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**FINAL LEAKING UNDERGROUND STORAGE TANK
COMPREHENSIVE SITE ASSESSMENT**

BUILDING 1613, USTs 1613 1-4

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

MAY 17, 1996

VOLUME I

**Contract No. N62470-93-D-4020
Richard Catlin & Associates, Inc. Job No. 94127-F**



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TABLE OF CONTENTS
VOLUME I

	<u>PAGE</u>
EXECUTIVE SUMMARY	
STATEMENT OF PROFESSIONAL CONDUCT	
1.0 INTRODUCTION	1
1.1 <i>Purpose of Investigation</i>	1
1.2 <i>Scope of Work</i>	2
1.3 <i>Area of Investigation</i>	2
2.0 SITE HISTORY AND SOURCE CHARACTERIZATION	2
2.1 <i>Site History and Operations</i>	2
2.2 <i>Contaminant Source Inventory</i>	2
2.3 <i>Release Incident History</i>	3
2.4 <i>Previous Investigations</i>	4
2.5 <i>History of Corrective Actions</i>	5
3.0 MIGRATION PATHWAYS AND POTENTIAL RECEPTORS	5
3.1 <i>Water Well Inventory</i>	5
3.2 <i>Utility Survey</i>	6
3.3 <i>Potential Receptor Survey</i>	6
3.4 <i>Exposure Pathways Assessment</i>	7
4.0 SOIL INVESTIGATION	8
4.1 <i>Site Topography</i>	8
4.2 <i>Regional Geology</i>	8
4.3 <i>Site Soils and Geology</i>	9
4.4 <i>Soil Contamination</i>	10
5.0 GROUND WATER INVESTIGATION	13
5.1 <i>Regional Hydrogeology</i>	13
5.2 <i>Site Hydrogeology</i>	14
5.3 <i>Hydropunch Investigation</i>	14
5.4 <i>Extent of Free Product</i>	16
5.5 <i>Ground Water Dissolved Contamination</i>	16
5.6 <i>Aquifer Testing</i>	20
5.7 <i>Vertical Gradient Determinations</i>	23
5.8 <i>Rate of Contaminant Migration</i>	23

TABLE OF CONTENTS (CONT'D)

	<u>PAGE</u>
6.0 QUALITY CONTROL PROCEDURES	24
6.1 <i>Equipment Decontamination</i>	24
6.2 <i>Sample Collection and Shipment</i>	26
6.3 <i>Chemical Data Evaluation</i>	28
7.0 PRELIMINARY RECOMMENDATIONS AND CORRECTIVE ACTIONS	28
7.1 <i>Soil Remediation</i>	28
7.2 <i>Ground Water Remediation</i>	29
7.3 <i>Additional Data Needs for Corrective Action Plan Development</i>	30
7.4 <i>Recommendations</i>	30
8.0 REFERENCES	31
 TABLES	
2.1 Contaminant Source Inventory	
3.1 Well Inventory Summary	
3.2 Summary of Exposure Pathways	
4.1 Summary of Headspace Analysis	
4.2 Summary of Laboratory Analytical Results-Soil	
5.1 Summary of Monitoring Well Development	
5.2 Summary of Aquifer Parameter Estimations	
5.3 Summary of Vertical Hydraulic Gradient Determinations	
5.4 Summary of Laboratory Analytical Results-Hydropunch Ground Water Samples	
5.5 Summary of Laboratory Analytical Results-Monitoring Well Ground Water Samples	

TABLE OF CONTENTS (CONTD)

FIGURES

- 1.1 General Location-USGS Topographic Quadrangle
- 2.1 Contaminant Source Inventory
- 3.1 Water Supply Well Location Map
- 3.2 Site Utilities Location Map
- 4.1 Boring, Monitoring Well, and Hydropunch Location Plan
- 4.2 Cross Section-Plan View
- 4.3 Cross Section A-A'
- 4.4 Cross Section B-B'
- 4.5 TPH Concentrations (Soil) - Isopleth Map
- 5.1 Water Table Contour Map
- 5.2 Free Product Spatial Extent Isopleth Map
- 5.3 Hydropunch Data Map
- 5.4 Benzene Concentrations (Water) - Isopleth Map
- 5.5 Toluene Concentrations (Water) - Isopleth Map
- 5.6 Ethylbenzene Concentrations (Water) - Isopleth Map
- 5.7 Total Xylenes Concentrations (Water) - Isopleth Map
- 5.8 Total BTEX Concentrations (Water)
- 5.9 Total EPA Method 601 Concentrations (Water)

VOLUME II

APPENDICES

- A. Comprehensive Site Assessment Workplan
- B. Soil Test Boring Records
- C. Grain Size Distribution, Rising Head Test Data-Hydraulic Conductivity Calculations, and Site Sensitivity Evaluation (SSE)
- D. Well Construction Records and Ground Water Monitoring Well Installation Details
- E. Monitoring Well Casing and Water Elevation Worksheet
- F. Ground Water Flow Direction and Velocity of Surficial Aquifer
- G. Monitoring Well and Sampling Field Data Worksheets
- H. Contaminant Velocity Calculations
- I. Laboratory Analytical Test Reports/ Chain of Custody Records
- J. Analytical Data Review Report
- K. Eight Hour Aquifer Test Data and Calculations

**LEAKING UNDERGROUND STORAGE TANK
COMPREHENSIVE SITE ASSESSMENT
BUILDING 1613, USTs 1613 1-4**

EXECUTIVE SUMMARY

Former underground storage tanks (USTs) 1613 1-4 were located northeast of Building 1613, the PCX service station, in the Hadnot Point area. The tanks supplied various grades of gasoline to the service station and were removed January 13, 1995. Hydrocarbon impact to the surrounding subsurface soils was confirmed in the UST Closure Report prepared and submitted on March 8, 1995 by Geosciences, Inc. Soil contamination and free product were identified from previous investigations.

As part of this investigation, Richard Catlin and Associates, Inc. (RC&A) installed 15 Hydropunches, 12 Type II monitoring wells, three Type III monitoring wells, and one pumping well to determine site geology and the extent of impact to subsurface soils and ground water. Depth to ground water beneath the site was found to range between approximately six to 21 feet. Ground water flow direction at the site was found to be toward the northeast with a velocity of 0.54 feet/day. Geology beneath the site consists of interfingering very fine to medium grained sands, silty sands, sand-clay mixtures, and limestone-clay mixtures. No confining unit was identified.

Free product, soil and ground water dissolved petroleum related contamination were identified from this and previous investigations. Soil contamination was identified during the Comprehensive Site Assessment (CSA) from the former UST basin at concentrations less than State action levels. A Site Sensitivity Evaluation (SSE) was completed by RC&A for the subject site resulting in proposed final cleanup levels of 60 parts per million (ppm) for total petroleum hydrocarbons (TPH) gasoline and 240 ppm for TPH-diesel. Dissolved purgeable aromatic constituents were identified and delineated in the area of the former UST basin and free product plume areas. Dissolved purgeable halocarbon compounds were identified above State ground water standards in three isolated areas, suggesting multiple sources. In addition, the vertical extent of purgeable halocarbons is to at least 50 feet.

At this time, no soil remediation is recommended. However, additional soil sampling and analysis may be necessary to determine that soil contamination does not exist along the margins of the former UST basin. Due to the site specific conditions, a combination of remediation strategies may be implemented to contain and remove free product, and reduce ground water contamination. Appropriate pilot testing should be performed and a Corrective Action Plan (CAP) prepared.

STATEMENT OF PROFESSIONAL CONDUCT

I, Teresa M. Piver, a Professional Geologist in the State of North Carolina, confirm that this report and its contents have been prepared in accordance with the approved Workplan dated March 10, 1995 and with the standards of best professional practice.



Teresa M. Piver
Professional Geologist
State of North Carolina
Registration Number 1409

LEAKING UNDERGROUND STORAGE TANK
COMPREHENSIVE SITE ASSESSMENT

BUILDING 1613, USTs 1613 1-4

MARINE CORPS BASE
CAMP LEJEUNE, NORTH CAROLINA

MAY 17, 1996

1.0 INTRODUCTION

1.1 *Purpose of Investigation*
(Refer to Figure 1.1 and Appendix A)

The purpose of this Leaking Underground Storage Tank (LUST) Comprehensive Site Assessment (CSA) was to accomplish the following goals:

- Determine the magnitude of and extent of soil and ground water petrochemical contamination associated with Building 1613 and underground storage tanks (USTs) 1613 1-4
- Identify and delineate possible free product accumulation, if present
- Assess the potential for exposure to possible subsurface petroleum-related contaminants
- Provide a CSA report for Building 1613 and the former USTs 1613 1-4, Marine Corps Base (MCB), Camp Lejeune, North Carolina

The location of the project site is shown in Figure 1.1.

This CSA document was prepared in accordance with the Workplan (Appendix A) approved by the Atlantic Division (LANTDIV) of the Naval Facilities Engineering Command (NAVFACENGCOM) and requirements listed as Elements 1 through 12 for "Comprehensive Site Assessments at LUST Sites" of the document entitled "Groundwater Section Guidelines for the Investigation and Remediation of Soils and Groundwater" prepared by the Groundwater Section of the North Carolina Department of Environment, Health, and Natural Resources (NCDEHNR), March 1993. The objective of the CSA is to provide sufficient data to satisfy the requirements of Section 280.65 of 40 CFR Part 280, Federal Technical Standards for Underground Storage Tanks, and Section .0706 of the North Carolina Administration Code Title 15A, Chapter 2, Subchapter 2N (NCAC T15A:02N), Criteria and Standards Applicable to Underground Storage Tanks.

1.2 *Scope of Work*

Throughout the site investigation, a total of 15 Hydropunch penetrometers (Hydropunches) were advanced in the area and shallow ground water samples for on-site laboratory analysis. The on-site laboratory results were available within 24 hours to provide data to assist in determining the location of subsequently installed boreholes. The Hydropunches were located predominantly downgradient of the source, with respect to shallow ground water flow. Previously established information (i.e. contaminant concentrations, presence of free product, buried utilities, etc.) was also used to assist in the placement of the Hydropunches. At least six of the Hydropunches were used to perimeter the crossgradient and upgradient sides of the suspected plume and the remaining were utilized for downgradient plume delineation.

The investigation also involved the advancement of 16 soil borings, into which 12 Type II, three Type III monitoring wells, and one pumping test well were installed. Samples were collected from the soil borings (soil) and monitoring wells (ground water) for both on-site and off-site laboratory analysis.

Three slug tests were conducted at the site to determine site hydrogeological conditions, and an eight hour pumping test was performed on the pumping well to determine aquifer parameters.

1.3 *Area of Investigation* (Refer to Figure 1.1 and Figure 2.1)

The site is located in the Hadnot Point area of the MCB, Camp Lejeune, North Carolina, approximately 1,000 feet south of Beaver Dam Creek (see Figure 1.1). The project area is Building 1613, the PCX Service Station on West Street. The former USTs were located to the northeast of Building 1613 (see Figure 2.1).

2.0 **SITE HISTORY AND SOURCE CHARACTERIZATION**

2.1 *Site History and Operations*

Building 1613 is the PCX Service Station and the former site of one 10,000 gallon gasoline UST, two 30,000 gallon gasoline UST, and a 9,000 gallon gasoline UST. These tanks were reportedly installed during the 1950s.

2.2 *Contaminant Source Inventory* (Refer to Table 2.1 and Figure 2.1)

Site reconnaissance and research of previous investigations revealed at least eight potential sources for subsurface impact in the area. Additional

sources may exist in the area that are not identified here. Potential sources (PS) are listed in Table 2.1 and are illustrated in Figure 2.1. All potential source locations are approximated.

Potential sources for the Building 1613 area are:

- PS #1 - The former basin for USTs 1613 1-4 which contained various grades of gasoline, located northeast of Building 1613, near the West Street and Fir Street intersection.
- PS #2 - Building 1700, a steam generating plant which houses a 5,000 gallon fuel oil aboveground storage tank (AST).
- PS #3 - A large coal storage facility and two ASTs located on the east side of Building 1700. Tank capacities and contents are unknown by RC&A personnel.
- PS #4 - Building 1612, a vehicle repair and virgin fuel storage facility located near the Fir Street and West Street intersection.
- PS #5 - A waste oil AST located adjacent to and south of Building 1612. The tank capacity is unknown by RC&A personnel.
- PS #6 - Building 1610, a tire and electric repair shop. This site houses hydraulic fluid for car lifts and is located south of the former UST basin, near the West Road and Fir Street intersection.
- PS #7 - Three 12,000 gallon capacity ASTs; two contain regular unleaded gasoline and the other contains premium unleaded gasoline. The ASTs are located to the northwest of Building 1613.
- PS #8 - Building 1500, a Base laundry facility located to the southeast of Building 1613. This site houses dry cleaning solvents.

2.3 *Release Incident History*

Building 1613 is the site of the PCX Service Station located in the Hadnot Point area. Former USTs 1613 1-4 were located northeast of Building 1613. These USTs were removed on January 13, 1995 and contained various grades of gasoline. A site assessment was requested as part of the ongoing

UST investigations within the Hadnot Point area. Petroleum soil contamination was discovered during the UST excavation activities.

2.4 *Previous Investigations*

Building 1613 is located in the Hadnot Point Industrial Area (HPIA) of Camp Lejeune. The HPIA has been the focus of several environmental investigations. A Remedial Investigation (RI) was conducted by Baker Environmental, Inc. in 1993, which included the HPIA. The purpose of the study was to evaluate the nature and extent of the threat to public health and the environment caused by the release or threatened release of hazardous substances, pollutants, or contaminants at the sites. In general, the study revealed that soil, ground water, surface water, and sediment within portions of the HPIA had been impacted by organic compounds and metals. Concentrations of both halogenated and non-halogenated volatile organic compounds (VOCs) were detected primarily in shallow monitoring wells (78GW01, 78GW05) in the area of Building 1601. It was noted that the deeper water bearing zone also exhibited elevated VOC concentrations. Contaminants identified from the RI included: trichloroethene (TCE), 1,2-dichloroethene (DCE), dichloromethane, aluminum, arsenic, barium, chromium, copper, iron, and lead. The study concluded that there was no particular pattern trend for the contaminants identified.

Past documents revealed that USTs 1613 1-4 contained various grades of gasoline that supplied Building 1613, the PCX Service Station in the Hadnot Point area. Tank installation dates are assumed by MCB personnel to be during the 1950s. A VacuTect™ leak detection test report was provided on July 18, 1994 for USTs 1613-1 and 1613-2. No leakage from the USTs was detected. Underground storage tank 1613-3 and all pressure lines were not tested due to mechanical problems.

Geosciences, Inc. conducted and prepared a UST Closure Report for USTs 1613 1-4, which were removed by Omega Environmental Services, Inc., (OES) between January 12th and 19th, 1995. All petroleum product was drained and removed from the USTs and associated piping prior to excavation by Noble Oil Services. Approximately 61,134 gallons of petroleum fuel were removed from the four USTs.

Soil samples were collected from each end of the USTs and additionally from below the middle of USTs over 20 feet long. The samples were laboratory analyzed for benzene, toluene, ethylbenzene, and total xylenes (BTEX) per EPA Method 8020, Toxicity Characteristic Leaching Procedure (TCLP) metals per EPA Method 200.7, and total petroleum hydrocarbons (TPH) per EPA Method 5030.

Results of the laboratory analysis revealed total BTEX concentrations ranging from 0.15 parts per million (ppm) to 5,963 ppm. No TCLP lead

concentrations were detected in the soil samples. TPH concentrations ranged from below detection limits (BDL) to 6,500 ppm.

2.5 *History of Corrective Actions*

The subject USTs 1613 1-4 were removed between January 12th and 19th, 1995. Approximately 2,127.93 tons of contaminated soil were removed from the subject site by Soil Reclaiming, Inc. and delivered to Lee Brick & Tile Company, Inc.. However, over excavation of suspected contaminated soils was not performed. A free product recovery system was recognized on-site during site reconnaissance. Per communications with MCB personnel it was learned that free product is being recovered from well HPGW-6. This well was installed by Environmental Science and Engineering, Inc (ESE) as part of a two-phased Confirmation Study focusing on potential source areas at Site 78 (Hadnot Point Industrial Area). This study was conducted from 1986 through 1988 (Baker, June 1994). Prior to installation of the active product skimming system, approximately six feet of product was measured in well HPGW-6. The recovery system was installed in November 1994. Well HPGW-6 is monitored monthly by Geophex, Ltd. According to Geophex personnel, the product level is checked on a monthly basis and when product levels reach a thickness of approximately one foot, the skimmer is operated until all measurable product is removed. As of February 1996, a total of 339.5 gallons of free product have been recovered.

3.0 MIGRATION PATHWAYS AND POTENTIAL RECEPTORS

3.1 *Water Well Inventory* (Refer to Table 3.1 and Figure 3.1)

No active water supply wells were identified within a 1,500 foot radius of the site. One out of service well (HP-603) and two permanently abandoned wells (HP-601 and HP-608) were within 1,500 feet of the site. According to Baker Environmental, Inc. (1994), water samples from these wells revealed concentrations of DCE, TCE, and benzene. Per communication with the Camp Lejeune Water Treatment Plant personnel, Well HP-608 was de-activated in the 1980's and later permanently abandoned. Well HP-603 is out of service, but has not yet been abandoned. These wells reportedly accessed the Castle Hayne aquifer when they were active. Refer to Table 3.1 for well inventory summary and Figure 3.1 for locations.

3.2 Utility Survey
(Refer to Figure 3.2)

Underground utilities were identified through field observation and information provided by the Technical Records at the Public Works Department of Camp Lejeune. Utilities are displayed in Figure 3.2, and include the following:

- Water - An underground water line is located approximately five feet to the south of Building 1613. This line intersects with another water line that lies along the eastern side of Gum Street. An underground water line lies parallel with Holcomb Boulevard approximately 340 feet north of Building 1613.
- Storm Drain - An underground storm drain lies parallel to Building 1613 approximately 100 feet to the south. Three additional storm drains are located to the west of Building 1613. Two of the underground storm drains lie along either side of Gum Street. The third storm drain line lies between the two previous storm drains.
- Sanitary Sewer - Underground sanitary sewer lines lie within the subsurface of the subject site. Exact locations are not known by RC&A personnel.
- Telephone - Two overhead telephone lines lie parallel with Holcomb Boulevard, to the north of Building 1613.
- Electric- Several overhead electrical lines with power poles are located around the subject site. Two lines lie west of Building 1613 and three electrical lines are located to the northwest, northeast, and southeast of Building 1613.
- Steam - Underground steam lines lie 80 feet east and 422 feet west of Building 1613.

3.3 Potential Receptor Survey
(Refer to Table 3.2)

Petroleum migration may result in multi-media contamination, upon its release to the land surface or subsurface environment. As petroleum seeps through the subsurface, petroleum-related hydrocarbons adsorb onto soil particles and volatilize into pore spaces. The remaining petroleum moves vertically downward (in the absence of preferred lateral routes of migration) until it reaches the capillary fringe (in the absence of an impermeable barrier above the capillary fringe). Upon reaching the

capillary fringe, petroleum spreads laterally and also dissolves into the ground water. As a result, receptors may be potentially exposed to petroleum hydrocarbons (contaminants) through a variety of mechanisms.

As defined by the NCDEHNR in Section .0102 of 15A NCAC 2L, potential receptors include any human, plant, animal or structure with the potential to be adversely affected by the release or migration of contaminants. Guidance documents issued by the regulatory agency indicate that structures may include items such as utility lines, basements, and elevator shafts. Although not specifically included in the rule definition (.0102 15 NCAC 2L), regulatory officials also consider potential receptors to include environmental resources such as water supply wells, surface waters, drinking water supplies, and "regions of ground water that have been identified for planned resource development".

The potential receptor survey involves an evaluation of the presence of potential receptors and evaluates transport mechanisms (e.g., ground water migration) by which the contaminants (in this case, petroleum hydrocarbons) are transported from the source to the receptor. The survey also involves a cursory evaluation of exposure pathways including ingestion, inhalation, and adsorption, with respect to human receptors. Contaminants found in the soil can be exposed to potential human receptors through inhalation of volatilized compounds and dermal contact with contaminated soil. Ingestion of drinking water obtained from contaminated water wells or contaminated public water supplies is an additional example of a human exposure pathway.

No active water supply wells were identified within a 1,500 foot radius of the site.

The buildings in the near vicinity of the project site are slab-on-grade construction. Underground utilities in the area of investigation include water, storm drains, and steam lines. Beaver Dam Creek is the nearest mapped body of surface water, located approximately 1,000 feet north of the site. The water table in the source area is measured at six to 21 feet below land surface (BLS). Underground utility depths are reportedly less than five feet deep and; therefore, the utility trenches are not considered a potential receptor or as preferential pathways for contaminant migration.

3.4 *Exposure Pathways Assessment* (Refer to Table 3.2)

The following contaminants were identified at this site through this investigation:

- benzene
- toluene
- total xylenes
- trans-1,2-dichloroethene
- naphthalene
- total petroleum hydrocarbons

- ethylbenzene
- trichloroethene
- 1,1-dichloroethene
- 1,1,1-trichloroethane
- chloroform
- trichlorofluoromethane
- chloromethane
- bromomethane

Table 3.2 summarizes the potential for exposure to contamination from the subject site. Given the characteristics of the local subsurface and the nature of the contamination medium, exposure is unlikely.

4.0 SOIL INVESTIGATION

4.1 *Site Topography*

The project area is dominated by relatively flat topography. The nearest mapped body of surface water is the Beaver Dam Creek, located approximately 1,000 feet to the north of Building 1613.

4.2 *Regional Geology*

The area of investigation lies within the Coastal Plain Physiographic province. The North Carolina Coastal Plain is approximately 90 to 150 miles wide from the Atlantic Ocean westward to its boundary with the Piedmont Province. Two natural subdivisions of the Coastal Plain were described by Stuckey (1965): the Tidewater region and the Inner Coastal Plain. The project area is located within the Tidewater region which consists of the coastal area where large streams and many of their tributaries are affected by ocean tides (Winner, Jr., and Coble, 1989).

The Coastal Plain is comprised of a wedge shaped sequence of stratified marine and non-marine sedimentary rocks deposited on crystalline basement rocks. The sedimentary sequences range in age from Recent to lower Cretaceous (Narkunas, 1980).

The crystalline basement rocks in the Camp Lejeune area are overlain by 700 to 1,800 feet of unconsolidated sediments. The surficial Quaternary age deposits range from 23 to 80 feet thick. These deposits are underlain by Tertiary age rock units consisting of Castle Hayne limestone and sand followed by the Beaufort Formation. Underlying Cretaceous age rocks range in thickness from 700 to more than 1,400 feet and include the Peedee, Black Creek, and Upper and Lower Cape Fear Formations (Winner, Jr. and Coble, 1989).

Regional lithological units were identified from a U.S. Marine Corps well drilled in Camp Lejeune, North Carolina (Map No. 101, Winner, Jr. and Coble, 1989). These units were identified as follows:

FORMATION	DEPTH IN FEET	DESCRIPTION
Quaternary Surficial Deposits	0-10	Sand, clay, gravel, and peat deposits in marine, fluvial, eolian, and lacustrine environments. Quaternary age deposits not shown at altitudes greater than approximately 25 feet above mean sea level.
Tertiary Castle Hayne	10-332	Upper level molluscan-mold limestone, indurated, very sandy. Grades downward into calcareous sand and laterally into a bryozoan-echinoid skeletal limestone, locally dolomitized, solution cavities common. Lower level phosphate-pebble conglomerates, micritic, thin; restricted to basal part of the Castle Hayne Formation in southeastern counties.
Tertiary Beaufort	332-432	Upper level sand and silty clay, glauconitic, fossiliferous, and locally calcareous. Lower level siliceous mudstone with sandstone lenses; thin bedded, basal phosphatic pebble conglomerates.
Cretaceous Peedee	432-?	Sand, clayey sand, and clay; greenish-gray to olive black; massive, glauconitic, locally fossiliferous and calcareous. Patches of sandy molluscan-mold, limestone in upper part (NCDNRCD, 1985).

4.3 *Site Soils and Geology*

4.3.1 *Soil Boring Installation* (Refer to Figure 4.1)

Prior to the installation of the monitoring well boreholes, Hydropunch penetrometers (HP-1 through HP-15) were utilized to provide additional contamination data to assist with the location of the subsequent monitoring wells. The Hydropunch investigation will be further discussed in Section 5.3.

