

LEAKING UNDERGROUND STORAGE TANK
COMPREHENSIVE SITE ASSESSMENT

BUILDING AS-410

MARINE CORPS AIR STATION NEW RIVER
JACKSONVILLE, NORTH CAROLINA

OCTOBER 4, 1994

VOLUME I

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**LEAKING UNDERGROUND STORAGE TANK
COMPREHENSIVE SITE ASSESSMENT
BUILDING AS-410**

EXECUTIVE SUMMARY

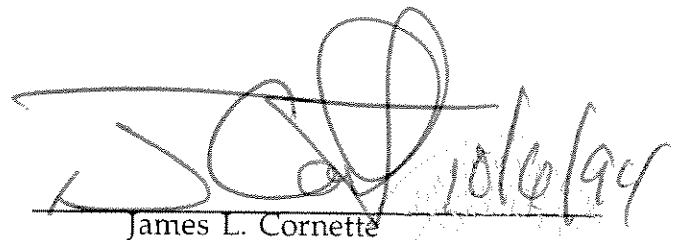
Building AS-410 is an active gasoline station and vehicle maintenance facility. According to previous reports, six gasoline underground storage tanks (USTs) were excavated and removed from the site in July 1992. Analysis of water infiltrating the excavation site revealed petrochemical impact to the surrounding subsurface.

As part of the investigation, Richard Catlin and Associates, Inc. (RC&A) installed ten 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 be four to six feet. No clear ground water direction was determined, this situation may be influenced by a storm water retention pond located nearby. No evidence of free product was observed in any of the monitoring wells. Geology beneath the site is described as interfingering and interbedded layers of poorly graded sands, silty sands, clayey sands, and clays to a depth of approximately 28 feet. Limestone bedrock was encountered between approximately 28 and 51 feet. No confining layer was encountered.

Two petrochemical plumes have been delineated horizontally and vertically in the areas of the former UST basin and the active UST basin. Air sparging and soil venting are recommended to reduce low levels of contamination found in these areas.

STATEMENT OF PROFESSIONAL CONDUCT

I, James L. Cornette, as a duly registered Professional Geologist in the State of North Carolina, have been authorized to observe and direct the underground storage tank subsurface investigation at Building AS-410, at the Marine Corps Air Station New River, Jacksonville, North Carolina for the Atlantic Division Naval Facilities Engineering Command. To the best of my abilities, due care and diligence was used in the observation and supervision of the investigation, such that the investigation was conducted in accordance with the approved workplan and North Carolina laws and guidelines.



James L. Cornette
Certified Professional Geologist
State of North Carolina
Registration Number 1214

LEAKING UNDERGROUND STORAGE TANK COMPREHENSIVE SITE ASSESSMENT

BUILDING AS-410
MARINE CORPS AIR STATION NEW RIVER
JACKSONVILLE, NORTH CAROLINA

OCTOBER 4, 1994

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;
- Identify and delineate possible free product accumulation, if present;
- Assess the potential for exposure to possible subsurface petroleum-related contaminants; and
- Provide a CSA report for the former UST basin at Building AS-410 in Marine Corps Air Station (MCAS) New River, Jacksonville, North Carolina.

The location of the project site within the base 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*

The project was conducted in two phases. The first phase involved the advancement of ten Hydropunch penetrometers (Hydropunches) and collection of shallow ground water samples for on-site laboratory analysis. The on-site laboratory results were available within 24 to 72 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 three 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 second phase of the investigation involved the advancement of 16 soil borings, into which 12 Type II and three Type III monitoring wells, and one pumping well were installed. Samples were collected from the soil borings (soil) and monitoring wells (ground water) for both on-site and off-site analysis. Three slug tests were conducted at the site to determine site hydrogeological conditions. An eight hour pumping test was also performed to determine the surficial aquifer parameters.

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

The site is located at the New River MCAS in the northern region of the Marine Corps Base (MCB), Camp Lejeune, North Carolina (see Figure 1.1). The facility is an active service station for the Marine Corps Commissary. Building AS-410 is approximately 2,000 feet north of the MCAS air field. The area immediately adjacent to Building AS-410 is comprised of buildings that house maintenance and support facilities for the base. Site topography is relatively flat with a gentle grade toward the north-northwest. Surface drainage is by sheet flow over the paved surfaces to drainage ditches which empty into a storm water retention pond west of the site.

