? ______

23. Was there a minimum two-inch annulus around the casing (between casing and borehole wall or inside augers)?
Yes ______ No ______
Comments ____________________________________

TABLE 11-1
FIELD SITE AUDIT INSPECTION FORM

24. What was the length of the well screen(s)?

____

25. What was the slot size of the well screen(s)?

____

26. Was the well screen(s) commercially manufactured?
Yes _______ No _______
If yes, by whom? ______________________________

27. Was the bottom of the well screen(s) plugged or capped?
Yes _______ No _______
Comments __________________________________

28. Were sand and/or gravel (filter) packs installed?
Yes _______ No _______
Comments __________________________________

29. Specify type of materials in 28 [(play sand, Ottawa sand, etc.) and grain size (20/30, 20/40, etc.)], if known.

____

30. Was a sieve analysis conducted to determine well screen slot size and filter pack grain size?
Yes _______ No _______
Comments __________________________________

31. Were the wells installed to the proper depths?
Yes _______ No _______
Comments __________________________________

32. Were well screens placed at the proper intervals?
Yes _______ No _______
Comments __________________________________

33. Were the filter packs placed a minimum of two feet above the well screens?
Yes _______ No _______
Comments __________________________________

34. Was the tremie tube method used to place the filter packs?
Yes _______ No _______
Comments __________________________________

35. Were seals placed above the filter packs?
Yes _______ No _______

36. If yes to 35, what materials was used for the seals?

____

37. Was the vertical thickness of the seals a minimum of two feet?
Yes _______ No _______
Comments __________________________________

TABLE 11-1
FIELD SITE AUDIT INSPECTION FORM

38. If bentonite pellets were used for the seals above the filter packs, were they allowed to hydrate a minimum of 8 hours?
Yes ________ No ________
Comments ____

39. Did contractor/driller have documentation from manufacturer stating recommended hydration time?
Yes ________ No ________
Comments ____

40. Was the tremie tube method used to place the bentonite pellets?
Yes ________ No ________
Comments ____

41. Was the annulus grouted from the seal to within two feet of the ground surface, or below the frost line?
Yes ________ No ________
Comments ____

42. Was the tremie tube method used to place the grout in the annulus?
Yes ________ No ________
Comments ____

43. If no to 42, what method was used?
Yes ________ No ________

44. What type of grout was used to seal the annulus (neat cement, cement/bentonite, cement/sand, etc.)?
____

45. What grout mix ratio was used (should be stated in the POP)?
____

46. What was the density of the grout (lb./gal., etc.)?
____

47. If bentonite grout was used, was the density at least 9.4 lb./gal.?
Yes ________ No ________

48. Was the density determined using a mud balance?
Yes ________ No ________

49. Was the grout allowed to set a minimum of 24 hours before the surface pad was installed?
Yes ________ No ________
Comments ____

50. Was a concrete surface pad installed with an outer protective casing and locking cap?
Yes ________ No ________
Comments ____

51. How far below the ground surface did the concrete pad extend?
____

TABLE 11-1
FIELD SITE AUDIT INSPECTION FORM

52. What were the dimensions of the concrete pads?

____

53. Did the well casings extend to a minimum of 2.5 feet above the ground surface?
Yes ______ No ______
Comments ______________________________________

54. How far above the ground surface did the outer protective casings extend?

____

55. Did the outer protective casings have weep holes?
Yes ______ No ______
Comments ______________________________________