Sixteen soil borings were advanced by a trailer-mounted drill rig to install 12 Type II (1613-1 through 1613-12), three Type III (1613-13 through 1613-15) monitoring wells, and one pumping well (1613-16). Refer to Figure 4.1 for boring/well locations. Hollow-stem augers were used to advance the soil borings to the proper depths.

4.3.2 *Description of Subsurface Samples*
(Refer to Appendix B, and Figures 4.2, 4.3, and 4.4)

Soil samples were obtained from intervals of five feet from the Type II and pumping well boreholes utilizing a split-spoon sampler in accordance with ASTM D-1586. The Type III well boreholes were continuously sampled using the split-spoon device. Soils were described in the field by an engineer or geologist trained in using visual/manual techniques as described in ASTM D-2487 and D-2488. The soils were classified in accordance with the Unified Soils Classification System (USCS) and a boring record of each borehole was produced. Boring logs are provided in Appendix B.

Two aquifer profiles were generated based on information obtained and interpreted from borehole samples. Figure 4.2 illustrates the plan view of the aquifer profile layout, and Figures 4.3 and 4.4 depict aquifer profile A-A' and B-B', respectively. Geology beneath the site appears to be underlain by interfingering layers of very fine to medium grained sands, silty sands/sand-clay mixtures, and sand-limestone mixtures to a depth of approximately 52 feet or more. No confining unit or aquiclude was encountered during drilling activities.

4.4 *Soil Contamination*

4.4.1 *Field Screening and Laboratory Sample Collection*

Field screening was conducted during drilling of the monitoring well boreholes to determine if organic vapors were present in the unsaturated zone and to identify areas of suspected near-surface releases.

Each split-spoon sample was divided, and placed in two pre-labelled, air tight, plastic bags. One sample bag was immediately placed on ice pending selection of the appropriate laboratory sample depth. The second sample bag was left undisturbed for several minutes to allow the organic vapors to reach equilibrium. The gas contained in the headspace of the bag was tested with an Organic Vapor Analyzer (OVA) flame-ionization detector. The first laboratory sample for each borehole was taken from a depth of two to four feet. The second sample from the Type II boreholes was collected from the ten to 12 foot split-spoon interval. The second soil sample from the Type III boreholes was taken at a depth of approximately 40 feet. All of the soil samples for this investigation were sent to the off-site laboratory.

All soil samples collected for laboratory analyses were immediately placed on ice. Soil was collected and placed into containers in

accordance with the type of analyses scheduled for that sample as follows:

Analytical Method	Bottle Type and Size	Total Number of Bottles per Sample, Off-Site Lab	Preservative
TPH 5030/3550	Glass Separate Jar/8 oz.	1	<4°C
Grain Size	Glass Wide Mouth/32 oz.	32 oz. total	NR
Flash Point-EPA 1010	Amber Glass Wide Mouth/8 oz.	1	<4°C
pH- EPA 9045	Glass or Plastic/8 oz.	1	<4°C
Total Lead	Clear Glass Wide Mouth/8 oz.	1	<4°C

NR = Not Required

4.4.2 Results of Soil Analyses (Refer to Table 4.1, Table 4.2, and Appendix I)

4.4.2.1 Field Screening

Results of the field screening using the OVA are provided in Table 4.1. Organic vapor recordings ranged from zero to greater than 1,000 parts per million (ppm).

4.4.2.2 Laboratory Analyses

The following soil analyses were performed:

- 35 TPH (gasoline/diesel)- EPA Method 5030/3550
- Two Ignitability (Flashpoint) - EPA Method 1010
- Two pH - EPA Method 9045
- Five Total Lead - EPA Methods 3030C/7421
- Three Grain Size

Two TPH samples were collected from each borehole drilled on site. The first TPH sample collected from each Type II, Type III, and pumping well borehole was obtained from the upper five feet of the vadose zone. The second TPH soil sample from each Type II and pumping well borehole was collected from within five feet of the water table. The second sample from each Type III borehole was collected from

approximately 40 feet deep. Table 4.1 denotes the soil samples selected for the TPH analysis and the sample depths for each borehole. Flashpoint and pH samples were collected from selected boreholes at the ten to 12 foot interval. Samples were collected from the two to four foot interval from selected boreholes for total lead analysis. Grain size samples were collected from 1613-7, 1613-8, and 1613-16 from the 15-17 foot interval. In addition, one composite sample, 1613-SC, was also collected for waste soil characterization.

4.4.2.3 Results of Soil Sampling

(Refer to Table 4.2, Figure 4.5, Appendix I, and Appendix C)

The NCDEHNR has established action levels for petroleum hydrocarbons in soils. The current minimum action levels are: 10 ppm for gasoline and 40 ppm for diesel/kerosene. Results of the TPH-diesel analysis revealed 20.7 ppm from sample 1613-14 (two to four feet). Concentrations of TPH-diesel were not identified above method detection limits in any other sample. No detectable concentrations of TPH-gasoline were identified during the analysis. Figure 4.5 depicts the TPH-gasoline (EPA Method 5030) and diesel (EPA Method 3550) data. Laboratory results are summarized in Table 4.2A.

Samples 1613-1, 1613-2, 1613-3, 1613-4 and 1613-16 were analyzed for total lead. Results revealed 13.7 ppm of lead from sample 1613-3. No detectable concentrations of lead were identified from samples 1613-1, 1613-2, 1613-4 and 1613-16. Results are summarized in Table 4.2B.

According to the UST Closure Report (Geosciences, Inc., March 1995), soil samples collected during the UST excavation activities revealed TPH-gasoline concentrations ranging from BDL to 6,500 ppm. The soil samples were collected from the base of the excavation area and from stockpiled soils. Approximately 2,127.93 tons of contaminated soil was removed from the subject site. It is not known if vadose contamination exists along the margins of the excavation area to the north, east, or south.

A Site Sensitivity Evaluation (SSE) was performed in accordance with the North Carolina Division of

Environmental Management Ground water Section's document entitled "Groundwater Section Guidelines for the Investigation and Remediation of Soils and Groundwater, 1993". Based on the SSE for a site Category B classification, final cleanup levels for TPH-gasoline and TPH-diesel were determined to be 60 ppm and 240 ppm respectively. Refer to Appendix C for the SSE.

Flashpoint values from selected soil samples (1613-16 and 1613-2) were reported at greater than 100°C to 130°C. Analysis of pH from the same samples revealed values of 8.43, 6.37, and 6.67. Results are summarized in Table 4.2A. Grain size results are discussed in Section 5.6.2.

Sample 1613-SC collected for characterization of waste soil generated during the course of the investigation, revealed no detectable concentrations of TPH-gasoline or diesel.

Laboratory reports are provided in Appendix I.

5.0 GROUND WATER INVESTIGATION

5.1 *Regional Hydrogeology*

The Coastal Plain ground water system consists of aquifers comprised of permeable sands, gravels, and limestone separated by confining units of less permeable sediments. The three main aquifers utilized for water consumption in Onslow County include the surficial aquifer, Peedee aquifer, and Castle Hayne aquifer (LeGrand, 1960).

According to Winner, Jr. and Coble (1989), the surficial aquifer consists primarily of fine sands, clays, shells, peat beds, and scattered deposits of coarse grained material in the form of relic beach ridges and floodplain alluvium. The areal extent of the surficial aquifer in the Coastal Plain is approximately 25,000 square miles with an average thickness of 35 feet. The average estimated hydraulic conductivity is 29 feet per day. In the Camp Lejeune area, the thickness of the surficial aquifer averages approximately ten feet thick with an estimated hydraulic conductivity of 50 feet per day.

Underlying the surficial aquifer is the Castle Hayne aquifer and confining unit. The Castle Hayne confining unit consists of beds of clay, sandy clay, and clay with sandy streaks. In the Camp Lejeune area this confining layer is typically ten feet thick. The Castle Hayne aquifer is composed predominantly of limestone and sand with minor amounts of clay. The

approximate areal extent of the Castle Hayne aquifer is 11,500 square miles. Thickness of this aquifer unit ranges from 952 feet to seven feet. The average estimated aquifer thickness is 65 feet thick with an estimated hydraulic conductivity of 45 feet per day (Winner, Jr. and Coble, 1989).

The Castle Hayne aquifer unconformably overlies the Beaufort aquifer and confining unit. The Beaufort confining unit consists of the uppermost sediments of the Beaufort Formation; predominantly sandy clay to clay. The thickness ranges from zero to 80 feet, and averages about 24 feet. At Camp Lejeune, the thickness is typically 20 feet. The Beaufort aquifer is composed primarily of fine to medium grained glauconitic sand, clayey sand, and clay beds. The areal extent of this aquifer is approximately 10,700 square miles with an average thickness of 70 feet. The average hydraulic conductivity is 35 feet per day. In Camp Lejeune, the Beaufort aquifer is 80 feet thick with a hydraulic conductivity of 55 feet per day (Winner, Jr. and Coble, 1989).

Unconformably underlying the Beaufort aquifer is the Peedee aquifer and confining unit. The Peedee confining unit is composed of clay, silty clay, and sandy clay. The average thickness of this confining unit is nearly 25 feet. In the Camp Lejeune area, this unit is approximately 42 feet thick. The Peedee aquifer is composed of fine to medium grained sand interbedded with gray to black marine clay and silt. Sand beds contain varying amounts of glauconite. Shells are common throughout the aquifer. The approximate areal extent of the aquifer is 13,900 square miles. Average thickness is 146 feet with an estimated hydraulic conductivity of 34 feet per day (Winner, Jr. and Coble, 1989).

5.2 *Site Hydrogeology* (Refer to Figure 5.1, and Appendices E and F)

This investigation revealed the depth to ground water to be approximately between six to 21 feet beneath the site. As shown in Figure 5.1, strict interpolation of the ground water table elevations reveals ground water flow to be overall toward the east-northeast. However, there appears to be a "trough" or undulation trending north-south which may be associated with channel deposits. A hydraulic gradient calculated from water level measurements between wells 1613-4 and 1613-10 was determined to be 3.14 percent. Ground water velocity was determined to be 0.54 feet per day to the northeast. Ground water measurements and hydraulic gradient/velocity calculations are provided in Appendices E and F, respectively.

5.3 *Hydropunch Investigation* (Refer to Figure 4.1 and Table 5.4)

Fifteen hydropunch penetrometers (HP-1 through HP-15) were installed in conjunction with the monitoring wells to provide additional information

of the spatial extent of the dissolved and free-phase plumes. The locations of these sampling points were selected based on known/suspected contaminant source locations and previous subsurface investigative results. Refer to Figure 4.1 for Hydropunch locations.

The Hydropunch penetrometer was advanced by a trailer-mounted drill rig. Depending upon the subsurface conditions at each sample location, the penetrometer was advanced by hammer blows or by a hydraulic press. If fill material, hard/dense soils, or a deep ground water table (greater than ten feet deep) was encountered, a shallow pilot boring was advanced until a more suitable sampling interval was encountered to avoid damage to the probe.

Collection of the ground water samples was accomplished by driving the Hydropunch into the water-bearing zone and pulling back on the body of the tool to allow ground water to enter into the screened portion of the sample chamber. Samples were then retrieved utilizing a small diameter, decontaminated, transparent Teflon bailer. Hydropunch samples were collected from the following approximate depths:

HP-1	7 - 11 feet
HP-1D	17 - 20 feet
HP-2	13 - 17 feet
HP-3, -6	15 - 19 feet
HP-4, -5, -9, -11	11 - 15 feet
HP-7	7 - 10 feet
HP-8	13 - 16 feet
HP-10	16 - 20 feet
HP-12	11 - 15 feet
HP-13, -14, -15	12 - 15 feet

Each ground water sample collected from the Hydropunch locations was analyzed for purgeable aromatics per EPA Method 602 and purgeable halocarbons per EPA Method 601. Results of the sample analysis identified purgeable aromatics in Hydropunch samples HP-1, HP-1D, HP-2, HP-5, and HP-7 through HP-15. Of these samples, only samples HP-8, HP-9, and HP-11 revealed concentrations in excess of State Standards. Ground water quality standards (NCAC T15A:02L) have been established for the maximum allowable concentrations of specific contaminants. Of the purgeable aromatics identified from Hydropunch samples, standards exist for benzene (1 part per billion or ppb), toluene (1,000 ppb), ethylbenzene (29 ppb), and total xylenes (530 ppb). Hydropunch HP-9 displayed 2.9 ppb benzene and HP-8 revealed noncompliant concentrations of benzene (17,300 ppb), toluene (20,700 ppb), ethylbenzene (2,140 ppb), and total xylenes (10,800 ppb). Hydropunch HP-11 also displayed noncompliant concentrations of benzene (7,700 ppb), toluene (10,800 ppb), ethylbenzene (1,100 ppb), and xylenes (5,420 ppb). All other samples analyzed for purgeable aromatics were BDL.

Results of the sampling analyses for total purgeable halocarbons revealed compounds in Hydropunches HP-1D and HP-10. Ground water quality standards have been established for trichlorofluoromethane (2,100 ppb), trans-1,2-dichloroethene (700 ppb), trichloroethene (2.8 ppb), 1,1-dichloroethene (7 ppb), and 1,1,1-trichloroethane (200 ppb). Trichlorofluoromethane and trichloroethene compounds were detected in HP-1D at 1.9 ppb and 29.2 ppb, respectively. HP-10 displayed 1.0 ppb trans-1,2-dichloroethene, 1.1 ppb 1,1-dichloroethene, and 1.0 ppb 1,1,1-trichloroethane. All noncompliant Hydropunch samples were collected from within the vicinity of the former UST basin. No detectable purgeable halocarbon concentrations were identified from samples HP-1 through HP-9, HP-14 through HP-15. Results are summarized in Table 5.4 and laboratory results are provided in Appendix I. Figure 5.3 depicts the Hydropunch data.

5.4 *Extent of Free Product* (Refer to Figure 5.2 and Appendix E)

Free product was not identified during the course of this investigation. However, free product was previously identified from well HPGW-6. The areal extent of free product has been delineated and is depicted on Figure 5.2. The actual size of the free product plume may vary from the depicted size due to the limited number of monitoring points within close proximity to well HPGW-6. Free product is being recovered via a product skimmer located in well HPGW-6. Free product thickness is measured in well HPGW-6 on a monthly basis. If product thickness exceeds one foot then the skimmer is activated until all product has been evacuated from the well. According to the February 1996 free product recovery report, a total of 339.5 gallons of product has been recovered since 1994 to 1996. Product gauging data is provided in Appendix E.

5.5 *Ground Water Dissolved Contamination*

5.5.1 *Monitoring Well Network* (Refer to Figure 4.1 and Appendices A and D)

Twelve Type II monitoring wells (1613-1 through 1613-12), three Type III monitoring wells (1613-13 through 1613-15), and one pumping well (1613-16) were installed to determine the areal and vertical extents of petroleum contamination at the subject site. Refer to Figure 4.1 for monitoring well locations. All wells were installed by a qualified driller registered in the State of North Carolina. Well installation was supervised by an experienced geologist or engineer specializing in subsurface investigations. The wells were constructed in accordance with North Carolina Well Construction Standards (NCAC T15:02C) and with design criteria established in the Workplan (Appendix A). Well

construction records and as-built well details are provided in Appendix D.

5.5.2 *Well Development*
(Refer to Tables 5.1 and 5.5A & B, and Appendix I)

Well development was performed no sooner than 24 hours after the grouting was completed. Development of the wells was accomplished by either continuous low yield pumping or bailing. As the wells were developed, ground water turbidity was visually monitored and recorded (see Table 5.1). Well development continued until turbidity stabilized. Water generated during the well development was containerized in Department of Transportation (DOT) approved drums. All fluids generated during well development were disposed of at a permitted, off-site facility.

An average of 13 gallons was removed from the Type II wells during development, and an average of 12 gallons was removed from the Type III wells. The pumping well had 100 gallons removed. All fluids generated during development and sampling activities were composited and a sample was collected for waste characterization purposes. A composite sample (1613-WC) was analyzed for purgeable aromatics per EPA Method 602 and purgeable halocarbon compounds per EPA Method 601. Results of purgeable aromatics analysis revealed 2.5 ppb benzene, 18.9 ppb toluene, 4.8 ppb ethylbenzene, and 23.1 ppb total xylenes. Results of the purgeable halocarbon analysis revealed 1 ppb chloroform and 0.9 ppb trichloroethene concentrations. The laboratory reports are provided in Appendix I and data summarized in Tables 5.5A and 5.5B.

5.5.3 *Sample Collection and Laboratory Analyses*
(Refer to Appendix G)

The sampling program consisted of purging the monitoring wells, then collecting the ground water samples from each. Well purging and sampling was performed in accordance with procedures established in the Workplan (Appendix A). Monitoring well and sampling field data worksheets are provided in Appendix G. Ground water samples were collected and placed into containers in the following order based upon the type of laboratory analysis scheduled for that sample:

Analytical Method	Bottle Type and Size	Total Number of Bottles per Sample On-Site/ Off-Site Lab	Preservative
EPA 602	Clear Glass Vial/40 ml	2/2	HCl/<4°C
EPA 601	Clear Glass Vial/40 ml	2/2	H ₂ SO ₄ / <4°C
EPA 625	Amber Glass Jar/1 liter	NA/1	<4°C

NA = Not Applicable

5.5.4 *Results of Ground Water Sampling*
(Refer to Tables 5.4 and 5.5A through 5.5C, Figures 5.2 through 5.9, and Appendix I)

Isopleth maps presented as part of this report were contoured using data from Type II monitoring wells and Hydropunches. Where applicable, isopleths were established by first interpreting a "compliance" isopleth based on the NCDEHNR action level for the particular contaminant. Hydropunch and monitoring well data were viewed qualitatively to establish this isopleth.

The following analyses were utilized to characterize the ground water dissolved contamination at Building 1613:

- 19 Purgeable Aromatics - EPA Method 602
- 19 Purgeable Halocarbons - EPA Method 601
- 4 Base/Neutrals and Acid Extractables - EPA Method 625
- 4 Purgeable Halocarbons per EPA Method 601

Monitoring wells 1613-1 through 1613-16 were analyzed for purgeable aromatics per EPA Method 602 and purgeable halocarbons per EPA Method 601.

Purgeable Aromatics

Concentrations of benzene, toluene, ethylbenzene, total xylenes (collectively referred to as BTEX) were identified from samples 1613-10, 1613-11, and 1613-16. As previously discussed, ground water quality standards have been established for the individual BTEX compounds. Table 5.5A summarizes the analytical data and compares them to ground water quality standards. Monitoring well 1613-10 contained noncompliant concentrations of benzene (804 ppb), toluene (6,780 ppb), ethylbenzene (1,280 ppb), and total xylenes (9,290 ppb). Samples 1613-11 and 1613-16 contained noncompliant levels of benzene at 8.8 ppb and 5.0 ppb, respectively. Detectable levels of toluene and ethylbenzene were identified, but were less than State standards. No detectable

concentrations of purgeable aromatics were identified from samples 1613-1 through 1613-9, 1613-12 through 1613-15. Figures 5.4 through 5.8 depict individual BTEX compounds and total BTEX concentrations. As depicted on Figures 5.4 through 5.8, areas of highest purgeable aromatics concentrations are in the former UST basin and adjacent to product recovery well HPGW-6.

Purgeable Halocarbon

Purgeable halocarbon (EPA Method 601) compounds were identified from samples 1613-6, 1613-9, 1613-13, 1613-14, and 1613-15. All other samples contained no purgeable halocarbon concentrations. Table 5.5B summarizes the laboratory data. Figure 5.9 depicts the estimated extent of dissolved purgeable halocarbons. Ground water standards have been established for trans-1,2-dichloroethene (700 ppb), trichloroethene (2.8 ppb), 1,1-dichloroethene (7 ppb), and chloroform (0.19 ppb). Specific numerical standards have not been established for chloromethane and bromomethane and; therefore, any detectable concentrations are considered an exceedance of NCAC T15A:02L standards.

The purgeable halocarbon analysis detected trans-1,2-dichloroethene concentrations in monitoring wells 1613-9 (1.1 ppb), 1613-13 (1.2 ppb), and 1613-14 (7.6 ppb). Noncompliant concentrations of trichloroethene were detected in monitoring wells 1613-9 (31.6 ppb), 1613-15 (15.7 ppb), and 1613-16 (1.3 ppb). Monitoring well 1613-14 also revealed noncompliant 1,1-dichloroethene (0.7 ppb) and chloroform (0.8 ppb) concentrations. Noncompliant chloromethane and bromomethane concentrations were detected in monitoring well 1613-6 at 5.3 ppb and 1.4 ppb, respectively.

Base/Neutrals and Acid Extractables

Four monitoring wells (1613-9 through 1613-12) were analyzed for base/neutrals and acid extractables (BNA) per EPA Method 625. Results of the analysis revealed 303 ppb and 280 ppb naphthalene in samples 1613-10 and 1613-10Dup, respectively. Interim ground water standards have proposed a standard of 21 ppb of naphthalene in ground water. All other BNA compounds were below detection limits (BDL). Table 5.5C summarizes the laboratory data and compares to NCDEHNR ground water quality standards.

Dissolved purgeable halocarbon compounds were identified at concentrations above NCAC T15:02L standards in Type III wells 1613-13, 1613-14, and 1613-15. However, detectable levels of purgeable aromatics were not identified in any of these wells. The

vertical extent of dissolved contamination extends to a depth of at least 50 feet. The data suggests that the source(s) for this contamination may not be solely attributed to Building 1613, former USTs 1613 1-4.

The areas of highest dissolved purgeable aromatic concentrations are in the vicinity of HP-8 free product plume and wells 1613-10 (former UST basin). As depicted in Figure 5.9 three isolated dissolved purgeable halocarbon plumes were identified. The purgeable halocarbons may not be related to activities associated with Building 1613. As mentioned previously, the study by Baker (1994) revealed purgeable halocarbon concentrations in shallow and deeper water bearing zones. The presence of purgeable halocarbons is most likely as result of other activities in the HPIA.

Sample 1613-WC, collected for waste water disposal, was analyzed for purgeable aromatics and purgeable halocarbon components. Trace levels of BTEX and purgeable halocarbon compounds were identified. Results are summarized in Tables 5.5A and 5.5B.

All laboratory reports are provided in Appendix I.

5.6 *Aquifer Testing*

5.6.1 *Slug Tests*

(Refer to Table 5.2 and Appendix C)

Subsequent to development and sampling of the shallow monitoring wells, three standard recovery slug tests were performed on three Type II wells (1613-1, 1613-2, and 1613-8). To perform the recovery test, the static head of ground water was measured first. A slug was introduced into the monitoring well and allowed to equilibrate. The slug was removed and measurements of the water level were taken at pre-determined time intervals and recorded utilizing a Hermit data logger. The recovery data was reduced by the AQTESOLV™ aquifer test solving software program utilizing the Bouwer and Rice (1976) method and assumptions as follows:

- Aquifer has infinite areal extent
- Aquifer is homogeneous and of uniform thickness
- Aquifer potentiometric surface is initially horizontal
- A volume of water, V , is injected into or discharged from the well instantaneously
- Aquifer is confined or unconfined
- Flow is steady

The hydraulic conductivity (K) value was determined from the following solution:

$$\ln(s_0) - \ln(s_t) = \frac{2KLt}{r_{ce}^2 \ln(r_e/r_{we})}$$

where:

S_0 = initial displacement in well due to instantaneous removal of water from well [L]

S_t = displacement in well at time t [L]

L = length of well screen [L]

r_{ce} = $\sqrt{r_c^2 + n(r_w^2 - r_c^2)}$

n = porosity of gravel pack [fraction]

$\ln(r_e/r_{we})$ = empirical "shape factor" determined from graphs provided in Bouwer and Rice (1976)

r_e = equivalent radius over which head loss occurs [L]

$r_{we} = r_w \sqrt{\frac{K_z}{K_r}}$

H = static height of water in well measured from based of well to static water level [L]

Hydraulic conductivity (K) values were determined to be 1.6 ft/day (1613-1), 13.4 ft/day (1613-2), and 22.5 ft/day (1613-8). Slug test calculations are provided in Appendix C. A summary of estimated aquifer parameters is provided as Table 5.2.