2.0 SITE HISTORY AND SOURCE CHARACTERIZATION

2.1 *Site History and Operations*

Building AS-410 is an active gasoline dispensing service station and light vehicle maintenance facility. Six 4,000 gallon steel USTs were formerly located at the facility and used to store various grades of gasoline.

On July 28, 1992 all six tanks were excavated and removed from the site. Analyses for petrochemicals were performed on a water sample collected

from water that had infiltrated the excavation site. Laboratory results reported concentrations of 6,640 parts per billion (ppb) benzene, less than 125 ppb toluene, 1,990 ppb ethylbenzene, 12,950 total xylenes, and 7,390 ppb Methyl-tertiary-butyl ether (MTBE).

The former tank basin is covered by asphalt. A new tank basin is located east of Building AS-410. This basin contains three active USTs, which supply gasoline to the facility.

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

Site reconnaissance indicates at least seven potential contamination sources in the area of Building AS-410.

Potential sources (PS) are listed in Table 2.1 and source locations are illustrated in Figure 2.1. Potential sources for Building AS-410 are:

- PS #1 - Subject tank basin previously fitted with six steel 4,000 gallon USTs. The tanks supplied various grades of gasoline to the facility and were removed in July 1992. All associated piping and venting lines are also suspect.
- PS #2 - Former 550 gallon heating oil UST basin.
- PS #3 - Former 285 gallon underground waste oil tank basin.
- PS #4 - Active heating oil above ground storage tank (AST).
- PS #5 - Active waste oil AST.
- PS #6 - Active UST basin for three gasoline storage tanks.
- PS #7 - Active product piping and fuel dispensing equipment associated with PS #6.

A separate investigation is currently underway for the area including potential sources PS #2 through PS #5.

2.3 Release Incident History

The USTs north of Building AS-410 were used to store gasoline for distribution at the facility. Water samples taken from the excavated tank basin at the time of closure revealed the presence of benzene, toluene, ethylbenzene, total xylenes, and MTBE above detection limits.

2.4 *Previous Investigations*

As a follow-up, Groundwater Technology Government Services, Inc. (GSI) conducted a site check to identify and/or verify the suspected hydrocarbon impact in the subsurface soils and ground water. GSI's services, as part of the site check, were to drill three soil borings, install three monitoring wells (AS410N-1 through AS410N-3) into these borings, collect soil and ground water samples for laboratory analysis for petroleum hydrocarbon concentrations, and determine the ground water flow gradient in the vicinity of the tank basin. GSI installed a total of three monitoring wells around the UST basin in March of 1993. The wells were installed to a depth of approximately 20 feet below grade with approximately 15 feet of well screen and five feet of riser. Ground water was measured between approximately four to five feet below land surface (BLS) in the three wells. Total petroleum hydrocarbon (TPH) analysis of three soil samples, one from each soil boring, revealed no detectable concentrations of TPH gasoline, diesel, mineral spirits, kerosene, fuel oil #6, or lubricating oil. The analysis of ground water samples for benzene, toluene, ethylbenzene, and total xylenes (collectively referred to as BTEX) detected maximum concentrations of 6,900 ppb benzene, 2,300 ppb toluene, 1,100 ppb ethylbenzene, and 2,500 ppb total xylenes. No free phase product was noted in any of the wells. Shallow ground water flow was calculated to be to the north. GSI also conducted a three well site check and additional well investigation on the former UST basins south of AS-410. The three well sites checks reportedly revealed no evidence of a release south of AS-410.

2.5 *History of Corrective Actions*

No corrective action has been performed to date other than removal of the six USTs.

3.0 **MIGRATION PATHWAYS AND POTENTIAL RECEPTORS**

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

It is reported that potable water for the area is supplied by two water supply wells, located at distances approximately 100 and 1,300 feet north of Building AS-410. The wells reportedly use water from the Castle Hayne aquifer. Water supply well locations are illustrated in Figure 3.1 and summarized in Table 3.1.