56. Were the wells properly developed?
Yes ______ No ______
Comments ______________________________________

57. Describe method of development.

____

58. Give a general evaluation of the activities observed during installation of the wells.

____

____

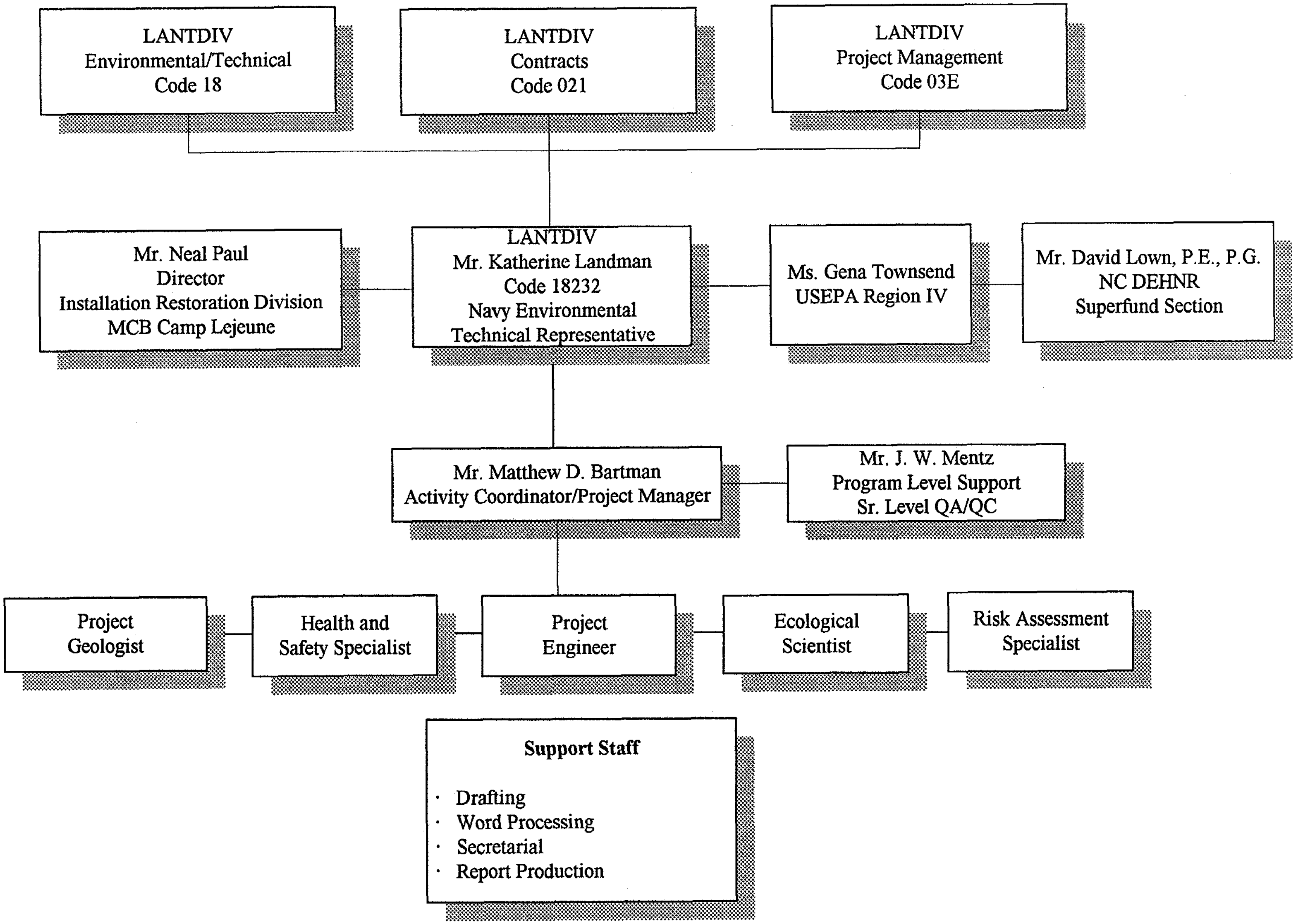
____

____

FIGURES

FIGURE 4-1

PROJECT ORGANIZATION



FINAL

SITE EVALUATION
HEALTH AND SAFETY PLAN

OPERABLE UNIT NO. 15 (SITE 88)
MCB CAMP LEJEUNE, NORTH CAROLINA

CONTRACT TASK ORDER 0356

FEBRUARY 21, 1997

Prepared For:

DEPARTMENT OF THE NAVY
ATLANTIC DIVISION
NAVAL FACILITIES
ENGINEERING COMMAND
Norfolk, Virginia

Under the:

LANTDIV CLEAN Program
Contract N62470-89-D-4814

Prepared By:

BAKER ENVIRONMENTAL, INC.
Coraopolis, Pennsylvania