5.6.2 Grain Size Analysis (Refer to Table 5.2 and Appendix C)

As specified, three soil samples were collected during monitoring well installation and analyzed for grain size distribution. Grain size distribution was performed in accordance with the American Society for Testing and Materials (ASTM) test procedure D-422, entitled "Standard Test Method for Particle-Size Analysis of Soils." Samples were collected at a depth of 15 to 17 feet below land surface from wells 1613-7, 1613-8, and 1613-16.

Sediment collected from samples 1613-7 and 1613-8 were described as light grey silty clay and USCS classified as OH. Sample 1613-16 was described as light grey fine grained sand and USCS classified as SP-SM.

Hydraulic conductivity was calculated for sample 1613-16 utilizing the Hazen equation (Maidment, 1993) and was determined to be 0.43 feet/day. Refer to Appendix C for the grain size analysis report and calculations. Table 5.2 summarizes the aquifer parameters.

5.6.3 *Eight Hour Pumping Test*
(Refer to Appendix K)

An eight hour pumping test was performed on well 1613-16. An aquifer yield test was performed initially to determine expected discharge pumping rates. This test involved pumping well 1613-16 continuously and recording the flow rate at each interval. The gauged flow rate was 2.4 gallons per minute (gpm).

Performance of the pumping well test revealed a significant influence in the majority of monitoring wells installed at the subject site. The water level in pumping well 1613-16 was lowered from approximately 15 feet (static) to 24 feet. The most significant drawdown measurement for the shallow, Type II wells was recorded from 1613-10 (0.20 feet). This well is located approximately 22 feet northeast of the pumping well. In addition, drawdown was recorded from well 1613-14 (Type III) at 0.16 feet. The remaining wells either demonstrated no measurable drawdown (0.0 feet) or indicated a rise in water levels. Pumping test drawdown results are provided in Appendix K.

In addition to the slug test data, hydraulic conductivity (K) values were also calculated using the pumping test data in accordance with the Dupuit methods and assumptions (Todd, 1980) as follows:

Assume:

- (1) The velocity of the flow is proportional to the tangent of the hydraulic gradient
- (2) The flow is horizontal and uniform everywhere in a vertical section
- (3) Steady state conditions have been obtained

$$K = \frac{Q}{\pi(h_2^2 - h_1^2)} \ln \frac{r_2}{r_1}$$

Where: K = Hydraulic Conductivity (feet/day)
 Q = Well Discharge (gallons/day)
 h₁ = Head in Well 1613-10 (feet)

- h_2 = Head in Well 1613-2 (feet)
 r_1 = Radius from Pumping Well to 1613-10 (feet)
 r_2 = Radius from Pumping Well to 1613-2 (feet)

An aquifer thickness of 34.06 feet was assigned for the purpose of these calculations. Hydraulic conductivity (K) was calculated to be 4.3 feet/day.

5.7 *Vertical Gradient Determinations* (Refer to Table 5.3)

As shown in Table 5.3, three well pairs were constructed as part of this investigation. Calculation of the vertical gradients revealed a positive gradient of 0.79 for 1613-7/1613-13, a gradient of 0.00 for 1613-10/1613-14, and a positive gradient of 1.23 for 1613-8/1613-15. A positive gradient indicates the potential for downward movement of ground water.

5.8 *Rate of Contaminant Migration* (Refer to Appendices F, H, and K)

Ground water travel time or average linear ground water flow velocity serves as the basis for estimating the rate of contaminant migration at the facility. Ground water flow rates should represent the maximum rate of contaminant migration with variations among contaminants due to geohydrochemical processes including molecular diffusion, mechanical mixing, sorption-desorption, ion-exchange, hydrolysis, and biodegradation. However, due to the difficulties in estimating the effects of many of the processes on contaminant migration rates and the desire to produce relatively conservative (higher) estimates, only adsorption processes are incorporated into rate calculations.

Ground water flow velocities are calculated using the following modification of Darcy's Law:

$$V = K/n_e(dh/dl)$$

Where:

K	=	Hydraulic conductivity (ft/day)
n_e	=	Effective porosity (unitless)
dh/dl	=	Hydraulic gradient (ft/ft)

Initial estimates of hydraulic conductivity were determined from published literature for interpretation of grain size distribution analyses of soil samples, from slug tests, and from the pumping test. Hydraulic gradients were calculated from water level measurements between wells 1613-4 and 1613-10 (3.14%).

For a conservative prediction of ground water velocity, the K value (4.3 ft/day) determined from the pumping test was used in the calculations.

Calculation of the maximum ground water velocity was determined to be 0.54 ft/day to the east-northeast (see Appendix F).

Estimates of bulk density and porosity were determined from results of visual/manual classification of soils. Average velocities of petroleum contaminant constituents were then calculated in accordance with the following equation (USEPA, 1985):

$$V_c = V/R_d$$

Where: V_c = Average velocity of contaminant constituent (ft/day)

V = Average linear ground water flow velocity (ft/day)

R_d = Retardation factor (unitless)

Evaluation of the petroleum contaminants revealed benzene to have the lowest retardation factor, thereby allowing it the highest migration velocity. As shown in the calculations in Appendix H, the V_c for chloromethane was found to be 0.46 ft/day to the east-northeast.

6.0 QUALITY CONTROL PROCEDURES

6.1 *Equipment Decontamination*

Equipment decontamination sites were established by the MCB environmental personnel prior to the initiation of drilling activities. Potable water obtained from on-site sources was utilized for equipment decontamination.

6.1.1 *Drill Rig*

The drill rig and tools were cleaned in accordance with the following guidelines:

- Drill rigs and all support equipment were cleaned of excess grease, oils, and caked-on soil prior to arrival at the site.
- Hollow stem augers, rods, and other drilling equipment were decontaminated between borings as follows:
- High temperature and pressure water rinse.
- If any noticeable petroleum hydrocarbon film was present, the tools were washed with phosphate-free detergent and tap water using a brush.

- High temperature and pressure tap water rinse.
- Allowed to air dry.
- Placed on and covered with clean plastic until next use.
- Equipment such as pumps and pump lines were flushed thoroughly with potable water prior to use.

6.1.2 *Soil and Ground Water Sample Collection Equipment*

Disposable Teflon bailers used for ground water sampling were disposed of after the sampling of each well.

Split-spoons, Hydropunch sample probes, submersible well development pump equipment, and other sample collection equipment were decontaminated between sample events as follows:

- Tap water rinse.
- Washed with phosphate-free detergent and tap water using a brush to remove any particle matter or surface film.
- Tap water rinse.
- Rinsed thoroughly with distilled water.
- Rinsed with isopropanol.
- Allowed to air dry or rinsed with distilled water.
- Wrapped completely with aluminum foil and sealed in airtight plastic bags or placed on clean plastic if planned for immediate reuse.

6.1.3 *Rinsate Sample Collection Methodology*

A rinsate water sample was collected for QA/QC purposes. Water that was used in the decontamination process outlined above was used to pour over previously decontaminated equipment. The rinsate water was collected in the sample bottles. The collected samples were analyzed in accordance with the parameters listed in Section 5.0 to confirm that equipment decontamination was conducted adequately and that no cross contamination occurred between sample locations. If the rinsate samples detected any contamination, a sample of the source rinsate water was collected and analyzed for the same laboratory parameters.

6.2 *Sample Collection and Shipment*

6.2.1 *Sample Identification*

Prior to collecting each soil and ground water sample, sample bottles were labelled with the following information:

- Date and time of sample collection;
- Project identification number;
- Sample location number;
- Initials of person collecting sample;
- Type of preservative added to sample; and,
- Parameter(s) or parameter group to be analyzed.

Additional specific information, such as sampling interval, may have been added. The sample location number on the label corresponds to the sample location numbers assigned on the field site map.

6.2.2 *Chain of Custody and Transportation Procedures*

Chain of Custody (COC) procedures were followed to establish documentation of sample possession from the time of collection until completion of analysis. As few people as possible handled the sample(s). The sampler was responsible for the care and custody of the samples until they were delivered to the on-site laboratory or dispatched for shipment to the off-site laboratory. An accurate record of sample collection, transport, and analysis was maintained and documented. Chain of Custody records are provided in Appendix I.

The COC Record was used by personnel responsible for ensuring the integrity of samples from the time of collection to shipment to both the on-site and off-site laboratories. The laboratory did not proceed with sample analysis without correctly prepared COC Records and Analytical Request Forms. The laboratory was responsible for maintaining COC of the sample(s) from time of receipt to disposal. Chain of Custody procedures were instituted and followed throughout the investigation.

The COC Record was signed by each individual who maintained custody of the samples. General preparation of the COC Record for samples to be delivered to the on-site and off-site laboratories was as follows:

- Samples were accompanied by a COC Record at all times.
- The COC Record was initiated in the field by the person collecting the samples. Every sample was assigned a

May 17, 1996

unique identification number that was entered on the COC Record.

- The COC Record was completed in the field identifying the project, sampler, RC&A assigned project number, etc.
- If the person collecting the samples did not transport the samples to the laboratory or deliver the sample containers for shipment, the first block for "Relinquished By _____" was signed by the sampler.
- The person transporting the samples to the laboratory or delivering them for shipment signed the Record as "Relinquished By _____".

6.2.2.1 Off-Site Laboratory

Collected soil and ground water samples were transported by courier to GeoChem, Inc. in Morrisville, North Carolina. Prior to the start of the field investigation, necessary arrangements were made with the laboratory to assure proper and prompt delivery and log in of the collected samples. Shipment and COC procedures were as follows:

- Samples were packed properly for shipment so that bottles would not dislodge and/or break. The samples were kept cool using either ice packs or ice in zip-lock bags.
- Samples were transported via a GeoChem, Inc. courier.
- The COC record was sealed in a watertight container and placed in the shipping container.
- The courier double checked the contents of the shipping container to assure that the samples were properly packed and the COC inventory was correct.

6.2.2.2 On-Site Laboratory

An on-site mobile laboratory provided expedient analytical data to assist in determining the placement of additional sample locations. The mobile laboratory was set up at a location central to other projects concurrently being conducted in the area.

Shipment and COC procedures are as follows:

- The samples were packed properly for transport so that bottles would not dislodge and/or break. The samples were kept cool using either ice packs or ice in zip-lock bags.
- Once the samples were properly packed, the container was adequately secured for transport to the laboratory.
- The COC Record was maintained.

6.3 *Chemical Data Evaluation* (Refer to Appendix J)

On-site and off-site laboratory data evaluation, performance, and QA/QC procedures are presented in Appendix J.

7.0 PRELIMINARY RECOMMENDATIONS AND CORRECTIVE ACTIONS

7.1 *Soil Remediation*

7.1.1 *Overview and Objectives of Soil Remediation*

In general, the goal of soil remediation is to reduce the levels of soil contamination within the unsaturated zone to acceptable levels established by the NCDEHNR so as not to be a source for continuing ground water contamination. The current action levels for TPH concentrations are: 10 ppm for gasoline and 40 ppm for diesel. TPH-diesel concentrations were present in sample 1613-14 at a concentration less than the NCDEHNR action level. No detectable levels of TPH-gasoline were identified in soil samples.

According to the UST Closure Report (Geosciences, Inc., March 1995), soil samples collected during the UST excavation activities revealed TPH-gasoline concentrations ranging from BDL to 6,500 ppm. The soil samples were collected from the base of the excavation area and from stockpiled soils.

7.1.2 *Preliminary Recommendation for Soil Remediation*

As previously mentioned, approximately 2,127.93 tons of contaminated soil were removed from the subject site following the UST excavation. Total petroleum hydrocarbon contamination was identified at depth from the excavation area. It is not known if all of the contaminated vadose soils were removed during excavation activities. In reviewing the data, the northern, eastern, and southern limits of vadose contamination have not been determined in the vicinity of the former UST basin. Additional soil samples should be collected outside of the former UST basin in the north, east, and

south directions. It is recommended to seek approval of the proposed final soil cleanup levels from the NCDEHNR-Wilmington Regional Office.

7.2 *Ground Water Remediation*

7.2.1 *Overview and Objectives of Ground Water Remediation*

As discussed, free product and dissolved petroleum hydrocarbons were identified at Building 1613, USTs 1613 1-4. The areal extent of free product has been delineated; however, the actual size of the free product plume may vary from the estimated size due to the limited number of monitoring points within close proximity to well HPGW-6. A dissolved purgeable aromatics (BTEX) plume encompasses the free product plume and former UST basin. Three isolated areas of dissolved purgeable halocarbon constituents were identified. The vertical extent of dissolved purgeable halocarbons extends to at least 50 feet. According to Baker (1993), purgeable halocarbon compounds were identified in the HPIA from the shallow and deeper water bearing zones. The study concluded that there was no particular pattern or trend for the contaminants identified. The purgeable halocarbons identified from this investigation may not be related to the former gasoline USTs, but may be associated with other activities in the HPIA. Supply wells HP-601 and HP-608 were permanently abandoned due to the presence of contaminant concentrations. Supply well HP603 has been de-activated due to the presence of TCE.

The objective of ground water remediation is to restore the affected aquifer to North Carolina Ground Water Standards (NCAC T15A:02L), or as closely thereto as is economically and technologically feasible.

7.2.2 *Preliminary Recommendations for Ground Water Remediation*

The project site may be a candidate for "Hot Spot" remediation in accordance with NCAC T15A:02L .0106 due to the unlikely impact to potential receptors. The areal extent of the free product plume should be better defined to determine the most appropriate strategy for free product recovery. Portions of the plume outside of the free product plume and "Hot Spot" areas could be designated for remediation via natural degradation/attenuation. Natural degradation/attenuation is an approach which allows natural processes to act upon and reduce the concentrations of the contaminants. The natural processes responsible for the degradation and attenuation of petroleum hydrocarbons released in the subsurface include aerobic and anaerobic biodegradation, dispersion, volatilization, and adsorption.

7.3 *Additional Data Needs for Corrective Action Plan Development*

As part of the corrective action plan phase, it is recommended that additional soil samples be collected to the north, east, and south of the former UST basin to determine if vadose contamination remains. In addition, temporary piezometers should be installed closer to well HPGW-6 to better define the limits of the free product plume. The temporary piezometers may be installed using direct push technology (DPT) equipment or by drilling rig. The areal extent of the dissolved petroleum hydrocarbon plume has been delineated. The vertical extent of dissolved purgeable halocarbon compounds was not delineated and extends to a depth of at least 50 feet. It is suspected that the dissolved purgeable halocarbon concentrations are not attributed to the release from Building 1613, USTs 1613 1-4. It is also recommended to perform pilot testing activities and/or contaminant fate and transport evaluation necessary for corrective action plan development.

7.4 *Recommendations*

Surficial aquifer contamination in excess of established State standards was identified through this investigation and previous investigations. It is recommended that a copy of this report be provided to the NCDEHNR-Wilmington Regional Office (WiRO). It is also recommended that additional sampling and pilot testing be performed, and that a Corrective Action Plan (CAP) be prepared and submitted to the NCDEHNR-WIRO.

8.0 REFERENCES

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May 17, 1996

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TABLES

TABLE 2.1

CONTAMINANT SOURCE INVENTORY
 BUILDING 1613, USTs 1613 1-4
 MARINE CORPS BASE
 CAMP LEJEUNE, NORTH CAROLINA

POTENTIAL SOURCE	SITE LOCATION	PRODUCT TYPE	SITE STATUS
1	BUILDING 1613	GASOLINE	The former underground storage tank (UST) basin for 1613 1-4, which contained various grades of gasoline, located near the West Road and Fir Street intersection.
2	BUILDING 1700	FUEL OIL	A steam generating plant, which houses a 5,000 gallon aboveground storage tank (AST).
3	BUILDING 1700	COAL/UNKNOWN	A large coal storage facility and two ASTs. Tank capacities and contents are unknown by RC&A personnel.
4	BUILDING 1612	PETROLEUM PRODUCTS	A vehicle repair and virgin fuel storage facility located near the Fir Street and West Road intersection.
5	BUILDING 1612	WASTE OIL	An AST of unknown capacity.
6	BUILDING 1610	HYDRAULIC FLUID	A tire and electric repair shop that houses hydraulic fluid for car lifts located south of the former UST basin.
7	BUILDING 1613	GASOLINE	Three active 12,000 gallon capacity ASTs. Two tanks contain regular unleaded gasoline and the other contains premium unleaded.
8	BUILDING 1500	DRY CLEANING SOLVENTS	Building 1500 is a Base laundry facility that houses dry cleaning solvents.

TABLE 3.1

WELL INVENTORY SUMMARY
BUILDING 1613, USTs 1613 1-4
MARINE CORPS BASE
CAMP LEJEUNE, NORTH CAROLINA

APPROXIMATE DISTANCE AND DIRECTION FROM PROJECT SITE (FT)	WELL USAGE
HP-608 1,140 SE	Permanently Abandoned
HP-603 450 NW	Out of Service
HP-601 1,150 NNE	Permanently Abandoned

**TABLE 3.2
SUMMARY OF EXPOSURE PATHWAYS**

**BUILDING 1613, USTs 1613 1-4
MARINE CORPS BASE
CAMP LEJEUNE, NORTH CAROLINA**

CONTAMINATED MEDIUM	INGESTION (EATING)	INGESTION (DRINKING)	INHALATION	ABSORPTION
Free Product	NA	No Exposure	NA	No Exposure ⁽¹⁾
Soil	Unlikely Exposure ⁽²⁾	NA	NA	Unlikely Exposure ⁽²⁾
Ground Water	NA	Potential Exposure ⁽³⁾	NA	Potential Exposure ⁽³⁾
Surface Water	Potential Exposure ⁽⁴⁾	Potential Exposure ⁽⁴⁾	NA	Potential Exposure ⁽⁴⁾
Vapor	NA	NA	Unlikely Exposure ⁽⁵⁾	NA

NOTES:

- (1) Free phase product was not observed on site during this investigation.
- (2) Potential for exposure if subsurface below concrete is disturbed/brought to the surface.
- (3) Two water supply wells are located 1,000 feet north-northeast and 2,375 feet north-northeast of the subject site.
- (4) The closest body of surface water is Beaver Dam Creek located approximately 1,000 feet north of the subject site.
- (5) Buildings in the vicinity of the contaminant plume appear to be slab-on-grade construction.

NA = Not Applicable

TABLE 4.1 (PAGE 1 OF 6)

SUMMARY OF HEADSPACE ANALYSIS

**BUILDING 1613, USTs 1613-1-4
MARINE CORPS BASE
CAMP LEJEUNE, NORTH CAROLINA**

SAMPLE ID.	SAMPLE DEPTH (ft)	OVA READING (ppm)	SAMPLE SELECTED FOR TPH ANALYSIS
1613-1	2 - 4	0.0	*
1613-1	5 - 7	1.4	
1613-1	10 - 12	1.0	*
1613-1	15 - 17	3.6	
1613-1	20 - 22	1.4	
1613-2	2 - 4	2.6	*
1613-2	5 - 7	1.2	
1613-2	10 - 12	0.0	*
1613-2	15 - 17	150.0	
1613-2	20 - 22	420.0	
1613-3	2 - 4	1.2	*
1613-3	5 - 7	2.6	
1613-3	10 - 12	5.8	*
1613-3	15 - 17	3.0	
1613-4	2 - 4	11.0	*
1613-4	5 - 7	6.2	
1613-4	10 - 12	3.4	*
1613-4	15 - 17	8.4	
1613-5	2 - 4	2.2	*
1613-5	5 - 7	12.0	
1613-5	10 - 12	3.6	*
1613-5	15 - 17	4.4	

Note:

OVA zeroed on upgradient ambient air

TABLE 4.1 (PAGE 2 OF 6)

SUMMARY OF HEADSPACE ANALYSIS

**BUILDING 1613, USTs 1613-1-4
MARINE CORPS BASE
CAMP LEJEUNE, NORTH CAROLINA**

SAMPLE I.D.	SAMPLE DEPTH (ft)	OVA READING (ppm)	SAMPLE SELECTED FOR TPH ANALYSIS
1613-6	2 - 4	1.0	*
1613-6	5 - 7	1.2	
1613-6	10 - 12	1.0	*
1613-6	15 - 17	3.4	
1613-7	2 - 4	5.6	*
1613-7	5 - 7	6.2	
1613-7	10 - 12	1.0	*
1613-7	15 - 17	0.8	
1613-8	2 - 4	2.6	*
1613-8	5 - 7	1.4	
1613-8	10 - 12	0.8	*
1613-8	15 - 17	0.8	
1613-9	2 - 4	1.6	*
1613-9	5 - 7	2.0	
1613-9	10 - 12	1.2	*
1613-9	15 - 17	12.0	
1613-10	0 - 2	18.0	
1613-10	2 - 4	16.0	*
1613-10	5 - 7	40.0	
1613-10	10 - 12	560.0	*
1613-10	15 - 17	750.0	

Note:

OVA zeroed on upgradient ambient air

TABLE 4.1 (PAGE 3 OF 6)

SUMMARY OF HEADSPACE ANALYSIS

BUILDING 1613, USTs 1613-14
MARINE CORPS BASE
CAMP LEJEUNE, NORTH CAROLINA

SAMPLE I.D.	SAMPLE DEPTH (ft)	OVA READING (ppm)	SAMPLE SELECTED FOR TPH ANALYSIS
1613-11	2 - 4	8.4	*
1613-11	5 - 7	3.2	
1613-11	10 - 12	14.0	*
1613-11	15 - 17	16.0	
1613-11	20 - 22	12.0	
1613-12	2 - 4	4.6	*
1613-12	5 - 7	7.8	
1613-12	10 - 12	0.6	*
1613-12	15 - 17	0.8	
1613-12	20 - 22	1.0	
1613-13	0 - 2.5	0.8	
1613-13	2.5 - 5	0.8	*
1613-13	5 - 7.5	4.4	
1613-13	7.5 - 10	3.4	
1613-13	10 - 12.5	1.0	
1613-13	12.5 - 15	6.8	
1613-13	15 - 17.5	1.8	
1613-13	17.5 - 20	9.2	
1613-13	20 - 22.5	18.0	
1613-13	22.5 - 25	8.8	
1613-13	25 - 27.5	15.0	
1613-13	27.5 - 30	1.6	

Note:

OVA zeroed on upgradient ambient air

TABLE 4.1 (PAGE 4 OF 6)

SUMMARY OF HEADSPACE ANALYSIS

**BUILDING 1613, USTs 1613-1-4
MARINE CORPS BASE
CAMP LEJEUNE, NORTH CAROLINA**

SAMPLE I.D.	SAMPLE DEPTH (ft)	OVA READING (ppm)	SAMPLE SELECTED FOR TPH ANALYSIS
1613-13	30 - 32.5	1.2	
1613-13	32.5 - 35	3.0	
1613-13	35 - 37.5	0.6	
1613-13	37.5 - 40	0.8	*
1613-13	40 - 42		
1613-13	45 - 47		
1613-13	50 - 52		
1613-14	0 - 2.5	8.0	
1613-14	2.5 - 5	4.4	*
1613-14	5 - 7.5	26.0	
1613-14	7.5 - 10	13.0	
1613-14	10 - 12.5	20.0	
1613-14	12.5 - 15	20.0	
1613-14	15 - 17.5	16.0	
1613-14	17.5 - 20	38.0	
1613-14	20 - 22.5	88.0	
1613-14	22.5 - 25	140.0	
1613-14	25 - 27.5	70.0	
1613-14	27.5 - 30	64.0	
1613-14	30 - 32.5	38.0	
1613-14	32.5 - 35	14.0	

Note:

OVA zeroed on upgradient ambient air

TABLE 4.1 (PAGE 5 OF 6)

SUMMARY OF HEADSPACE ANALYSIS

**BUILDING 1613, USTs 1613-1-4
MARINE CORPS BASE
CAMP LEJEUNE, NORTH CAROLINA**

SAMPLE I.D.	SAMPLE DEPTH (ft)	OVA READING (ppm)	SAMPLE SELECTED FOR TPH ANALYSIS
1613-14	35 - 37.5	20.0	
1613-14	37.5 - 40	10.0	*
1613-14	40 - 42	24.0	
1613-14	45 - 47	0	
1613-14	50 - 52	3.2	
1613-15	0 - 2.5	3.2	
1613-15	2.5 - 5	1.0	*
1613-15	5 - 7.5	1.8	
1613-15	7.5 - 10	2.0	
1613-15	10 - 12.5	9.2	
1613-15	12.5 - 15	8.0	
1613-15	15 - 17.5	4.2	
1613-15	17.5 - 20	1.5	
1613-15	20 - 22.5	0.8	
1613-15	22.5 - 25	0.8	
1613-15	25 - 27.5	1.8	
1613-15	27.5 - 30	6.2	
1613-15	30 - 32.5	4.4	
1613-15	32.5 - 35	3.2	
1613-15	35 - 37.5	5.2	
1613-15	37.5 - 40	3.8	*