Water supply wells are located through the Auto Cad database for Base Utility Maps, prepared and digitized by W.K. Dixon, Inc. These maps reference information collected from 1940 to 1984. Select information is also

included from data collected between 1984 and 1989. Site changes that have occurred since 1984 may not be noted in the maps provided.

3.2 *Utility Survey* (Refer to Figure 3.2)

Underground and above ground utilities were identified through field observation and information provided by the Camp Lejeune Engineering Office. Utilities are displayed in Figure 3.2, and include the following:

- Sanitary Sewer - Underground sanitary sewer pipes border the property of Building AS-410 along Campbell Street and Bancroft Street. These pipes are located approximately 50 feet and 100 feet respectively, from the former UST basin. The sanitary sewer parallel to Bancroft Street is located among the potential contaminant sources identified in section 2.2, and connects to Building AS-410.
- Water - Underground water mains lie parallel to the sanitary sewer pipes, along Campbell Street and Bancroft Street. The water mains consist of eight inch diameter piping. An additional water main is buried on the opposite side of Campbell Street, downgradient of the impacted area.
- Steam - An underground steam line is located along Bancroft Street, parallel to the water and sanitary sewer lines.
- Storm Drain - Surface drainage is by sheet flow over the paved surfaces to drainage ditches, which empty into a storm water retention pond located to the west.

All of these utilities are located within 100 feet of the former UST basin, and are all reportedly less than eight feet deep.

Utility information is identified through the Auto Cad database for Base Utility Maps, prepared and digitized by W.K. Dixon, Inc. These maps reference information collected from 1940 to 1984. Select information is also included from data collected between 1984 and 1989. Site changes that have occurred since 1984 may not be noted in the maps provided.

Storm drain information is provided from maps prepared in 1993 by Sirrine Environmental Consultants.

3.3 *Potential Receptor Survey*

(Refer to Table 3.1, Figure 3.1, and Figure 3.2)

Potential receptors of contamination, as defined by the NCDEHNR, include surface water bodies, ground water supply wells, and subsurface building structures. The potential receptor survey is conducted within a radius of 1,500 feet of the subject site.

The closest body of surface water is a tributary of Southeast Creek located approximately 1,000 feet to the south of the site.

Two municipal wells were identified within 1,500 feet of the site, at approximately 100 and 1,300 feet north of AS-410.

Underground sanitary sewer, water, and storm drain pipes are located within 100 feet of the contaminated area. The water table in the area was encountered at four to six feet below land surface (BLS). Utility depths intersect the water table; therefore, are susceptible to petrochemical impact.

Buildings in the area appear to be slab-on-grade construction.

3.4 *Exposure Pathway Assessment*

(Refer to Table 3.2)

The following contaminants were identified at this site:

• benzene	• 1,2 dichlorobenzene
• toluene	• 1,3 dichlorobenzene
• total xylenes	• 1,4 dichlorobenzene
• ethylbenzene	• lead

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 considered unlikely in most situations, with the exception of potential ground water contamination in the water supply wells.

4.0 SOILS INVESTIGATION

4.1 *Site Topography*

The project area is dominated by relatively flat topography. The former tank basin is covered with asphalt, surrounded by areas of grass and asphalt. The nearest body of surface water is a tributary of Southeast Creek, which is located approximately 1,000 feet to the south. There is a gentle grade to the north-northwest. A storm water retention pond was identified approximately 100 yards west of the site.

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 comprises a wedge shaped sequence of stratified marine and non-marine sedimentary rocks deposited on crystalline basement. 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. 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 Pee Dee, Black Creek, and upper and lower Cape Fear Formations (Winner, Jr., and Coble, 1989).

Lithological units beneath the area of investigation were identified from a production well drilled in Sneads Ferry, North Carolina (Winner, Jr., and Coble, 1989). These units were identified as follows:

FORMATION	DEPTH IN FEET	DESCRIPTION
Quaternary Surficial Deposits	0-20	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	20-349	Upper level molluscan-mold, limestone, indurated, very sandy. Grades downward into calcareous sand and laterally into the middle level. Middle level 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.