Note:

OVA zeroed on upgradient ambient air

TABLE 4.1 (PAGE 6 OF 6)

SUMMARY OF HEADSPACE ANALYSIS

BUILDING 1613, USTs 1613-1-4
MARINE CORPS BASE
CAMP LEJEUNE, NORTH CAROLINA

SAMPLE ID.	SAMPLE DEPTH (ft)	OVA READING (ppm)	SAMPLE SELECTED FOR TPH ANALYSIS
1613-16	2 - 4	18.0	*
1613-16	5 - 7	12.0	
1613-16	10 - 12	>1000	*
1613-16	15 - 17	>1000	
1613-16	20 - 22	>1000	
1613-16	25 - 27	400.0	
1613-16	30 - 32	64.0	
1613-16	35 - 37	22.0	
1613-16	40 - 42	10.0	

Note:

OVA zeroed on upgradient ambient air

TABLE 4.2A (Page 1 of 2)

SUMMARY OF LABORATORY ANALYTICAL RESULTS -- SOIL
TPH, FLASHPOINT, AND pH

BUILDING 1613, USTs 1613 1-4
MARINE CORPS BASE
CAMP LEJEUNE, NORTH CAROLINA

SAMPLE I.D.	SAMPLE DEPTH (ft)	LABORATORY RESULTS			
		TPH-5030 GASOLINE (mg/Kg)	TPH-3550 DIESEL (mg/Kg)	FLASHPOINT (Degree C)	pH
1613-1	2-4	BDL	BDL	NA	NA
	10-12	BDL	BDL	NA	NA
1613-2	2-4	BDL	BDL	>100	6.37
	10-12	BDL	BDL	NA	NA
1613-3	2-4	BDL	BDL	NA	NA
	10-12	BDL	BDL	NA	NA
1613-4	2-4	BDL	BDL	NA	NA
	10-12	BDL	BDL	NA	NA
1613-5	2-4	BDL	BDL	NA	NA
	10-12	BDL	BDL	NA	NA
1613-6	2-4	BDL	BDL	NA	NA
	10-12	BDL	BDL	NA	NA
1613-7	2-4	BDL	BDL	NA	NA
	10-12	BDL	BDL	NA	NA
1613-8	2-4	BQL	BDL	NA	NA
	10-12	BDL	BDL	NA	NA
1613-9	2-4	BDL	BDL	NA	NA
	10-12	BQL	BDL	NA	NA
1613-10	2-4	BDL	BDL	NA	NA
	10-12	BDL	BDL	NA	NA
1613-11	2-4	BDL	BDL	NA	NA
	10-12	BDL	BDL	NA	NA
NCDEHNR STANDARDS		10	40	N/A	N/A

NA = Not Analyzed
N/A = Not Applicable
BDL = Below Detection Limits

TABLE 4.2A (Page 2 of 2)

SUMMARY OF LABORATORY ANALYTICAL RESULTS -- SOIL
TPH, FLASHPOINT, AND pH

BUILDING 1613, USTs 1613 1-4
MARINE CORPS BASE
CAMP LEJEUNE, NORTH CAROLINA

SAMPLE ID.	SAMPLE DEPTH (ft)	LABORATORY RESULTS			
		TPH-5030 GASOLINE (mg/ Kg)	TPH-3550 DIESEL (mg/ Kg)	FLASHPOINT (Degree C)	pH
1613-12	2-4	BDL	BDL	NA	NA
	10-12	BDL	BDL	NA	NA
1613-13	2.5-5.0	BDL	BDL	NA	NA
	37.5-40	BDL	BDL	NA	NA
1613-14	2-4	BDL	20.7	NA	NA
	37.5-40	BDL	BDL	NA	NA
1613-15	2.5-5	BDL	BDL	NA	NA
	37.5-40	BDL	BDL	NA	NA
1613-16	2-4	BDL	BDL	>130	8.43
	10-12	BDL	BDL	NA	NA
1613-SC (5/17/95)		BDL	BDL	NA	NA
LAB BLANK (4/19/95)		BDL	BDL	NA	NA
LAB BLANK (4/25/95)		BDL	BDL	NA	NA
NCDEHNR STANDARDS		10	40	N/ A	N/ A

NA = Not Analyzed

N/A = Not Applicable

BDL = Below Detection Limits

TABLE 4.2B

SUMMARY OF LABORATORY ANALYTICAL RESULTS--SOIL*

TOTAL LEAD PER EPA METHOD 3030

**BUILDING 1613, USTs 1613 1-4
MARINE CORPS BASE
CAMP LEJEUNE, NORTH CAROLINA**

	REGULATORY LEVEL	1613-1 (5-7 ft.)	1613-2 (5-7 ft.)	1613-3 (5-7 ft.)	1613-4 (5-7 ft.)	1613-16 (5-7 ft.)	LAB BLANK	LAB BLANK
DATE SAMPLED		4/10/95	4/10/95	4/11/95	4/11/95	4/17/95	4/19/95	4/23/95
ANALYTE								
Total Lead	NE	BQL	BQL	13.7	BQL	BQL	BQL	BDL

* = Results in mg/L (ppm)
BQL = Below Quantitation Limits
BDL = Below Detection Limits
NE = None Established

TABLE 5.1**SUMMARY OF MONITORING WELL DEVELOPMENT****BUILDING 1613, USTs 1613 1-4
MARINE CORPS BASE
CAMP LEJEUNE, NORTH CAROLINA**

MCB WELL NO.	FINAL TURBIDITY (SUBJECTIVE)*	APPROXIMATE VOLUME OF WATER REMOVED (GAL.)
1613-1	2	15.0
1613-2	2	15.0
1613-3	1	10.0
1613-4	2	10.0
1613-5	1	10.0
1613-6	1	15.0
1613-7	1	15.0
1613-8	2	15.0
1613-9	3	10.0
1613-10	1	15.0
1613-11	2	10.0
1613-12	1	10.0
1613-13	1	10.0
1613-14	1	15.0
1613-15	1	10.0
1613-16	3	100.0

Notes:

* (1) Clear; (2) Slight; (3) Moderate; (4) High

TABLE 5.2

SUMMARY OF AQUIFER PARAMETER ESTIMATIONS

**BUILDING 1613, USTs 1613 1-4
MARINE CORPS BASE
CAMP LEJEUNE, NORTH CAROLINA**

AQUIFER PARAMETER	MONITORING WELL				
	1613-1	1613-2	1613-8	1613-16	General Aquifer Characteristics
I. Hydraulic Conductivity (K) (ft/day) by:					
a) Dupuit Method ⁽¹⁾	--	--	--	--	4.3
b) Slug Tests	1.6	13.4	22.5	--	--
c) Grain-Size Analysis ⁽²⁾	--	--	--	0.43	--
II. Ground Water Velocity (v)(ft/day)	--	--	--	--	0.54

NOTES: (1) Aquifer thickness assumed to be 34.06 feet.
(2) See calculations in Appendix C.

TABLE 5.3

SUMMARY OF VERTICAL HYDRAULIC GRADIENT DETERMINATIONS

BUILDING 1613, USTs 1613 1-4
MARINE CORPS BASE
CAMP LEJEUNE, NORTH CAROLINA

	WELL PAIR					
	TYPE II	TYPE III	TYPE II	TYPE III	TYPE II	TYPE III
	1613-7	1613-13	1613-10	1613-14	1613-8	1613-15
TOCE (ft.)	25.37	25.63	28.67	27.57	29.10	29.23
DTW (ft.)	11.42	13.03	16.89	15.94	7.97	19.24
Approx. Mid-Screen Depth (ft.)	13.5	47.5	13.0	47.0	13.0	38.5
Approx. Mid-Screen Elevation (ft.)	11.87	-21.87	15.67	-19.43	16.10	-9.27
SWLE (ft.)	13.95	-12.60	-11.78	-11.63	21.13	-9.99
Difference in SWLE (ft.)	26.55		-0.15		31.12	
Difference in Mid-Screen Elevation (ft.)	33.74		35.10		25.37	
Vertical Gradient	0.79		0.00		1.23	

NOTES:

DTW = Depth to Water as of May 17, 1995

TOCE = Top of Casing Elevation

SWLE = Static Water Level Elevation

Positive gradient indicates downward movement.

TABLE 5.4A (Page 1 of 3)

SUMMARY OF LABORATORY ANALYTICAL RESULTS*
HYDROPUNCH GROUND WATER SAMPLES

PURGEABLE AROMATICS-EPA METHOD 602

BUILDING 1613, USTs 1613 1-4
MARINE CORPS BASE
CAMP LEJEUNE, NORTH CAROLINA

	N.C. GROUND WATER STANDARD*	HP-1	HP-1D	HP-2	HP-3	HP-4	HP-5
DATE SAMPLED		3/28/95	3/29/95	3/29/95	4/12/95	4/6/95	4/6/95
ANALYTE							
Benzene	1	BDL	BDL	BDL	BDL	BDL	BDL
Toluene	1000	4.2	12.9	0.9	BDL	BDL	10.6
Chlorobenzene	50	BDL	BDL	BDL	BDL	BDL	BDL
Ethylbenzene	29	0.6	0.8	BDL	BDL	BDL	0.8
Xylenes	530	BDL	2.0	2.7	BDL	BDL	2.1
1,3 Dichlorobenzene	620	BDL	BDL	BDL	BDL	BDL	BDL
1,4 Dichlorobenzene	75	BDL	BDL	BDL	BDL	BDL	BDL
1,2 Dichlorobenzene	620	BDL	BDL	BDL	BDL	BDL	BDL
TOTALS		4.8	15.7	3.6	BDL	BDL	13.5

* = All results in ug/L (ppb)
BDL = Below Detection Limits

TABLE 5.4A (Page 2 of 3)

SUMMARY OF LABORATORY ANALYTICAL RESULTS*
HYDROPUNCH GROUND WATER SAMPLES

PURGEABLE AROMATICS-EPA METHOD 602

BUILDING 1613, USTs 1613 1-4
MARINE CORPS BASE
CAMP LEJEUNE, NORTH CAROLINA

	N.C. GROUND WATER STANDARD*	HP-6	HP-7	HP-8	HP-9	HP-10	HP-11	HP-12
DATE SAMPLED		4/12/95	4/5/95	4/5/95	4/5/95	4/6/95	4/6/95	4/5/95
ANALYTE								
Benzene	1	BDL	BDL	17,300	2.9	BDL	7,700	BDL
Toluene	1000	BDL	12.8	20,700	11.2	21.6	10,800	14.4
Chlorobenzene	50	BDL	BDL	BQL	BDL	BDL	BQL	BDL
Ethylbenzene	29	BDL	4.0	2,140	1.1	1.3	1,100	1.4
Xylenes	530	BDL	149.0	10,800	3.0	BDL	5,420	2.4
1,3 Dichlorobenzene	620	BDL	BDL	BQL	BDL	BDL	BQL	BDL
1,4 Dichlorobenzene	75	BDL	BDL	BQL	BDL	BDL	BQL	BDL
1,2 Dichlorobenzene	620	BDL	BDL	BQL	BDL	BDL	BQL	BDL
TOTALS		BDL	165.8	50,940	18.2	22.9	25,020	18.2

* = All results in ug/L (ppb)

BDL = Below Detection Limits

BQL = Below Quantitation Limits

Shaded areas indicate noncompliant concentrations.

TABLE 5.4A (Page 3 of 3)

SUMMARY OF LABORATORY ANALYTICAL RESULTS*
HYDROPUNCH GROUND WATER SAMPLES

PURGEABLE AROMATICS-EPA METHOD 602

BUILDING 1613, USTs 1613 1-4
MARINE CORPS BASE
CAMP LEJEUNE, NORTH CAROLINA

	N.C. GROUND WATER STANDARD*	HP-13	HP-14	HP-15	LAB BLANK	LAB BLANK	LAB BLANK	LAB BLANK	LAB BLANK
DATE SAMPLED		4/6/95	4/5/95	4/5/95	3/29/95	3/30/95	4/6/95	4/7/95	4/13/95
ANALYTE									
Benzene	1	BDL	0.6	BDL	BDL	BDL	BDL	BDL	BDL
Toluene	1000	9.0	1.6	44.9	BDL	BDL	BDL	BDL	0.6
Chlorobenzene	50	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL
Ethylbenzene	29	BDL	BDL	1.7	BDL	BDL	BDL	BDL	BDL
Xylenes	530	BDL	BDL	55.1	BDL	BDL	BDL	BDL	BDL
1,3 Dichlorobenzene	620	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL
1,4 Dichlorobenzene	75	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL
1,2 Dichlorobenzene	620	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL
TOTALS		9.0	2.2	101.7	BDL	BDL	BDL	BDL	0.6

* = All results in ug/L (ppb)
BDL = Below Detection Limits

TABLE 5.4B (Page 1 of 3)

**SUMMARY OF LABORATORY ANALYTICAL RESULTS*
HYDROPUNCH GROUND WATER SAMPLES**

PURGEABLE HALOCARBONS - EPA METHOD 601

**BUILDING 1613, USTs 1613 1-4
MARINE CORPS BASE
CAMP LEJEUNE, NORTH CAROLINA**

	NC GROUND WATER STANDARD*	HP-1	HP-1D	HP-2	HP-3	HP-4	HP-5	HP-6	HP-7
DATE SAMPLED		3/28/95	3/29/95	3/29/95	4/12/95	4/6/95	4/6/95	4/12/95	4/5/95
ANALYTE									
Chloromethane	NE	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL
Trichlorofluoromethane	2100	BDL	1.9	BDL	BDL	BDL	BDL	BDL	BDL
Trans-1,2-dichloroethene	700	BDL	0.9	BDL	BDL	BDL	BDL	BDL	BDL
Trichloroethene	2.8	BDL	29.2	BDL	BDL	BDL	BDL	BDL	BDL
1,1-Dichloroethene	7	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL
1,1,1-Trichloroethane	200	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL
All other compounds**	Varies	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL

* = All results in ug/L (ppb)

** = All compounds listed in Laboratory Analytical Reports in Appendix I.

BDL = Below Detection Limits

NE = None Established

Shaded areas indicate noncompliant concentrations.

TABLE 5.4b (Page 2 of 3)

SUMMARY OF LABORATORY ANALYTICAL RESULTS*
HYDROPUNCH GROUND WATER SAMPLES

PURGEABLE HALOCARBONS - EPA METHOD 601

BUILDING 1613, USTs 1613 1-4
MARINE CORPS BASE
CAMP LEJEUNE, NORTH CAROLINA

	NC GROUND WATER STANDARD*	HP-8	HP-9	HP-10	HP-11	HP-12	HP-13	HP-14	HP-15
DATE SAMPLED		4/5/95	4/5/95	4/5/95	4/6/95	4/5/95	4/6/95	4/5/95	4/5/95
ANALYTE									
Chloromethane	NE	BQL	BDL	BDL	BQL	BDL	BDL	BDL	BDL
Trichlorofluoromethane	2100	BQL	BDL	1.0	BQL	BDL	BDL	BDL	BDL
Trans-1,2-dichloroethene	700	BQL	BDL	0.8	BQL	BDL	BDL	BDL	BDL
Trichloroethene	2.8	BQL	BDL	BDL	BQL	BDL	BDL	BDL	BDL
1,1-Dichloroethene	7	BQL	BDL	1.1	BQL	BDL	BDL	BDL	BDL
1,1,1-Trichloroethane	200	BQL	BDL	1.0	BQL	BDL	BDL	BDL	BDL
All other compounds**	Varies	BQL	BDL	BDL	BQL	BDL	BDL	BDL	BDL

* = All results in ug/L (ppb)

** = All compounds listed in Laboratory Analytical Reports in Appendix I.

BDL = Below Detection Limits

BQL = Below Quantitation Limits

NE = None Established

TABLE 5.4B (Page 3 of 3)

SUMMARY OF LABORATORY ANALYTICAL RESULTS*
HYDROPUNCH GROUND WATER SAMPLES

PURGEABLE HALOCARBONS - EPA METHOD 601

BUILDING 1613, USTs 1613 1-4
MARINE CORPS BASE
CAMP LEJEUNE, NORTH CAROLINA

	NC GROUND WATER STANDARD*	LAB BLANK	LAB BLANK	LAB BLANK	LAB BLANK	LAB BLANK
DATE SAMPLED		3/29/95	3/30/95	4/6/95	4/7/95	4/13/95
ANALYTE						
Chloromethane	NE	0.5	BDL	BDL	0.5	BDL
Trichlorofluoromethane	2100	BDL	BDL	BDL	BDL	BDL
Trans-1,2-dichloroethene	700	BDL	BDL	BDL	BDL	BDL
Trichloroethene	2.8	BDL	BDL	BDL	BDL	BDL
1,1-Dichloroethene	7	BDL	BDL	BDL	BDL	BDL
1,1,1-Trichloroethane	200	BDL	BDL	BDL	BDL	BDL
All other compounds**	Varies	BDL	BDL	BDL	BDL	BDL

* = All results in ug/L (ppb)

** = All compounds listed in Laboratory Analytical Reports in Appendix I.

BDL = Below Detection Limits

NE = None Established

Shaded areas indicate noncompliant concentrations.

TABLE 5.5A (Page 1 of 3)

SUMMARY OF LABORATORY ANALYTICAL RESULTS*
MONITORING WELL GROUND WATER SAMPLES

PURGEABLE AROMATICS-EPA METHOD 602

BUILDING 1613, USTs 1613 1-4
MARINE CORPS BASE
CAMP LEJEUNE, NORTH CAROLINA

	N.C. GROUND WATER STANDARD*	1613-1	1613-2	1613-3	1613-4	1613-5	1613-6	1613-7
DATE SAMPLED		5/3/95	5/3/95	5/4/95	5/3/95	5/3/95	5/3/95	5/3/95
ANALYTE								
Benzene	1	BDL						
Toluene	1000	BDL						
Chlorobenzene	50	BDL						
Ethylbenzene	29	BDL						
Xylenes	530	BDL						
1,3 Dichlorobenzene	620	BDL						
1,4 Dichlorobenzene	75	BDL						
1,2 Dichlorobenzene	620	BDL						
TOTALS		BDL						

* = All results in ug/L (ppb)
BDL = Below Detection Limits

TABLE 5.5A (Page 2 of 3)

SUMMARY OF LABORATORY ANALYTICAL RESULTS*
MONITORING WELL GROUND WATER SAMPLES

PURGEABLE AROMATICS-EPA METHOD 602

BUILDING 1613, USTs 1613 1-4
MARINE CORPS BASE
CAMP LEJEUNE, NORTH CAROLINA

	N.C. GROUND WATER STANDARD*	1613-8	1613-9	1613-10	1613-11	1613-12	1613-13	1613-14
DATE SAMPLED		5/3/95	5/4/95	5/3/95	5/3/95	5/4/95	5/3/95	5/4/95
ANALYTE								
Benzene	1	BDL	BDL	804	8.8	BDL	BDL	BDL
Toluene	1000	BDL	BDL	6,780	4.3	BDL	BDL	BDL
Chlorobenzene	50	BDL	BDL	BQL	BDL	BDL	BDL	BDL
Ethylbenzene	29	BDL	BDL	1,280	2.3	BDL	BDL	BDL
Xylenes	530	BDL	BDL	9,290	18.9	BDL	BDL	BDL
1,3 Dichlorobenzene	620	BDL	BDL	BQL	BDL	BDL	BDL	BDL
1,4 Dichlorobenzene	75	BDL	BDL	BQL	BDL	BDL	BDL	BDL
1,2 Dichlorobenzene	620	BDL	BDL	BQL	BDL	BDL	BDL	BDL
TOTALS		BDL	BDL	18,154	34.3	BDL	BDL	BDL

* = All results in ug/L (ppb)

BDL = Below Detection Limits

BQL = Below Quantitation Limits

Shaded areas indicate noncompliant concentrations.

TABLE 5.5A (Page 3 of 3)

SUMMARY OF LABORATORY ANALYTICAL RESULTS*
MONITORING WELL GROUND WATER SAMPLES

PURGEABLE AROMATICS-EPA METHOD 602

BUILDING 1613, USTs 1613 1-4
MARINE CORPS BASE
CAMP LEJEUNE, NORTH CAROLINA

	N.C. GROUND WATER STANDARD*	1613-15	1613-16	1613-WC	1613-TB	LAB BLANK	LAB BLANK
DATE SAMPLED		5/4/95	5/4/95	5/4/95	5/4/95	5/5/95	5/8/95
ANALYTE							
Benzene	1	BDL	5.0	2.5	BDL	BDL	BDL
Toluene	1000	BDL	2.4	18.9	BDL	BDL	BDL
Chlorobenzene	50	BDL	BDL	BDL	BDL	BDL	BDL
Ethylbenzene	29	BDL	BDL	4.8	BDL	BDL	BDL
Xylenes	530	BDL	44.8	23.1	BDL	BDL	BDL
1,3 Dichlorobenzene	620	BDL	BDL	BDL	BDL	BDL	BDL
1,4 Dichlorobenzene	75	BDL	BDL	BDL	BDL	BDL	BDL
1,2 Dichlorobenzene	620	BDL	BDL	BDL	BDL	BDL	BDL
TOTALS		BDL	52.2	49.3	BDL	BDL	BDL

* = All results in ug/L (ppb)

BDL = Below Detection Limits

Shaded areas indicate noncompliant concentrations.

TABLE 5.5B (Page 1 of 3)

SUMMARY OF LABORATORY ANALYTICAL RESULTS*
MONITORING WELL GROUND WATER SAMPLES

PURGEABLE HALOCARBONS-EPA METHOD 601

BUILDING 1613, USTs 1613 1-4
MARINE CORPS BASE
CAMP LEJEUNE, NORTH CAROLINA

	N.C. GROUND WATER STANDARD*	1613-1	1613-2	1613-3	1613-4	1613-5	1613-6	1613-7
DATE SAMPLED		5/3/95	5/3/95	5/4/95	5/3/95	5/3/95	5/3/95	5/3/95
ANALYTE								
Chloromethane	NE	BDL	BDL	BDL	BDL	BDL	5.3	BDL
Bromomethane	NE	BDL	BDL	BDL	BDL	BDL	1.4	BDL
Trans-1,2-dichloroethene	700	BDL						
Trichloroethene	2.8	BDL						
1,1-Dichloroethene	7	BDL						
Chloroform	0.19	BDL						
TOTALS		BDL	BDL	BDL	BDL	BDL	6.7	BDL

* = All results in ug/L (ppb)

BDL = Below Detection Limits

NE = None Established

Shaded areas indicate noncompliant concentrations.

TABLE 5.5B (Page 2 of 3)

SUMMARY OF LABORATORY ANALYTICAL RESULTS*
MONITORING WELL GROUND WATER SAMPLES

PURGEABLE HALOCARBONS - EPA METHOD 601

BUILDING 1613, USTs 1613 1-4
MARINE CORPS BASE
CAMP LEJEUNE, NORTH CAROLINA

	N.C. GROUND WATER STANDARD*	1613-8	1613-9	1613-10	1613-11	1613-12	1613-13	1613-14
DATE SAMPLED		5/3/95	5/4/95	5/3/95	5/3/95	5/4/95	5/3/95	5/4/95
ANALYTE								
Chloromethane	NE	BDL	BDL	BQL	BDL	BDL	BDL	BDL
Bromomethane	NE	BDL	BDL	BQL	BDL	BDL	BDL	BDL
Trans-1,2-dichloroethene	700	BDL	1.1	BQL	BDL	BDL	1.2	5.6
Trichloroethene	2.8	BDL	31.6	BQL	BDL	BDL	36.9	78.9
1,1-Dichloroethene	7	BDL	BDL	BQL	BDL	BDL	BDL	0.7
Chloroform	0.19	BDL	BDL	BQL	BDL	BDL	BDL	0.8
TOTALS		BDL	32.7	BQL	BDL	BDL	38.1	86.0

* = All results in ug/L (ppb)

BDL = Below Detection Limits

BQL = Below Quantitation Limits

NE = None Established

Shaded areas indicate noncompliant concentrations.

TABLE 5.5B (Page 3 of 3)

SUMMARY OF LABORATORY ANALYTICAL RESULTS*
MONITORING WELL GROUND WATER SAMPLES

PURGEABLE HALOCARBONS -EPA METHOD 601

BUILDING 1613, USTs 1613 1-4
MARINE CORPS BASE
CAMP LEJEUNE, NORTH CAROLINA

	N.C. GROUND WATER STANDARD*	1613-15	1613-16	1613-WC	1613-TB	LAB BLANK	LAB BLANK
DATE SAMPLED		5/4/95	5/4/95	5/4/95	5/4/95	5/5/95	5/8/95
ANALYTE							
Chloromethane	NE	BDL	BDL	BDL	BDL	BDL	BDL
Bromomethane	NE	BDL	BDL	BDL	BDL	BDL	BDL
Trans-1,2-dichloroethene	700	BDL	BDL	BDL	BDL	BDL	BDL
Trichloroethene	2.8	15.7	1.3	0.9	BDL	BDL	BDL
1,1-Dichloroethene	7	BDL	BDL	BDL	BDL	BDL	BDL
Chloroform	0.19	BDL	BDL	1.0	BDL	BDL	BDL
TOTALS		15.7	1.3	1.9	BDL	BDL	BDL

* = All results in ug/L (ppb)

BDL = Below Detection Limits

NE = None Established

Shaded areas indicate noncompliant concentrations.

TABLE 5.5C (Page 1 of 1)

SUMMARY OF LABORATORY ANALYTICAL RESULTS*
MONITORING WELL GROUND WATER SAMPLES

BASE/ NEUTRALS AND ACID EXTRACTABLES - EPA METHOD 625

BUILDING 1613, USTs 1613 1-4
MARINE CORPS BASE
CAMP LEJEUNE, NORTH CAROLINA

	NC GROUND WATER STANDARD*	1613-9	1613-10	1613-10D	1613-11	1613-12	LAB BLANK
DATE SAMPLED		5/4/95	5/3/95	5/3/95	5/3/95	5/4/95	5/8/95
ANALYTE							
625 BASE/ NEUTRALS							
Naphthalene	21	BDL	303	280	BDL	BDL	BDL
Bis2EthylhexylPhthalate	3	BDL	BDL	BDL	BDL	BDL	18.0
All other compounds**	varies	BDL	BDL	BDL	BDL	BDL	BDL
625 ACID EXTRACTABLES							
All compounds**	varies	BDL	BDL	BDL	BDL	BDL	BDL

* = All results in ug/L (ppb)

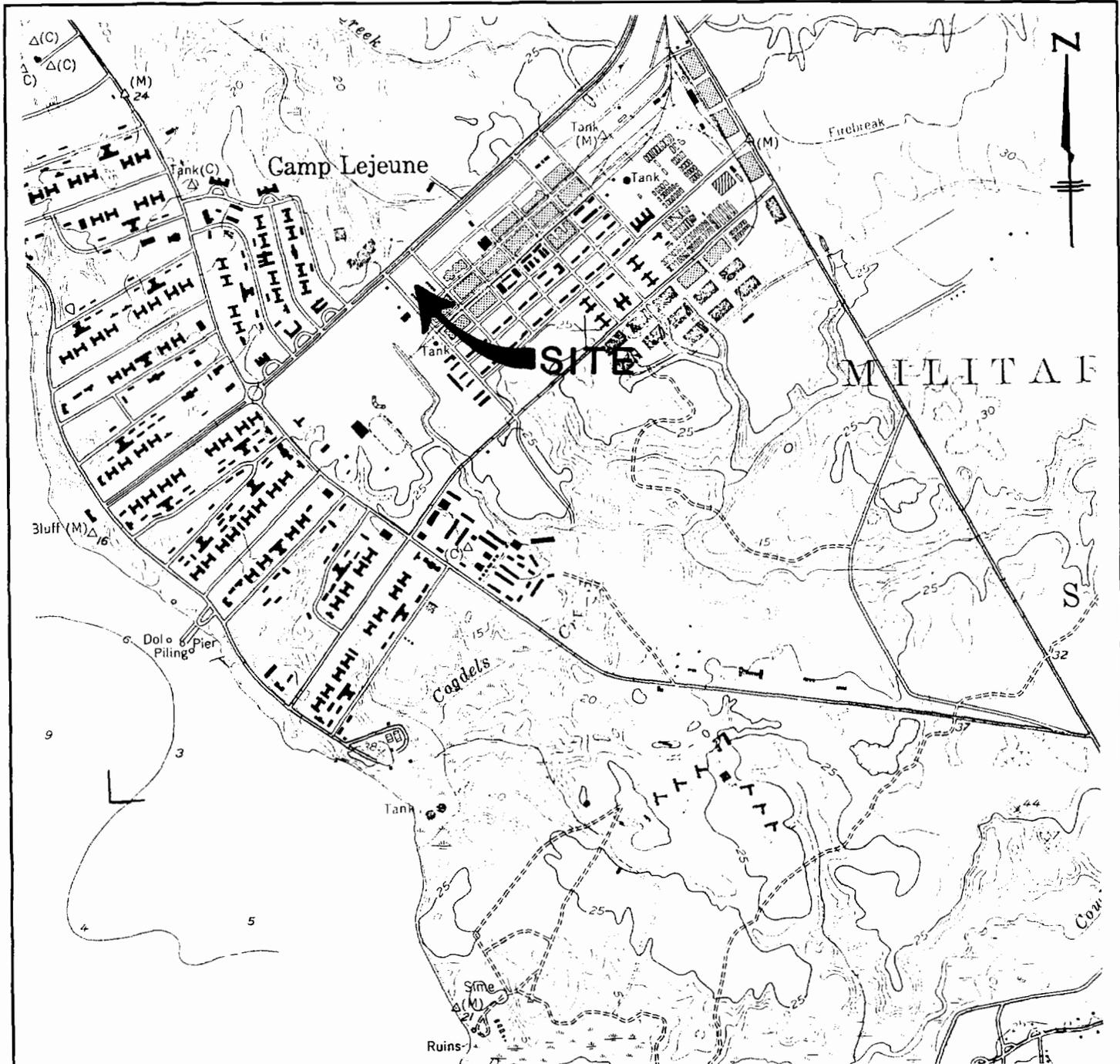
** = All compounds listed in Laboratory Analytical Reports in Appendix I.

BDL = Below Detection Limits

Shaded areas indicate noncompliant concentrations.

Interim maximum allowable concentrations for Naphthalene has been proposed by the NCDEHNR and has been applied to this investigation.

FIGURES

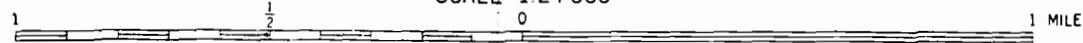


CAMP LEJEUNE. N. C.

N3437.5—W7715/7.5

1952
 PHOTOREVISED 1971
 AMS 5553 III NE—SERIES V842

SCALE 1:24 000



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 WILMINGTON, NC CHARLESTON, SC ATLANTA, GA CHARLOTTE, NC

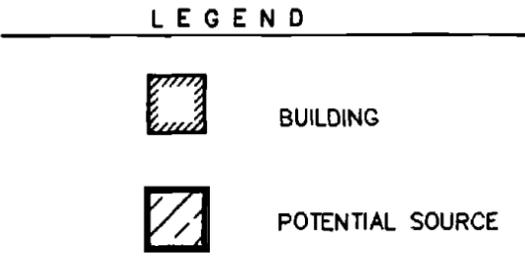
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 BLDG 1613 USTs 1-4
 LANTDIV NAVFACENGCOM
 CAMP LEJEUNE, NC

JOB NO: 94127CA DATE: MAY 1996

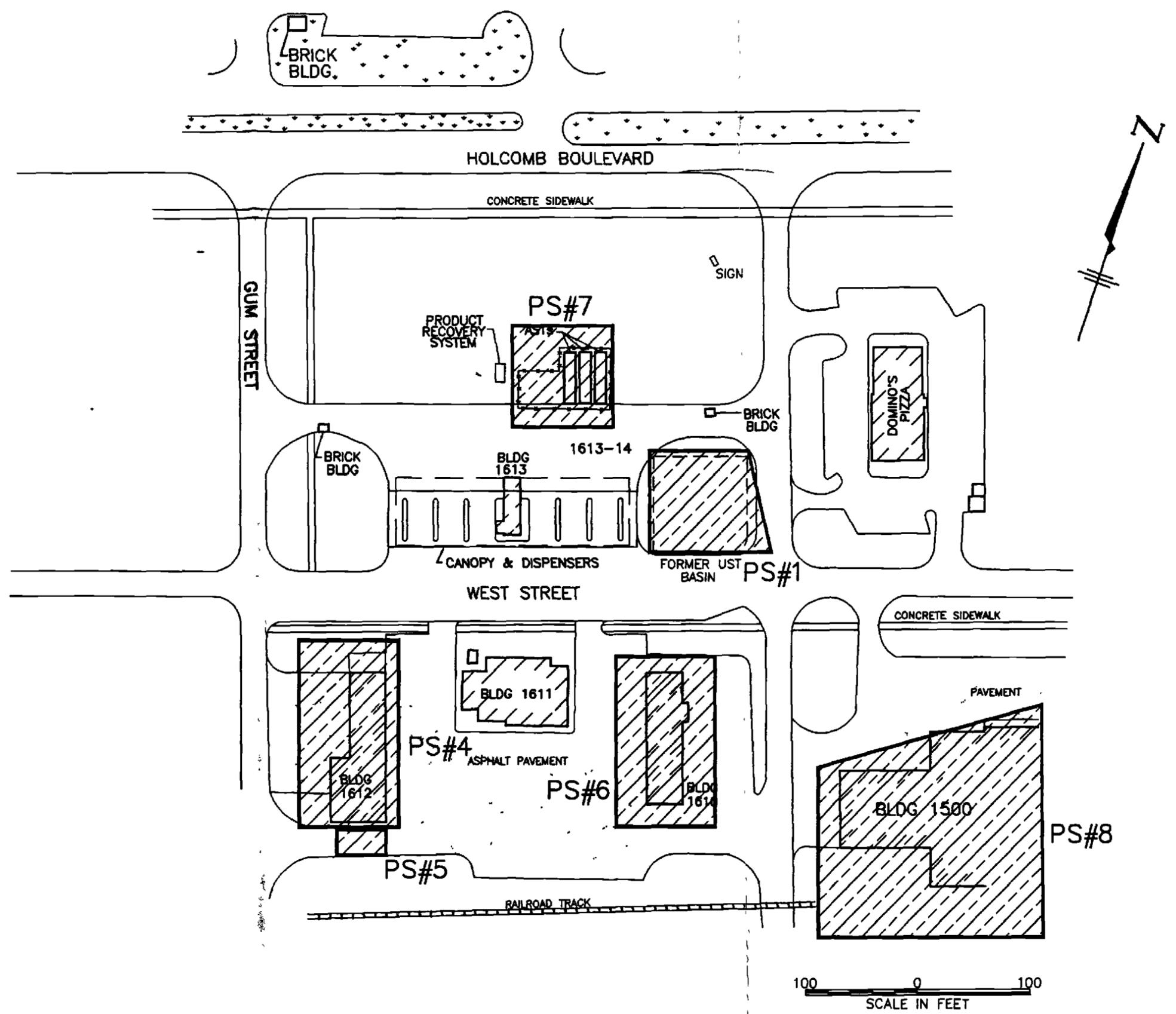
TITLE
 GENERAL LOCATION
 USGS TOPOGRAPHIC QUADRANGLE

SCALE: AS SHOWN DRAWN BY: WHW CHECKED BY: JC

FIGURE
1.1

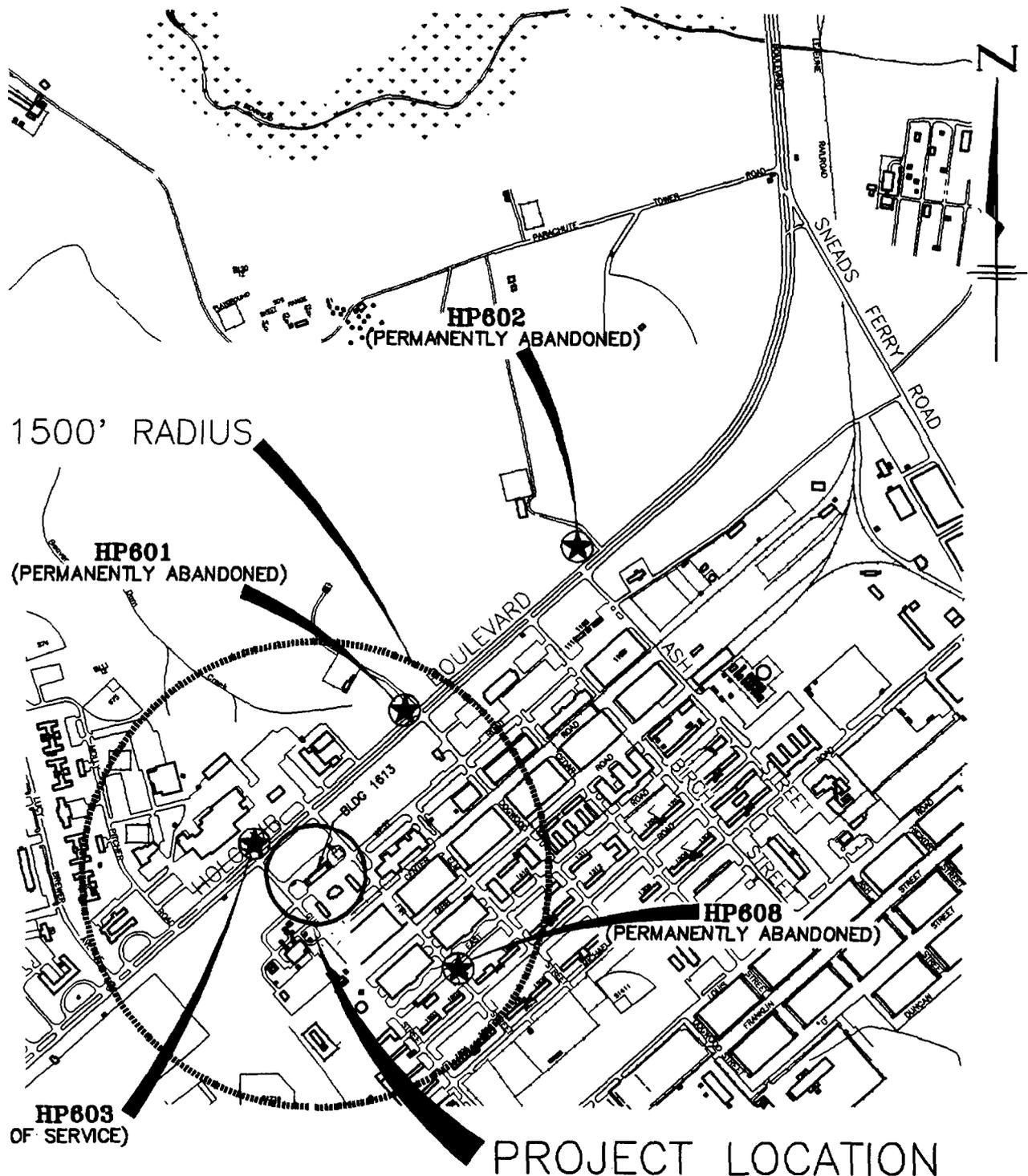


NOTES
 ALL POTENTIAL SOURCE LOCATIONS ARE APPROXIMATED
 PS#2 AND PS#3 ARE NOT SHOWN DUE TO THEIR LOCATION ON ADJACENT PROPERTY

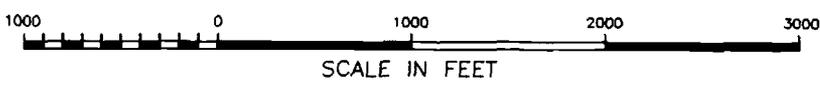


00076D01Z

Richard Catlin & Associates, Inc. ENVIRONMENTAL ENGINEERS AND HYDROGEOLOGISTS <small>WILMINGTON, NC CHARLESTON, SC ATLANTA, GA MOORESVILLE, NC</small>		PROJECT BLDG 1613, USTs 1613 1-4 LANTDIV NAVFACENGCOM CAMP LEJEUNE, N.C.	FILE CONTAMINANT SOURCE INVENTORY	FIGURE 2.1
<small>RC&A</small>		JOB NO. 94127CSA	DATE 25 MAY, 95	SCALE 1"=100'
		DRAWN BY: DMH	CHECKED BY: TP	

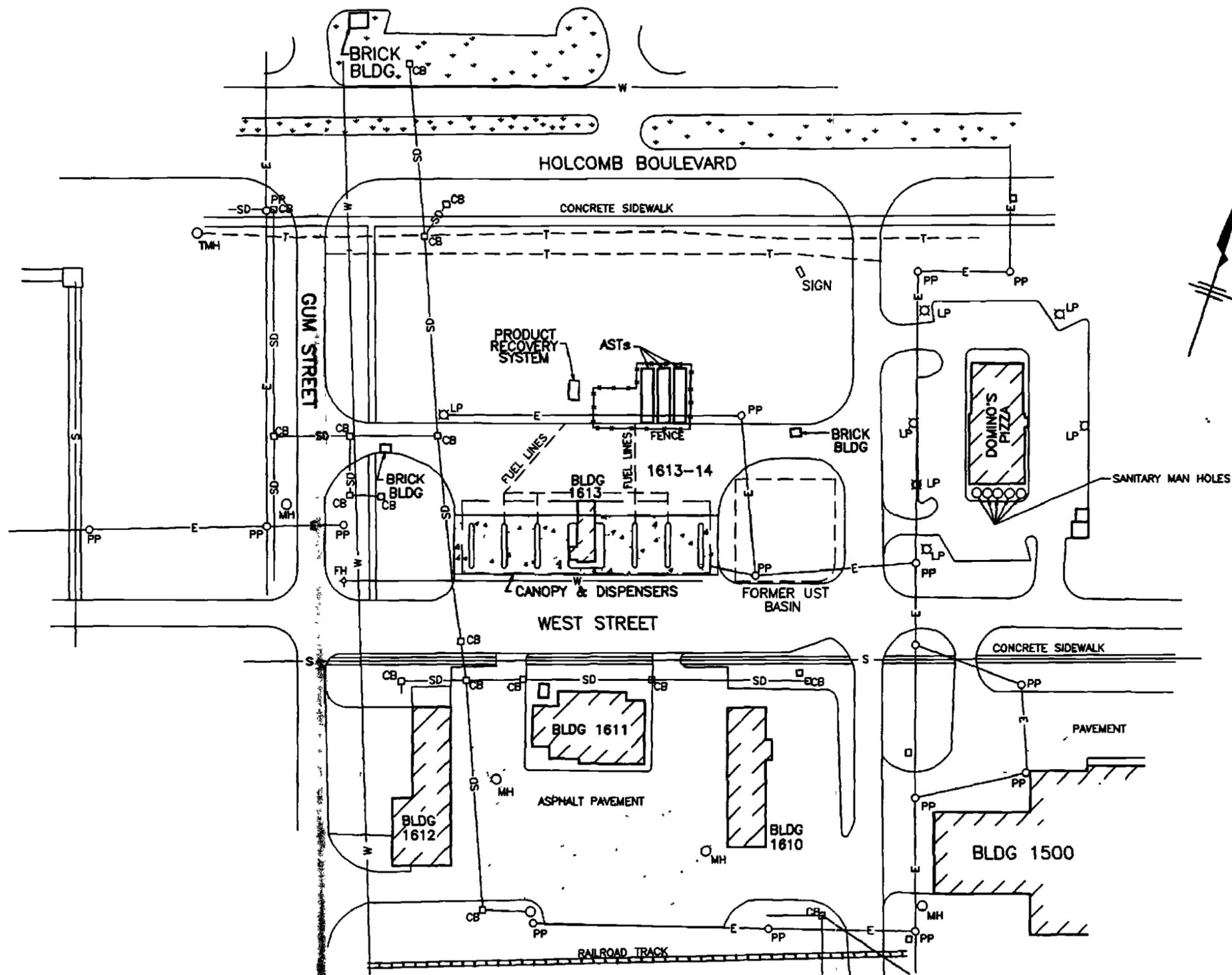


PROJECT LOCATION

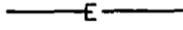
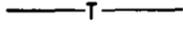
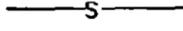
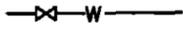
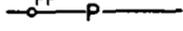
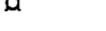


WELL LOCATIONS ARE FROM THE AUTOCAD DATABASE FURNISHED BY THE CAMP LEJEUNE ENGINEERING OFFICE. ALL WELL LOCATIONS ARE APPROXIMATED AND CURRENT THROUGH 1984.