FORMATION	DEPTH IN FEET	DESCRIPTION
Tertiary Beaufort	349-435	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	435-780	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.
Cretaceous Black Creek	780-1,229	Clay, gray to black, lignitic; contains thin beds and laminae of fine-grained micaceous sand and thick lenses of cross-bedded sand. Glauconitic, fossiliferous, clayey sand; sand lenses in upper part.
Cretaceous Cape Fear	1,229-?	Sandstone and sandy mudstone, yellowish-gray to bluish-gray, mottled red to yellowish-orange; indurated, graded, and laterally continuous bedding; blocky clay, faint cross-bedding, feldspar and mica common (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, ten Hydropunch penetrometers (HP-1 through HP-10) were utilized to provide preliminary contamination data so as to assist with the location of the permanent 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 (AS410N-4 through AS410N-15), three Type III (AS410N-16 through AS410N-18) monitoring wells, and one pumping well (AS410N-19). Refer to Figure 4.1 for boring/well locations. Hollow-stem augers were used to advance the soil borings to the appropriate depth.

4.3.2 *Description of Subsurface Samples* (Refer to Appendix B, Figure 4.2, Figure 4.3, and Figure 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 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 depicts aquifer profile A-A' and B-B', respectively. The site is underlain with interfingering and interbedded layers of poorly graded sands, silty sands, clayey sands, and clays to a depth of approximately 28 feet. Underlying the surficial sediments, from approximately 28 to 51 feet, limestone bedrock was encountered. This limestone unit appears to be part of the Castle Hayne Formation. No continuous confining layer was encountered during drilling operations.

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 five feet. The second sample from the Type II and pumping well boreholes was collected within five feet of the water table. The second soil sample from the Type III boreholes was taken at a depth of approximately 20 feet, or within the confining unit (if encountered). Approximately 50% of the first soil samples were

sent to the on-site laboratory and the remainder were sent to the off-site laboratory. Samples selected for on-site laboratory analysis were handled and analyzed in accordance with procedures outlined in Section 6.0.

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 Size and Type	Total Number of Bottles per Sample, On-Site/Off-Site Lab	Preservative
TPH-Methods 5030/3550	Glass Separate Jar Amber Glass Wide Mouth/2 oz.	2/2	<4°C <4°C
Flash Point	Amber Glass Wide Mouth/8 oz.	NA/1	<4°C
TCLP RCRA Metals	Plastic/1,000 ml	NA/1	NR
pH	Glass or Plastic/8 oz.	NA/1	<4°C

*NA = Not Applicable. Analysis not scheduled for on-site laboratory.
NR = Not Required.

4.4.2 Results of Soil Analyses

(Refer to Table 4.1, Table 4.2, Figure 4.5, and Appendix I)

4.4.2.1 Field Screening (Refer to Table 4.1)

Results of the field screening using the OVA are provided in Table 4.1. Organic vapor recordings ranged from less than one to 850 parts per million (ppm).

4.4.2.2 Laboratory Analyses

The following soil extractions/analyses were performed:

- 30 Total Petroleum Hydrocarbon (TPH)-California Methods 5030/3550 (8015);
- 10 pH- EPA Method 9045;
- 10 Ignitability (Flashpoint)- EPA Method 1010;
- 5 TCLP Metals - EPA Method 1311

The first TPH sample collected from each Type II well borehole was obtained from the upper five feet of the vadose zone (two to four foot interval). The second soil sample from each Type II borehole was collected from within five feet of the water table (4.5 to 6.5 foot interval). Table 4.1 denotes the soil samples selected for TPH analyses and the sample depth for each borehole. Flashpoint and pH samples were collected from boreholes at the ten to 12 foot interval. Samples from AS410N-12 through AS410N-14, and AS410N-16 were also analyzed for TCLP RCRA metals. In addition, three soil composite samples, AS410N-SC1 through AS410N-SC3, were analyzed for characterization of waste soils. Composite samples were collected from the roll-off boxes which contained all waste soils generated during the investigation. Samples AS410N-SC1 and AS410N-SC2 were analyzed for TPH-gasoline and TPH-diesel. Sample AS410N-SC3 was analyzed for TCLP RCRA metals.