Richard Catlin & Associates, Inc. ENVIRONMENTAL ENGINEERS AND HYDROGEOLOGISTS WILMINGTON, NC CHARLESTON, SC ATLANTA, GA CHARLOTTE, NC	PROJECT BLDG 1613, USTs 1613 1-4 LANTDIV NAVFACENGCOM CAMP LEJEUNE, N.C.	TITLE WATER SUPPLY WELL LOCATION MAP	FIGURE 3.1
	JOB NO: 94127CA DATE: MAY 1996	SCALE: AS SHOWN DRAWN BY: WHW CHECKED BY: JC	



LEGEND

- EXISTING
-  BUILDING
 -  STORM DRAIN LINE W/CATCH BASIN
 -  ELECTRIC
 -  TELEPHONE
 -  STEAM LINE
 -  WATERLINE W/VALVE
 -  POWER LINE W/POLE
 -  FIRE HYDRANT
 -  MANHOLE
 -  POWER TRANSFORMER
 -  AREA LIGHT

100 0 100
SCALE IN FEET

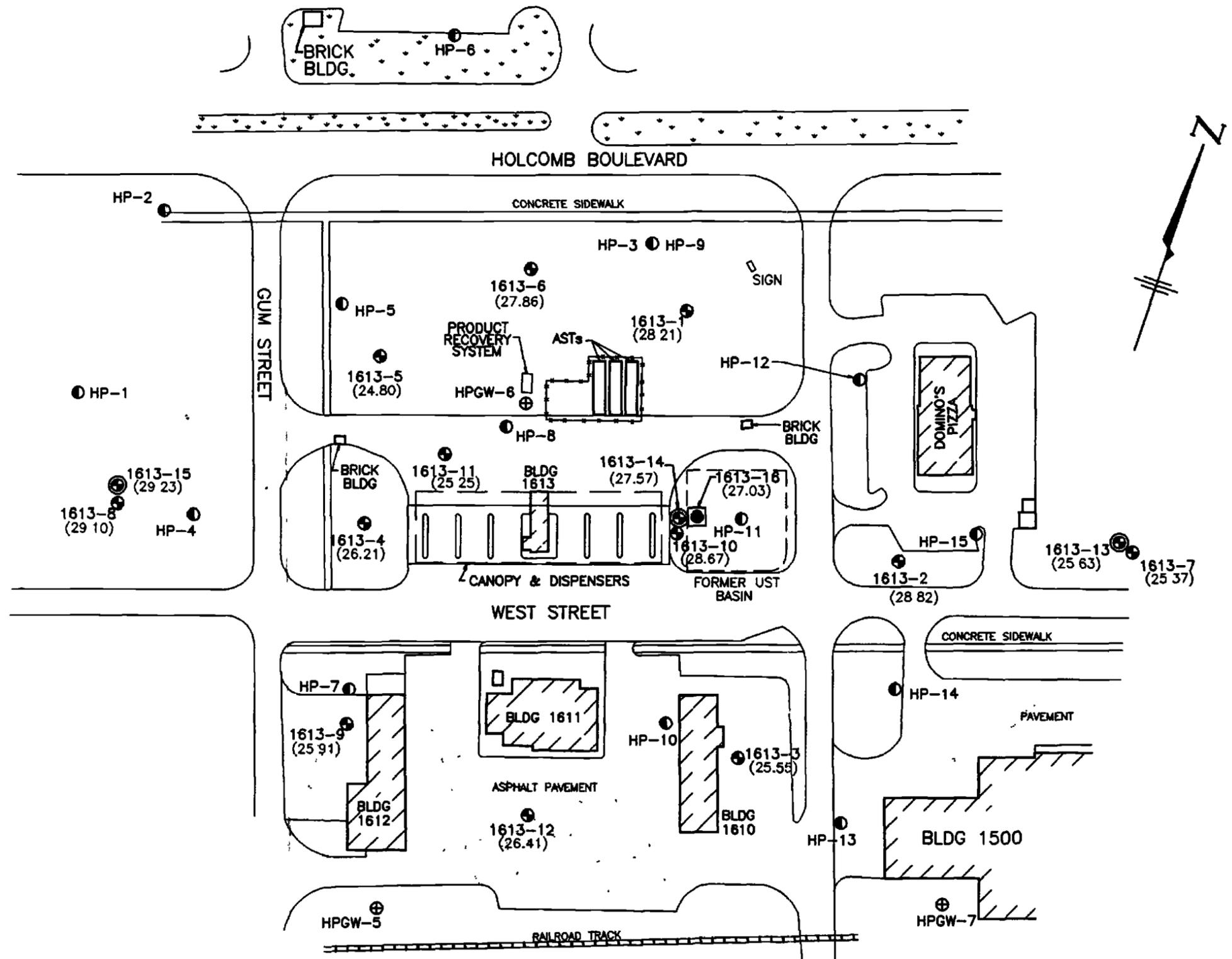
NOTE
UTILITY LOCATIONS ARE FROM THE AUTOCAD DATABASE FURNISHED
BY THE CAMP LEJEUNE ENGINEERING OFFICE.
ALL LOCATIONS ARE APPROXIMATE AND CURRENT THROUGH 1984

00076 D02 Z

Richard Collin & Associates, Inc. ENVIRONMENTAL ENGINEERS AND HYDROGEOLOGISTS R.C. & A. WILMINGTON, NC CHARLESTON, SC ATLANTA, GA MOORESVILLE, NC	PROJECT BLDG 1613, USTs 1613 1-4 LANTDIV NAVFACENCOM CAMP LEJEUNE, N.C.	TITLE SITE UTILITIES LOCATION MAP	FIGURE 3.2
	JOB NO. 94127CSA DATE 25 MAY, 95	SCALE 1"=100'	DRAWN BY: DMH

LEGEND

-  BUILDING
-  EXISTING TYPE II WELL
-  TYPE II WELL
-  TYPE III WELL
-  HYDROPUNCH
-  PUMPING WELL
- () TOP OF CASING ELEVATION (IN FEET)



100 0 100
SCALE IN FEET

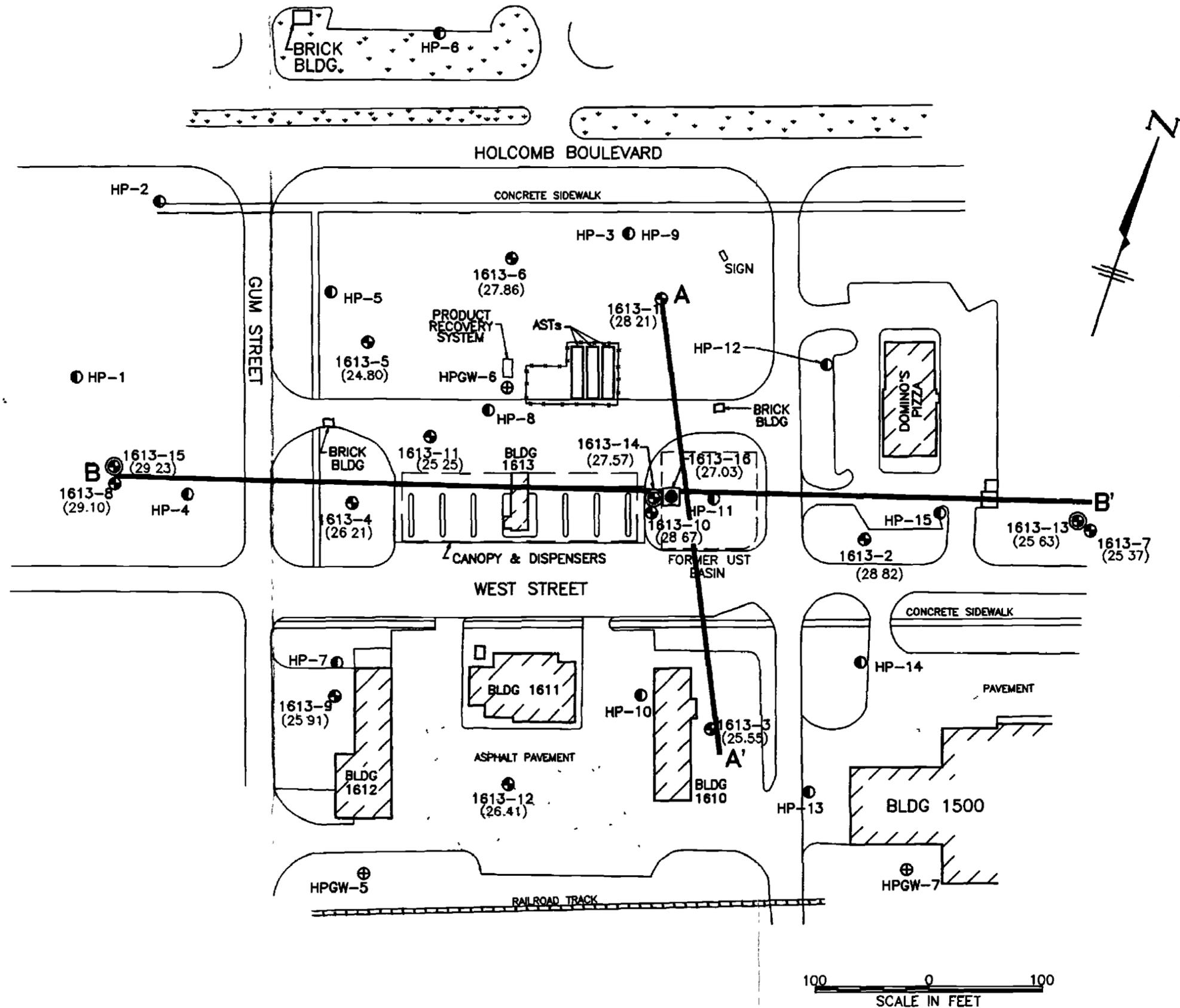
NOTE:
TOP OF CASING ELEVATIONS ARE REFERENCED TO MEAN SEA LEVEL BASED ON
MCB MONUMENT E-1 2d TOPO (EL 28 436 ft)

00076D03Z

Richard Collin & Associates, Inc. ENVIRONMENTAL ENGINEERS AND HYDROGEOLOGISTS <small>WILMINGTON, NC CHARLESTON, SC ATLANTA, GA MOORESVILLE, NC</small>	PROJECT BLDG 1613, USTs 1613 1-4 LANTDIV NAVFACENCOM CAMP LEJEUNE, N.C.	TITLE BORING, MONITORING WELL, AND HYDROPUNCH LOCATION PLAN	FIGURE 4.1
	JOB NO. 94127CSA DATE 25 MAY, 95	SCALE 1"=100'	DRAWN BY DMH CHECKED BY TP

LEGEND

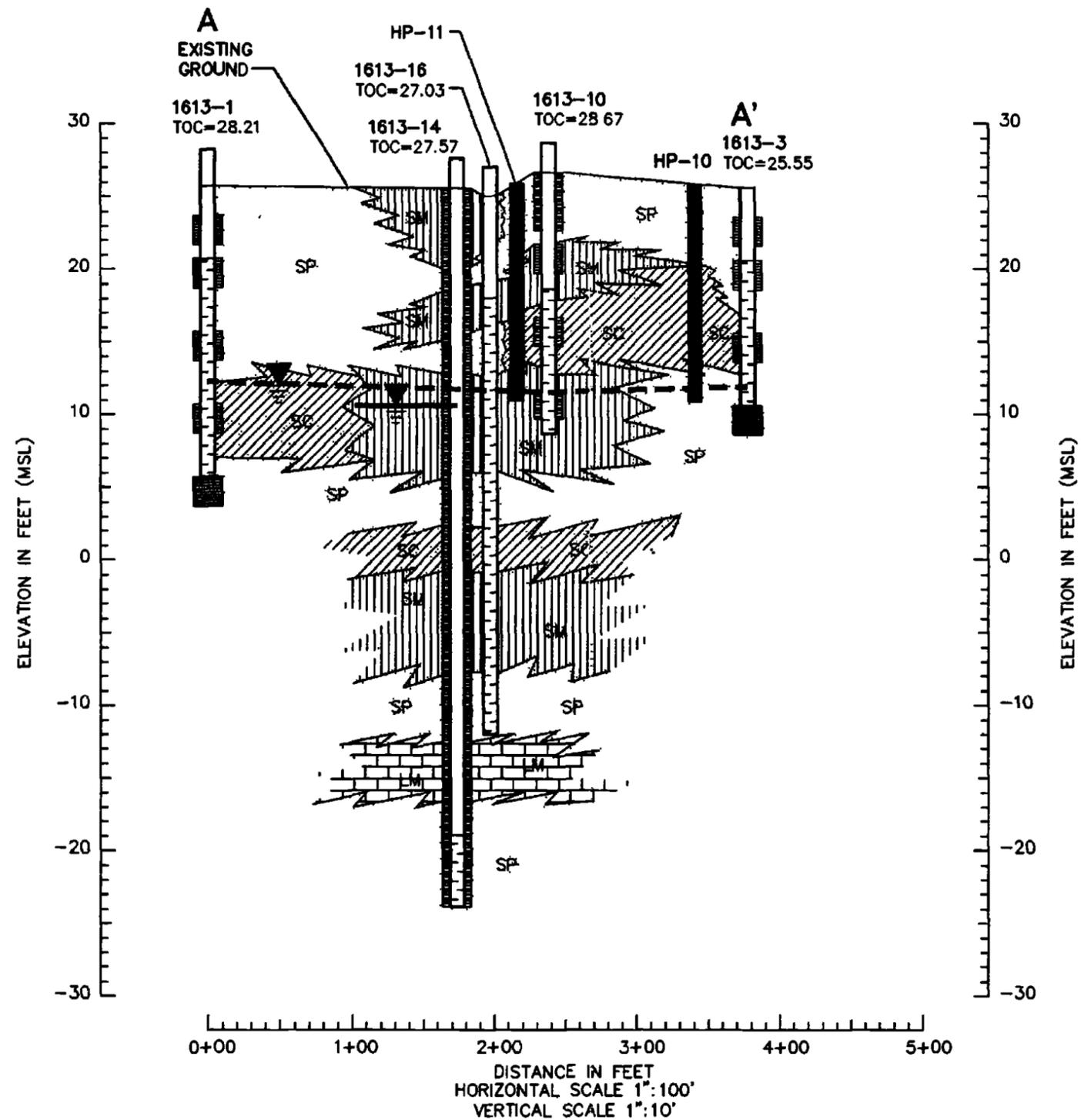
-  BUILDING
-  EXISTING TYPE II WELL
-  TYPE II WELL
-  TYPE III WELL
-  HYDROPUNCH
-  PUMPING WELL
- () TOP OF CASING ELEVATION (IN FEET)



NOTE:
TOP OF CASING ELEVATIONS ARE REFERENCED TO MEAN SEA LEVEL BASED ON
MCB MONUMENT E-1 2d TOPO (EL 28 436 ft)

Richard Catlin & Associates, Inc. ENVIRONMENTAL ENGINEERS AND HYDROGEOLOGISTS WILMINGTON, NC CHARLESTON, SC ATLANTA, GA MOORESVILLE, NC	PROJECT BLDG 1613, USTs 1613 1-4 LANTDIV NAVFACENCOM CAMP LEJEUNE, N.C.	TITLE CROSS SECTION - PLAN VIEW	FIGURE 4.2
	JOB NO. 94127CSA DATE 25 MAY, 95 SCALE 1"=100'	DRAWN BY DMH	CHECKED BY TP

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NOTE: CONTACTS REPRESENT GRADATIONAL CHANGES BETWEEN UNITS AND ARE APPROXIMATED

LEGEND

- | | | | |
|--|--|--|---|
| | SP POORLY GRADED SANDS OR GRAVELLY SANDS, LITTLE OR NO FINES | | GP POORLY GRADED SANDS OR GRAVEL-SANDS MIXTURES, LITTLE OR NO FINES |
| | SM SILTY SANDS, SAND-CLAY MIXTURES | | LM WEATHERED LIMESTONE |
| | SC CLAYEY SANDS, SAND-CLAY MIXTURES | | |
| | CL INORGANIC CLAYS OF LOW TO MEDIUM PLASTICITY, GRAVELLY CLAYS, SANDY CLAYS, SILTY CLAYS, LEAN CLAYS | | |

TOC TOP OF CASING ELEVATION ELEVATION BASED ON MEAN SEA LEVEL

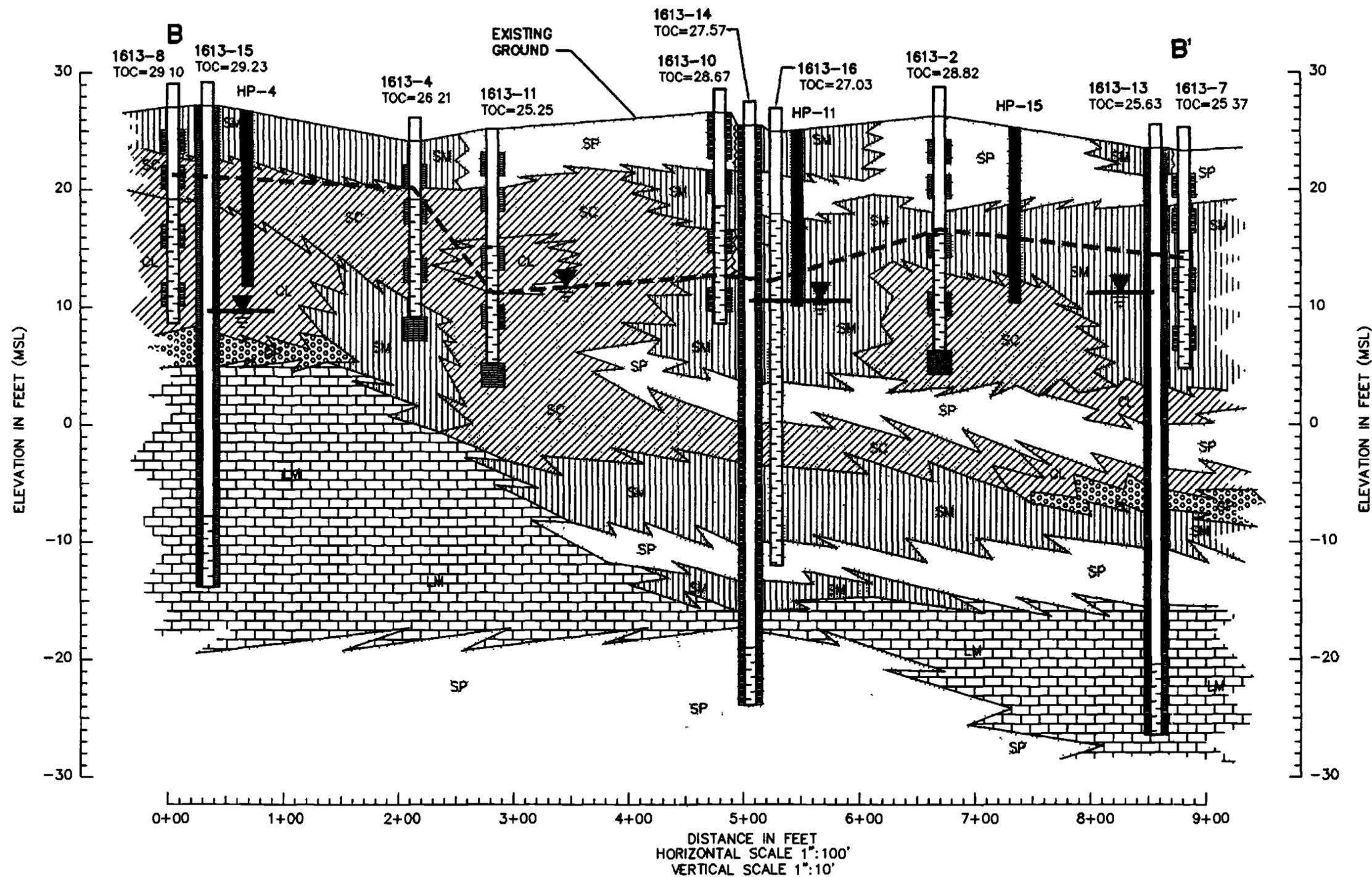
SCREEN INTERVAL

SOIL SAMPLE INTERVAL

WATER TABLE ELEVATION AS OF 5/17/95

Richard Collin & Associates, Inc. ENVIRONMENTAL ENGINEERS AND HYDROGEOLOGISTS <small>WILMINGTON, NC CHARLESTON, SC ATLANTA, GA MOORESVILLE, NC</small>	PROJECT BLDG 1613, USTs 1613 1-4 LANTDIV NAVFACENCOM CAMP LEJEUNE, N.C.	TITLE CROSS SECTION A - A'	FIGURE 4.3
	JOB NO. 94127CSA DATE 25 MAY, 95 SCALE: 1"=100'	DRAWN BY: DMH CHECKED BY: TP	

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000762062

NOTE: CONTACTS REPRESENT GRADATIONAL CHANGES BETWEEN UNITS AND ARE APPROXIMATED

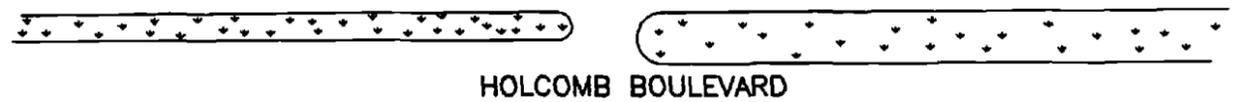
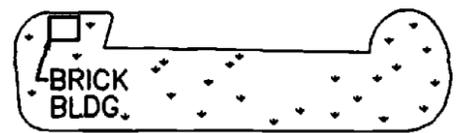
LEGEND

- SP POORLY GRADED SANDS OR GRAVELLY SANDS, LITTLE OR NO FINES
- SM SILTY SANDS, SAND-CLAY MIXTURES
- SC CLAYEY SANDS, SAND-CLAY MIXTURES
- CL INORGANIC CLAYS OF LOW TO MEDIUM PLASTICITY, GRAVELLY CLAYS, SANDY CLAYS, SILTY CLAYS, LEAN CLAYS
- GP POORLY GRADED SANDS OR GRAVEL-SANDS MIXTURES, LITTLE OR NO FINES
- LM WEATHERED LIMESTONE

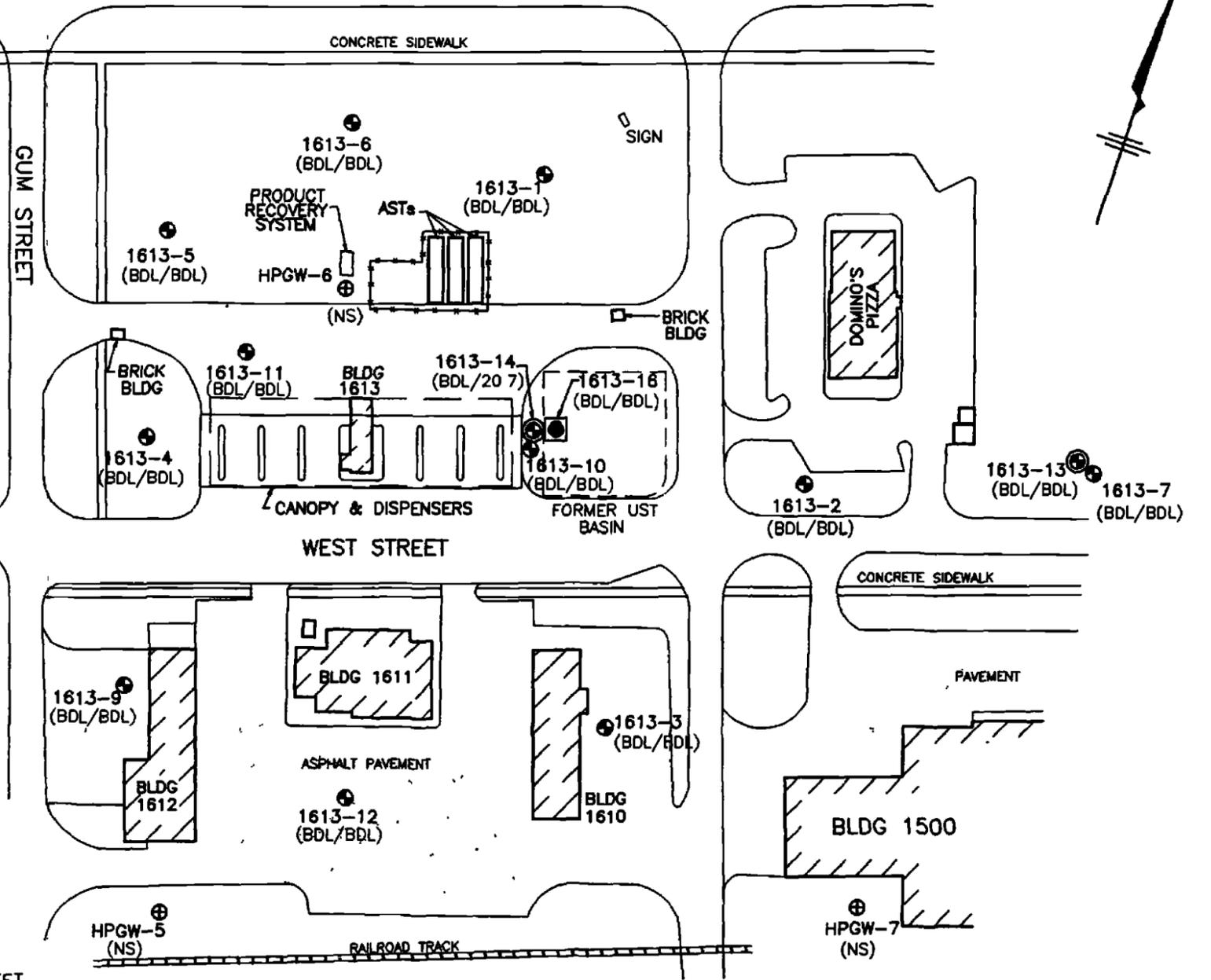
TOC TOP OF CASING ELEVATION ELEVATION BASED ON MEAN SEA LEVEL

- SCREEN INTERVAL
- SOIL SAMPLE INTERVAL
- WATER TABLE ELEVATION AS OF 5/17/95

Richard Catlin & Associates, Inc. ENVIRONMENTAL ENGINEERS AND HYDROGEOLOGISTS <small>WILMINGTON, NC CHARLESTON, SC ATLANTA, GA MOORESVILLE, NC</small>	PROJECT	BLDG 1613, USTs 1613 1-4	TITLE	CROSS SECTION B - B' 4.4
	LANTDIV NAVFACENGCOM	CAMP LEJEUNE, N.C.	FIGURE	
JOB NO. 94127CSA	DATE: 25 MAY, 95	SCALE: 1"=100'	DRAWN BY: DMH	CHECKED BY: TP



HOLCOMB BOULEVARD



LEGEND

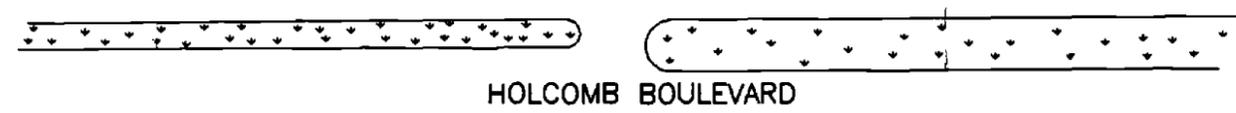
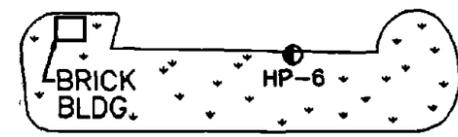
-  BUILDING
-  EXISTING TYPE II WELL
-  TYPE II WELL
-  TYPE III WELL
-  PUMPING WELL
- (/) TPH 5030/3550 CONCENTRATIONS IN ppm
- BQL BELOW QUANTITATION LIMITS
- BDL BELOW DETECTION LIMITS
- NS NOT SAMPLED

- NOTES**
- SAMPLES 1613-1 THROUGH 1613-12, AND 1613-16 WERE COLLECTED FROM A DEPTH OF 2 TO 4 FEET
SAMPLES 1613-13 THROUGH 1613-15 WERE COLLECTED FROM 2.5 TO 5 FEET.
 - NCDEHNR ACTION LEVELS FOR TPH ARE:
TPH 5030 = 10ppm
TPH 3550 = 40ppm



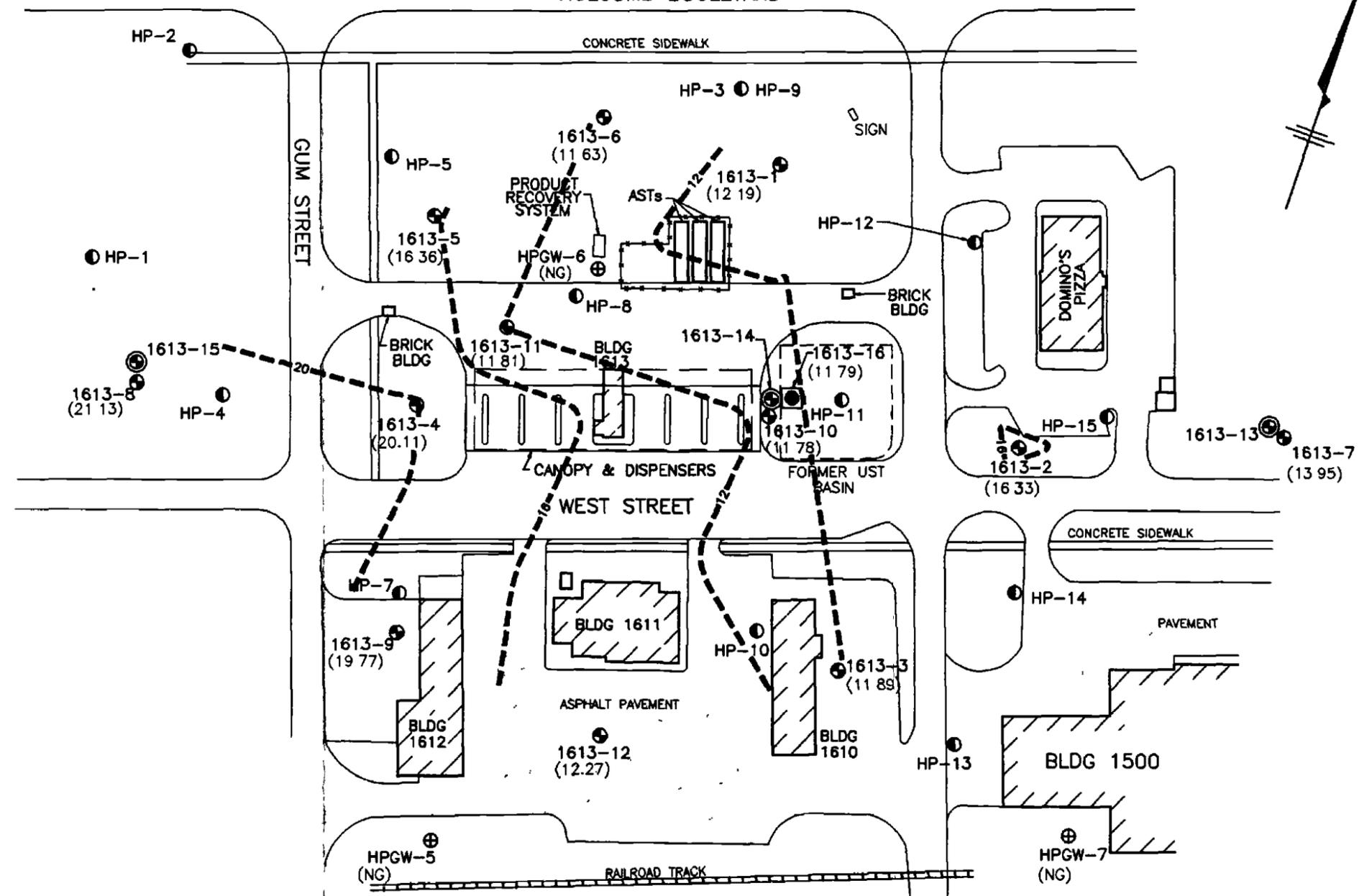
0076 D07Z

Richard Collin & Associates, Inc. ENVIRONMENTAL ENGINEERS AND HYDROGEOLOGISTS <small>WILMINGTON, NC CHARLESTON, SC ATLANTA, GA MOORESVILLE, NC</small>	PROJECT BLDG 1613, USTs 1613 1-4 LANTDIV NAVFACENGCOM CAMP LEJEUNE, N.C.	TITLE TPH CONCENTRATIONS (SOIL) - ISOPLETH MAP	FIGURE 4.5
	JOB NO. 94127CSA DATE: 25 MAY, 95	SCALE: 1"=100'	DRAWN BY: DMH



LEGEND

- BUILDING
- EXISTING TYPE II WELL
- TYPE II WELL
- TYPE III WELL
- HYDROPUNCH
- PUMPING WELL
- GROUND WATER ELEVATION (IN FEET)
- NOT GAUGED

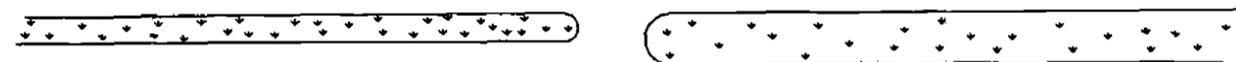
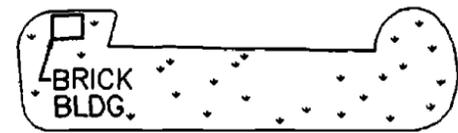


- NOTES**
- 1 GROUND WATER ELEVATIONS REFERENCED TO MEAN SEA LEVEL
 - 2 TYPE III WELLS, HPGW-5, HPGW-6, AND HPGW-7 NOT CONSIDERED IN CONTOURING AS OF MAY 17, 1995
 - 3 CONTOUR INTERVAL = 4 FEET
 - 4 WATER TABLE CONTOURS SHOWN HEREIN ARE COMPUTER GENERATED MATHEMATICAL INTERPRETATIONS BASED ON RAW DATA AND MAY DIFFER FROM ACTUAL WATER TABLE CONTOURS



00076 D082

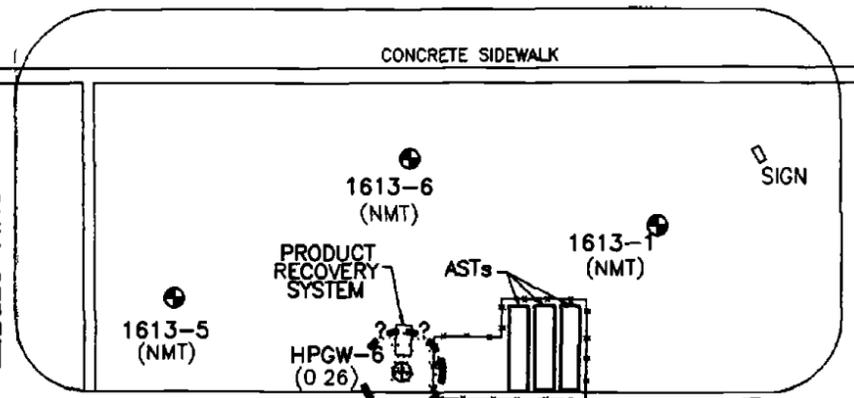
Richard Collin & Associates, Inc. ENVIRONMENTAL ENGINEERS AND HYDROGEOLOGISTS WILMINGTON, NC CHARLESTON, SC ATLANTA, GA MOORESVILLE, NC	PROJECT BLDG 1613, USTs 1613 1-4 LANTDIV NAVFACENGCOM CAMP LEJEUNE, N.C.	TITLE WATER TABLE CONTOUR MAP	FIGURE 5.1
	JOB NO. 94127CSA DATE: MAY 1996	SCALE: 1"=100'	DRAWN BY: DMH CHECKED BY: TP



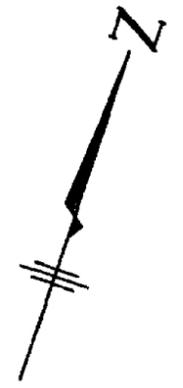
HOLCOMB BOULEVARD

ESTIMATED EXTENT OF FREE PRODUCT

GUM STREET

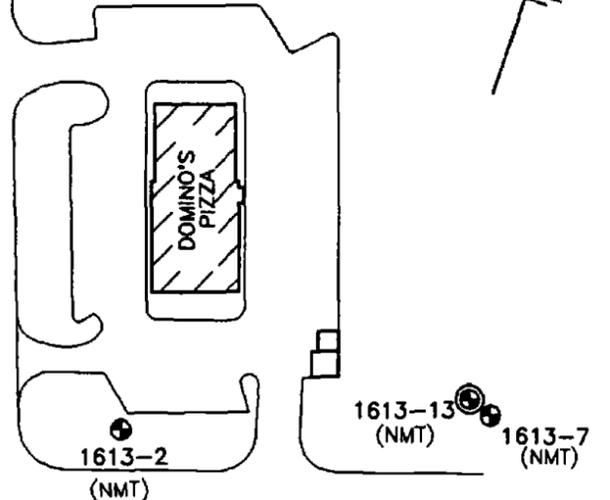
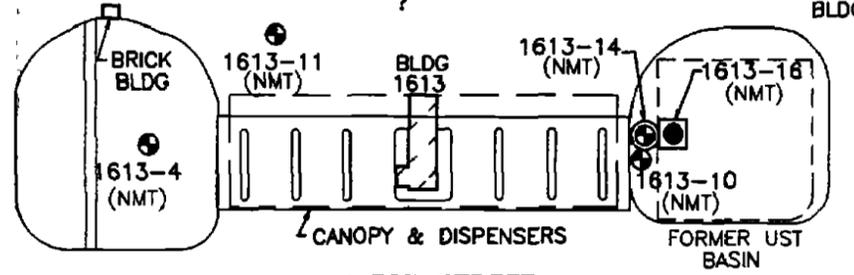
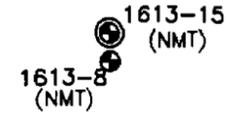


BRICK BLDG

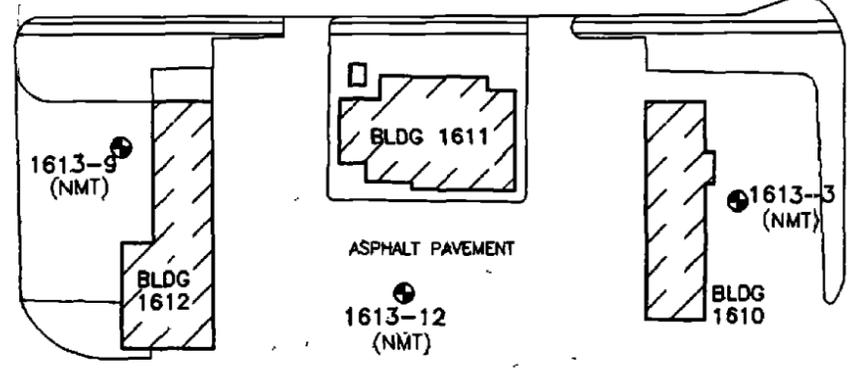


LEGEND

-  BUILDING
-  EXISTING TYPE II WELL
-  TYPE II WELL
-  TYPE III WELL
-  PUMPING WELL
-  () FREE PRODUCT THICKNESS (IN FEET)
- NM NOT MEASURED
- NMT NO MEASURABLE THICKNESS

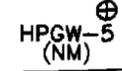


WEST STREET

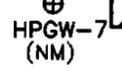


CONCRETE SIDEWALK

PAVEMENT



RAILROAD TRACK



NOTES
1 FREE PRODUCT PLUME EXTENT IS INTERPRETED FROM INFORMATION PROVIDED BY EMD PERSONNEL



00076 D09Z

Richard Catlin & Associates, Inc. ENVIRONMENTAL ENGINEERS AND HYDROGEOLOGISTS <small>WILMINGTON, NC CHARLESTON, SC ATLANTA, GA MOORESVILLE, NC</small>	PROJECT BLDG 1613, USTs 1613 1-4 LANTDIV NAVFACENGCOM CAMP LEJEUNE, N.C.	TITLE FREE PRODUCT SPATIAL EXTENT ISOPLETH MAP	FIGURE 5.2
	JOB NO. 94127CSA DATE: MAY 1996	SCALE: 1"=100'	DRAWN BY: DMH CHECKED BY: TP

LEGEND

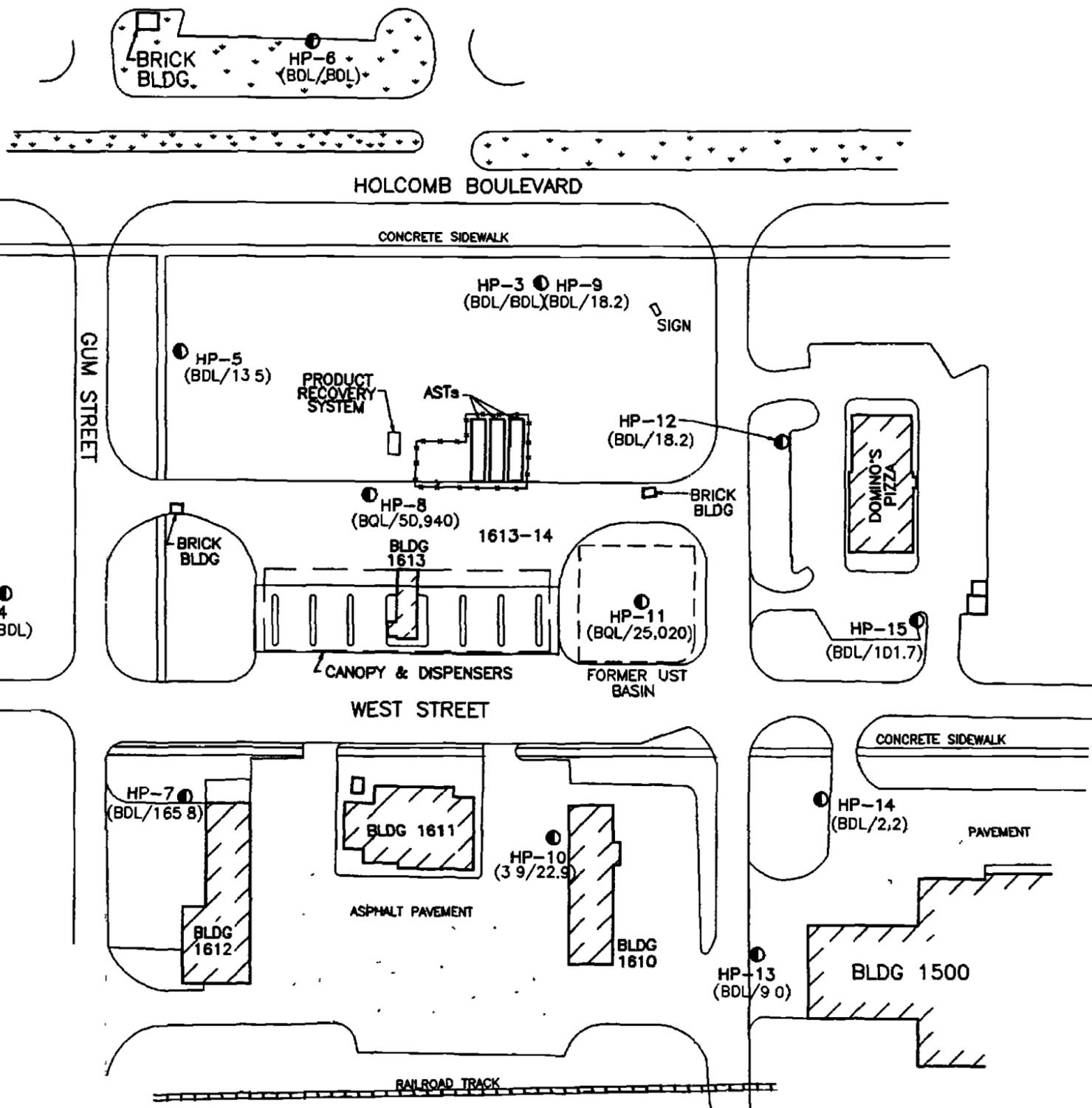
 BUILDING

 HYDROPUNCH

(/) TOTAL EPA METHODS 601/602 CONCENTRATIONS IN ppb

BDL BELOW DETECTION LIMITS

BQL BELOW QUANTITATION LIMITS



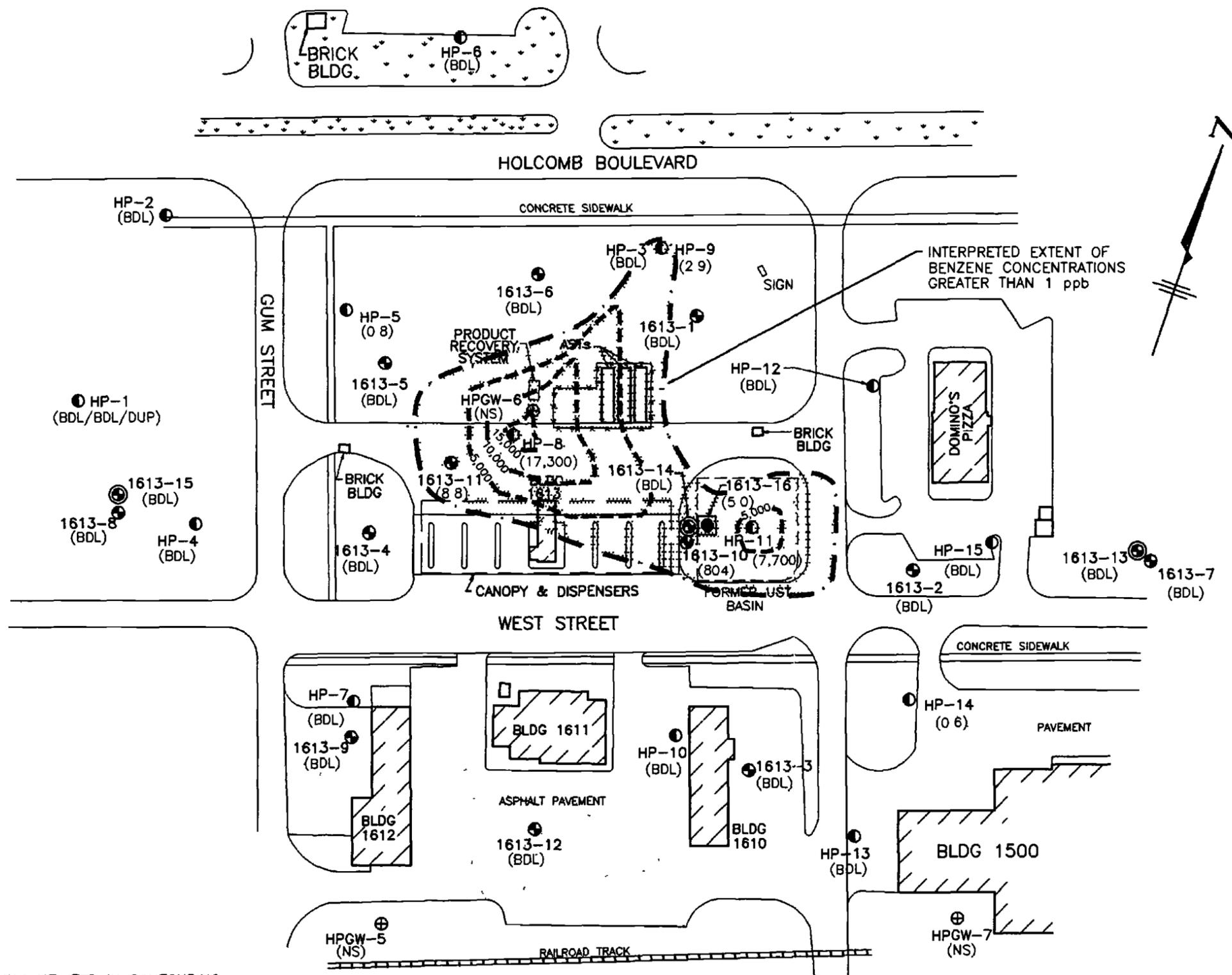
100 0 100
SCALE IN FEET

<p>Richard Collin & Associates, Inc. ENVIRONMENTAL ENGINEERS AND HYDROGEOLOGISTS WILMINGTON, NC CHARLESTON, SC ATLANTA, GA MOORESVILLE, NC</p>	<p>PROJECT BLDG 1613, USTs 1613 1-4 LANTDIV NAVFACENGGCOM CAMP LEJEUNE, N.C.</p>	<p>TITLE HYDROPUNCH DATA MAP</p>	<p>FIGURE 5.3</p>
	<p>JOB NO. 94127CSA DATE 25 MAY, 95</p>	<p>SCALE: 1"=100'</p>	<p>DRAWN BY: DMH CHECKED BY: TP</p>

00076D10Z

- LEGEND**
-  BUILDING
 -  EXISTING TYPE II WELL
 -  TYPE II WELL
 -  TYPE III WELL
 -  HYDROPUNCH
 -  PUMPING WELL
 - () BENZENE CONCENTRATIONS IN ppb
 - NS NOT SAMPLED
 - BDL BELOW DETECTION LIMITS

- NOTES**
1. WHERE DUPLICATE SAMPLES WERE COLLECTED THE HIGHER VALUE WAS UTILIZED IN CONTOURING
 2. TYPE III WELLS NOT CONSIDERED IN CONTOURING
 3. NCAC T15A O2L STANDARD FOR BENZENE IS 1 ppb
 4. CONTOUR INTERVAL = 10,000 ppb



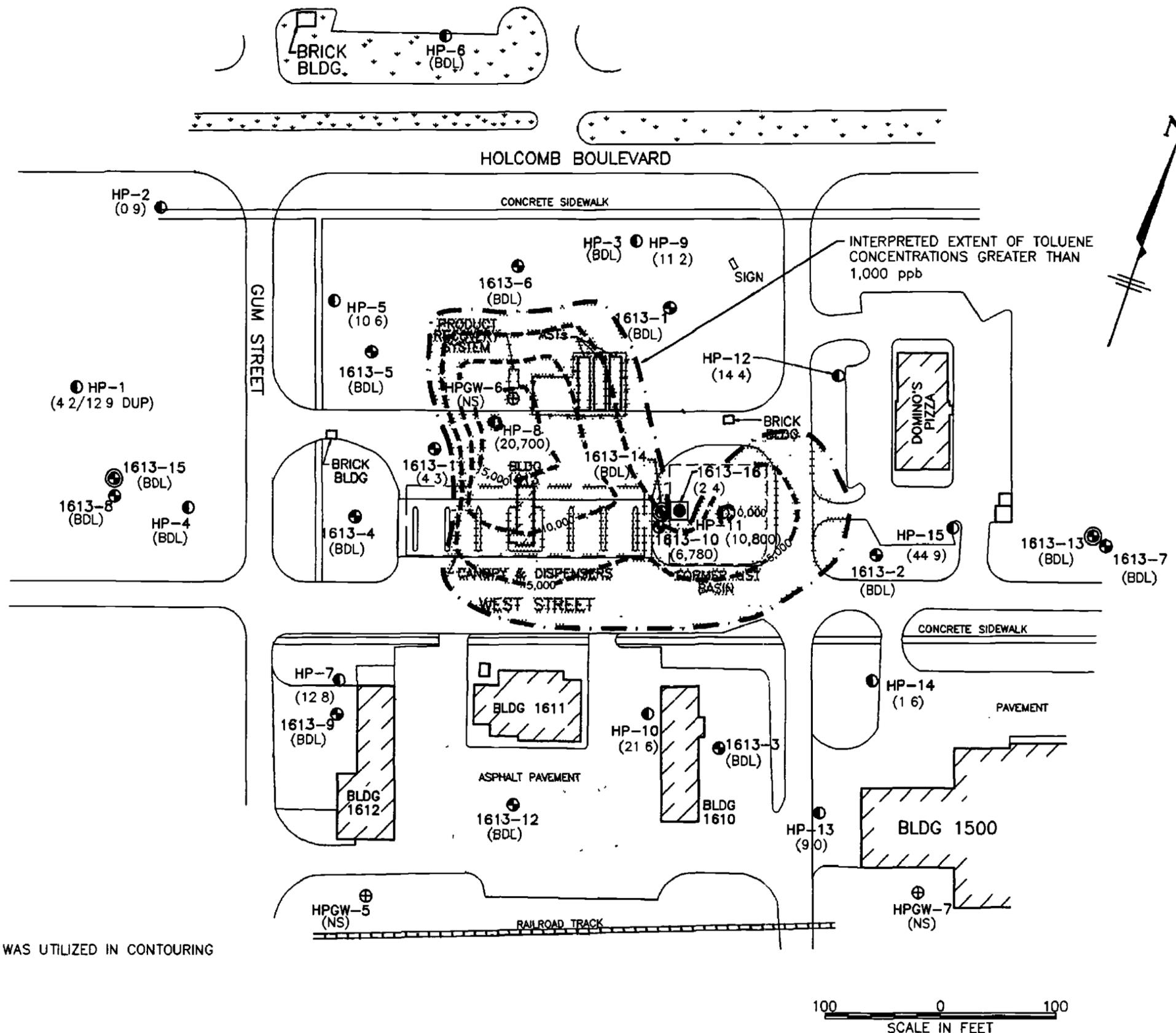
00076D11Z

Richard Catlin & Associates, Inc. ENVIRONMENTAL ENGINEERS AND HYDROGEOLOGISTS <small>WILMINGTON, NC CHARLESTON, SC ATLANTA, GA MOORESVILLE, NC</small>	PROJECT BLDG 1613, USTs 1613 1-4 LANTDIV NAVFACENGCOM CAMP LEJEUNE, N C	TITLE BENZENE CONCENTRATIONS (WATER) - ISOPLETH MAP	FIGURE 5.4
	<small>RC&A</small>	JOB NO. 94127CSA DATE: MAY 1996	SCALE: 1"=100'

LEGEND

-  BUILDING
-  EXISTING TYPE II WELL
-  TYPE II WELL
-  TYPE III WELL
-  HYDROPUNCH
-  PUMPING WELL
- () TOLUENE CONCENTRATIONS IN ppb
- NS NOT SAMPLED
- BDL BELOW DETECTION LIMITS

- NOTES
- 1 WHERE DUPLICATE SAMPLES WERE COLLECTED, THE HIGHER VALUE WAS UTILIZED IN CONTOURING
 - 2 TYPE III WELLS NOT CONSIDERED IN CONTOURING
 - 3 NCAC T15A 02L STANDARD FOR TOLUENE IS 1,000 ppb
 - 4 CONTOUR INTERVAL = 5,000 ppb



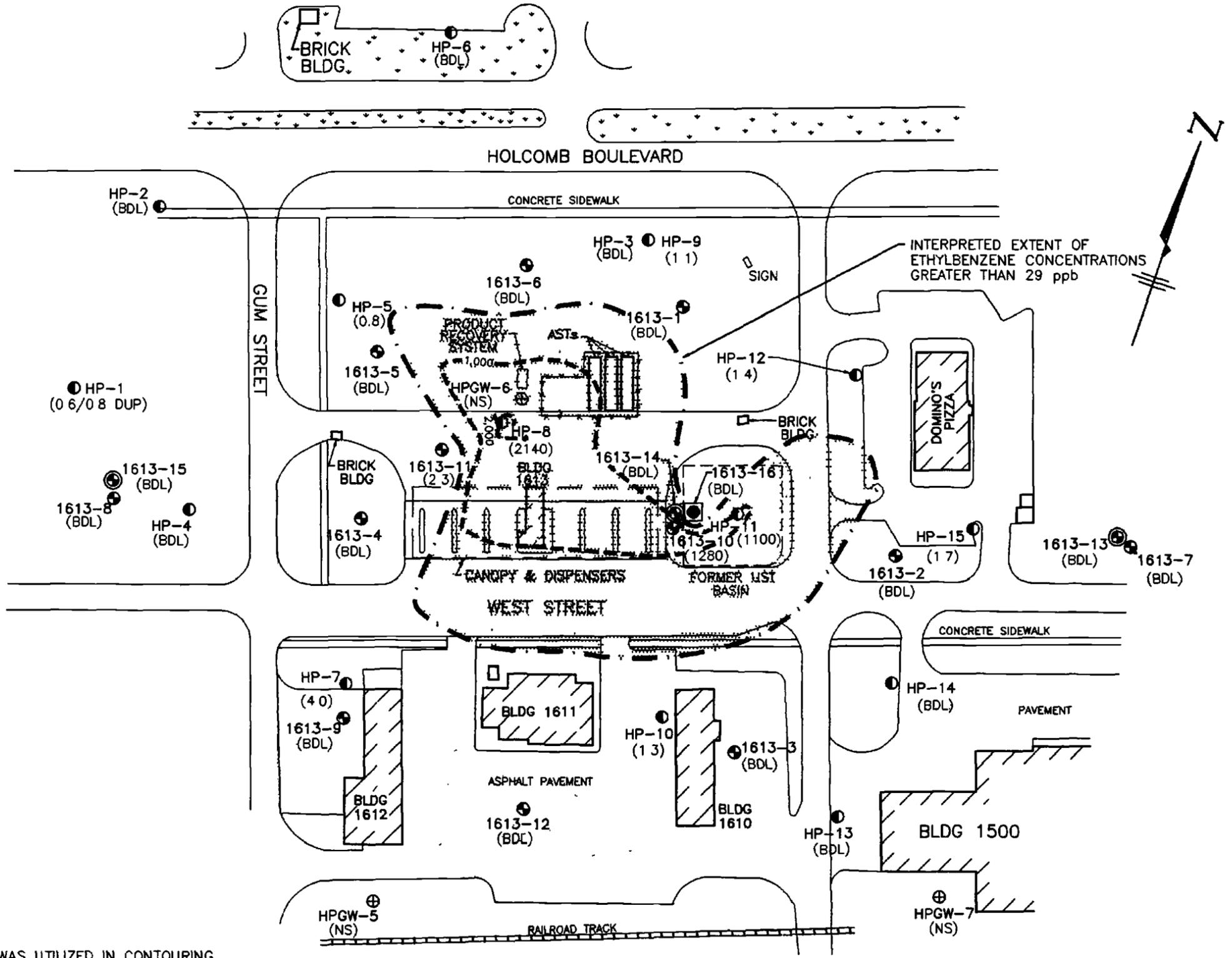
00076 D12Z

<p>Richard Catlin & Associates, Inc. ENVIRONMENTAL ENGINEERS AND HYDROGEOLOGISTS <small>WILMINGTON, NC CHARLESTON, SC ATLANTA, GA MOORESVILLE, NC</small></p>	<p>PROJECT BLDG 1613, USTs 1613 1-4 LANTDIV NAVFACENGCOM CAMP LEJEUNE, N.C.</p>	<p>TITLE TOLUENE CONCENTRATIONS (WATER) - ISOPLETH MAP</p>	<p>FIGURE 5.5</p>
<p><small>JOB NO. 94127CSA DATE MAY 1996</small></p>		<p><small>SCALE: 1"=100'</small></p>	<p><small>DRAWN BY: DMH CHECKED BY: TP</small></p>

LEGEND

-  BUILDING
-  EXISTING TYPE II WELL
-  TYPE II WELL
-  TYPE III WELL
-  HYDROPUNCH
-  PUMPING WELL
-
-  ETHYLBENZENE CONCENTRATIONS IN ppb
-  NS NOT SAMPLED
-  BDL BELOW DETECTION LIMITS

- NOTES**
- 1 WHERE DUPLICATE SAMPLES WERE COLLECTED THE HIGHER VALUE WAS UTILIZED IN CONTOURING
 - 2 TYPE III WELLS NOT CONSIDERED IN CONTOURING
 - 3 NCAC T15A 02L STANDARD FOR ETHYLBENZENE IS 29 ppb
 4. CONTOUR INTERVAL = 1,000 ppb

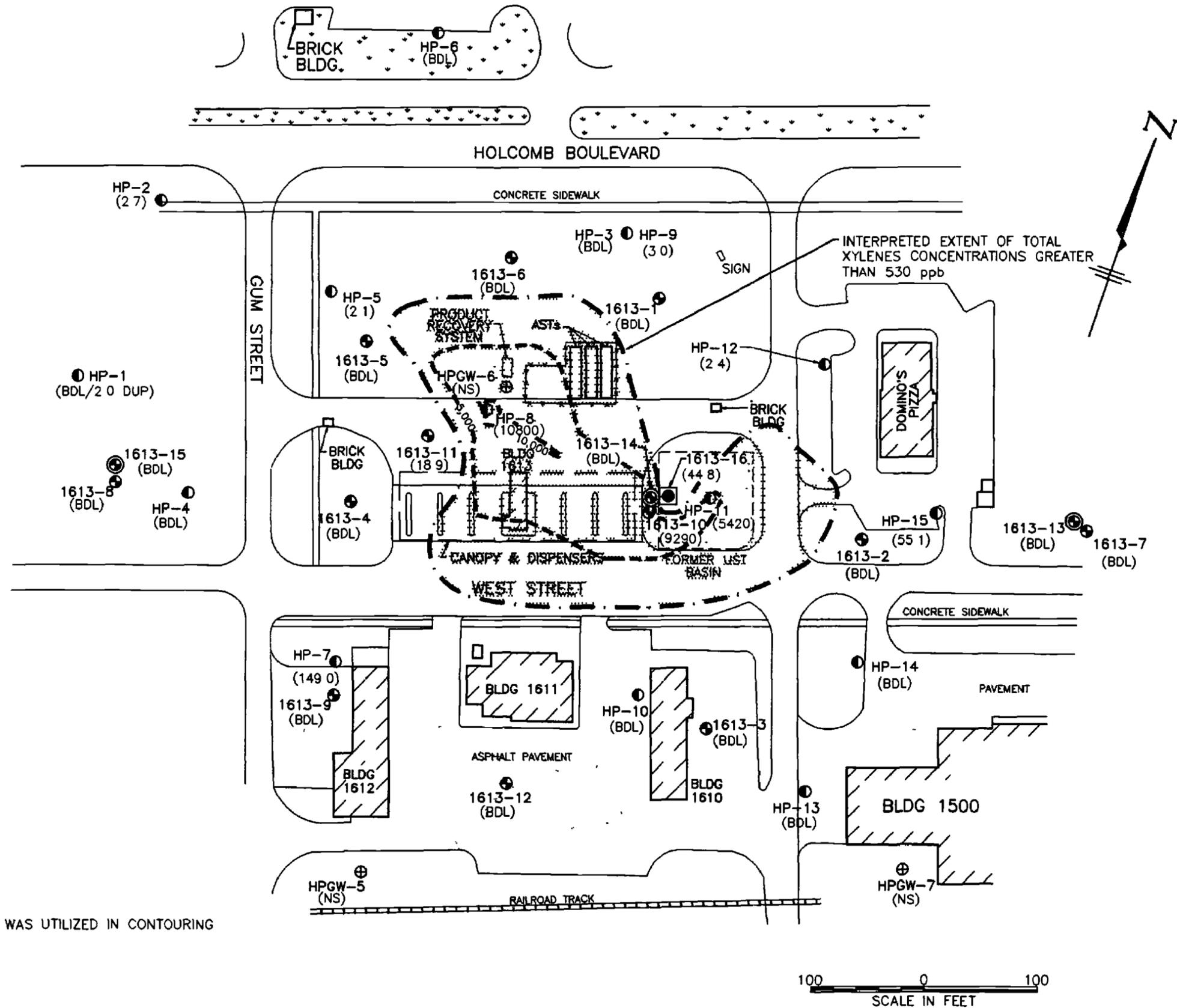


00076 D132

<p>Richard Catlin & Associates, Inc. ENVIRONMENTAL ENGINEERS AND HYDROGEOLOGISTS WILMINGTON, NC CHARLESTON, SC ATLANTA, GA MOORESVILLE, NC</p>	PROJECT BLDG 1613, USTs 1613 1-4 LANTDIV NAVFACENCOM CAMP LEJEUNE, N.C.	TITLE ETHYLBENZENE CONCENTRATIONS (WATER) - ISOPLETH MAP	FIGURE 5.6
	JOB NO. 94127CSA DATE MAY 1996	SCALE: 1"=100'	DRAWN BY: DMH CHECKED BY: TP

LEGEND	
	BUILDING
	EXISTING TYPE II WELL
	TYPE II WELL
	TYPE III WELL
	HYDROPUNCH
	PUMPING WELL
()	TOTAL XYLENES CONCENTRATIONS IN ppb
NS	NOT SAMPLED
BDL	BELOW DETECTION LIMITS

- NOTES
1. WHERE DUPLICATE SAMPLES WERE COLLECTED, THE HIGHER VALUE WAS UTILIZED IN CONTOURING
 2. TYPE III WELLS NOT CONSIDERED IN CONTOURING
 3. NCAC T15A O2L STANDARD FOR TOTAL XYLENES IS 530 ppb
 4. CONTOUR INTERVAL = 5,000 ppb



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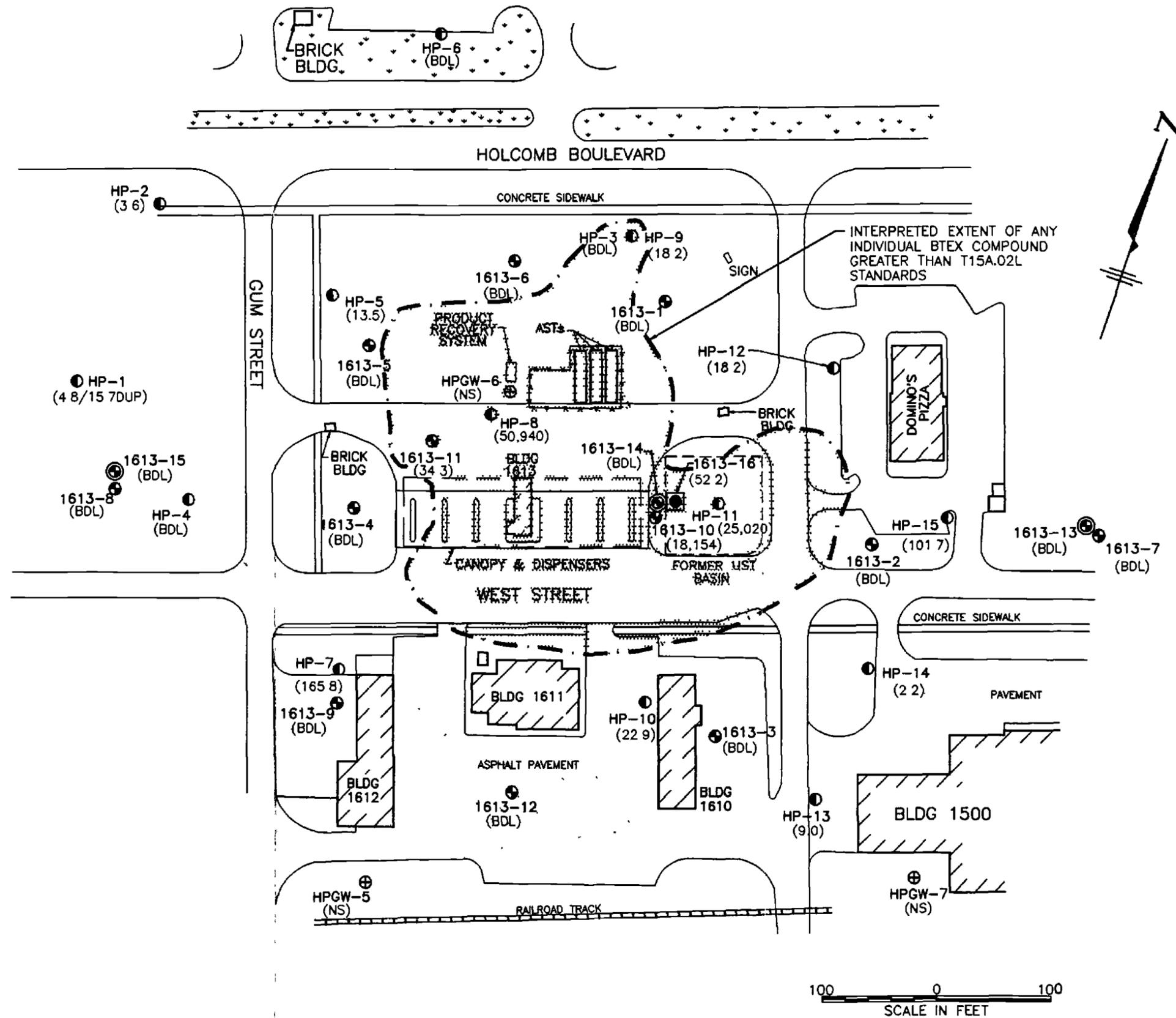
Richard Catlin & Associates, Inc. ENVIRONMENTAL ENGINEERS AND HYDROGEOLOGISTS <small>WILMINGTON, NC CHARLESTON, SC ATLANTA, GA MOORESVILLE, NC</small>	PROJECT BLDG 1613, USTs 1613 1-4 LANTDIV NAVFACENGCOM CAMP LEJEUNE, N.C.	TITLE TOTAL XYLENES CONCENTRATIONS (WATER) - ISOPLETH MAP	FIGURE 5.7	
	<small>JOB NO. 94127CSA</small>	<small>DATE: MAY 1996</small>	<small>SCALE: 1"=100'</small>	<small>DRAWN BY: DMH</small>

LEGEND

-  BUILDING
-  EXISTING TYPE II WELL
-  TYPE II WELL
-  TYPE III WELL
-  HYDROPUNCH
-  PUMPING WELL
- () TOTAL BTEX CONCENTRATIONS IN ppb
- NS NOT SAMPLED
- BDL BELOW DETECTION LIMITS

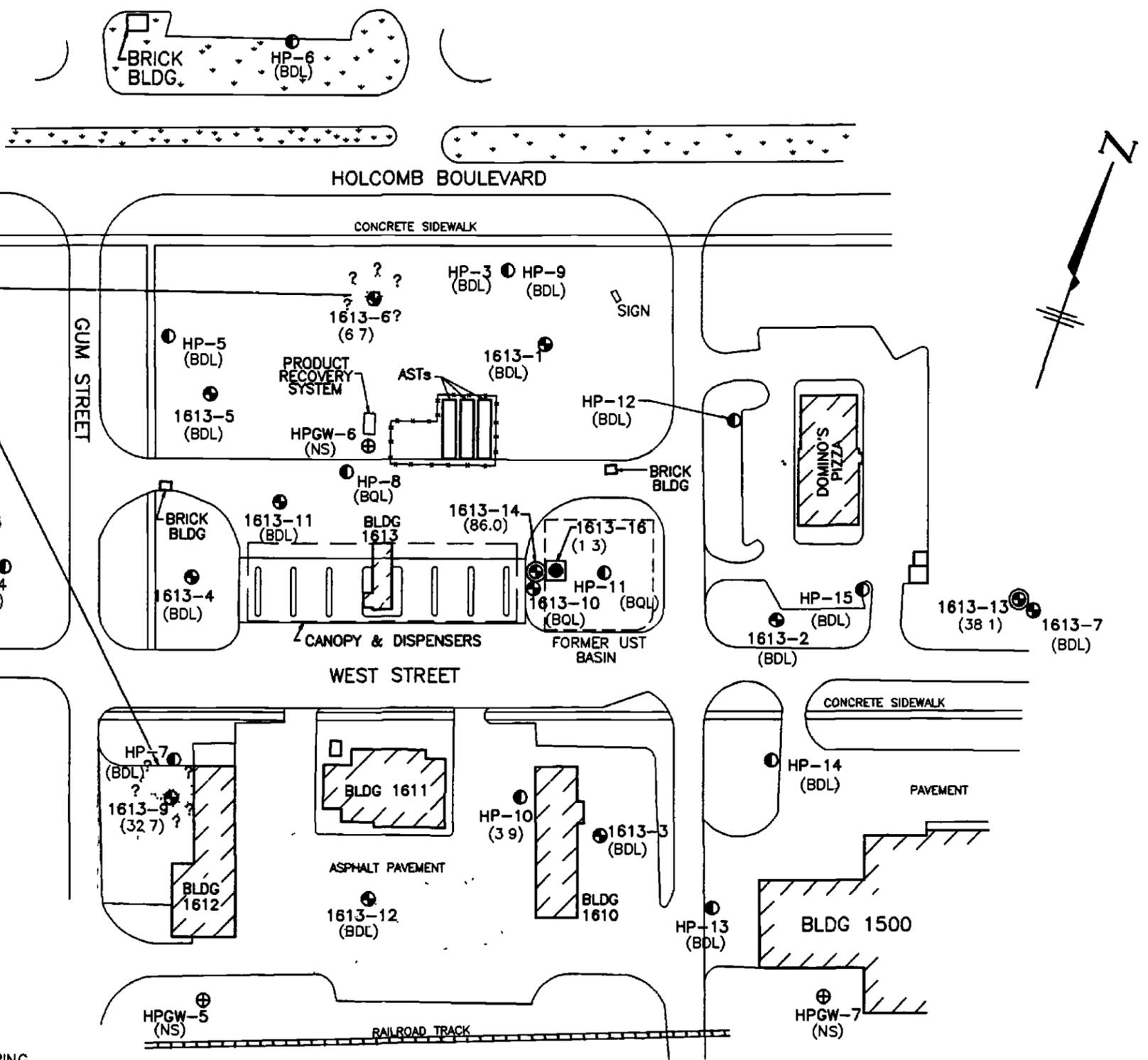
NOTE

1. NCAC T15A 02L STANDARD FOR INDIVIDUAL COMPOUNDS VARY



Richard Catlin & Associates, Inc. ENVIRONMENTAL ENGINEERS AND HYDROGEOLOGISTS WILMINGTON, NC CHARLESTON, SC ATLANTA, GA MOORESVILLE, NC	PROJECT BLDG 1613, USTs 1613 1-4 LANTDIV NAVFACENGCOM CAMP LEJEUNE, N.C.	TITLE TOTAL BTEX CONCENTRATIONS (WATER)	FIGURE 5.8
	JOB NO. 94127CSA DATE: MAY 1996	SCALE: 1"=100'	DRAWN BY: DMH CHECKED BY: TP

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AREA IN WHICH ANY INDIVIDUAL
EPA METHOD 601 COMPOUND WAS
DETECTED ABOVE NCAC T15A 02L
STANDARDS

LEGEND

- BUILDING
- EXISTING TYPE II WELL
- TYPE II WELL
- TYPE III WELL
- HYDROPUNCH
- PUMPING WELL
- () TOTAL EPA METHOD 601 CONCENTRATIONS IN ppb
- NS NOT SAMPLED
- BDL BELOW DETECTION LIMITS
- BQL BELOW QUANTITATION LIMITS

- NOTES
1. WHERE DUPLICATE SAMPLES WERE COLLECTED THE HIGHER VALUE WAS UTILIZED IN CONTOURING
 2. TYPE III WELLS NOT CONSIDERED IN CONTOURING
 3. NCAC T15A 02L STANDARD FOR INDIVIDUAL COMPOUNDS VARY



Richard Catlin & Associates, Inc. ENVIRONMENTAL ENGINEERS AND HYDROGEOLOGISTS <small>WILMINGTON, NC CHARLESTON, SC ATLANTA, GA MOORESVILLE, NC</small>	PROJECT BLDG 1613, USTs 1613 1-4 LANTDIV NAVFACENGCOM CAMP LEJEUNE, N.C.	TITLE TOTAL EPA METHOD 601 CONCENTRATIONS (WATER)	FIGURE 5.9
	JOB NO. 94127CSA DATE: MAY 1996	SCALE: 1"=100'	DRAWN BY: DMH

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