4.4.2.3

Results of Soil Sampling

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

No detectable concentrations of TPH-gasoline and TPH-diesel contaminants were identified in any of the borings sampled. Table 4.2 summarizes the TPH results. Figure 4.5 illustrates the TPH concentrations for the vadose zone samples taken from two to four feet deep.

Analysis of soil samples for TCLP metals (one from each AS410N-12 through AS410N-14 and AS410N-16) revealed no evidence of leachable metals (See Table 4.2B).

Flashpoint values were all reported at greater than 97°C and pH values ranged from 5.63 to 9.34.

Samples AS410N-SC1 and AS410N-SC2, collected for waste characterization, revealed no detectable TPH-diesel concentrations. Sample AS410N-SC1 reported 78 ppm of TPH-gasoline; sample AS410N-SC2 reported no TPH-gasoline. Sample AS410N-SC3 reported no detectable concentrations of TCLP RCRA metals.

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 hydraulic conductivity 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 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, Appendix E and Appendix F)

Preliminary field measurements (GSI Three Well Site Check) in the vicinity of the former UST basin between wells AS410N-1 through AS410N-3 indicated ground water flow to be toward the north. Ground water was found to range between approximately four to six feet beneath the site. Initial field measurements by RC&A indicated a preliminary flow direction to the east. However, as shown in Figure 5.1, strict interpolation of the ground water table elevations reveals no clear ground water flow direction. Several ground water flow components trending to the south-southeast, northeast, and east are indicated by the contour map. The complexity of the ground water flow direction may be influenced by a large capacity, storm water retention pond located to the west of the site. A hydraulic gradient was calculated from water level measurements between wells AS410N-1 and AS410N-4 and was determined to be less than one percent (0.45%). Ground water measurements and hydraulic gradient calculations are provided in Appendix E and F.

5.3 *Hydropunch Investigation*

(Refer to Figure 4.1, Figure 5.3, and Table 5.4)

Ten Hydropunch penetrometers (HP-1 through HP-10) were installed to provide preliminary 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	6 - 9 feet
HP-4, -5, -6, -7, -8	6 -10 feet
HP-3	7 -10 feet
HP-9	8 -12 feet
HP-2	29-33 feet

Each ground water sample collected from the Hydropunch locations was analyzed for purgeable organics by EPA Method 602. Detectable concentrations of BTEX were reported from HP-1, HP-2, HP-6, and HP-7. Preliminary data suggested a petrochemical impact in the vicinity of the former UST basin and the active UST basin, previously referred to as potential sources PS #1 and PS #6, respectively.

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

No evidence or measurable thickness of free product was identified during the course of this investigation.

5.5 *Ground Water Dissolved Contamination*

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

Prior to the involvement of RC&A, three wells were installed by GSI in the vicinity of the northern former UST basin (AS410N-1 through AS410N-3). As part of a separate site investigation, GSI also installed eight wells (AS410S-1 through AS410S-8) south of AS-410. The AS-410 south wells were not utilized as part of this investigation.

Twelve Type II monitoring wells (AS410N-4 through AS410N-15), three Type III monitoring wells (AS410N-16 through AS410N-18), and one pumping well (AS410N-19) were installed to determine the areal and vertical extents of petrochemical 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 Table 5.1 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 will be disposed of at a permitted, off-site facility.

An average of 22 gallons was removed from the Type II wells during development. An average of 31 gallons was removed from each Type III well, and 25 gallons was removed from the pumping well. All fluids generated during development and sampling activities were composited and a sample was collected for waste characterization purposes. A waste sample (AS410N-WC) was analyzed for purgeable organics per EPA Method 602. Results revealed detectable levels of BTEX.

Laboratory reports are provided in Appendix I.

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 Size and Type	Total Number of Bottles per Sample On-Site/Off-Site Lab	Preservative
EPA 602	Glass Vial/ 40 ml	3/NA	<4°C
Total Lead EPA 239.2	Plastic/500 ml	NA/1	HNO ₃

NA= Not Applicable

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

Organic compound isopleth maps presented as part of this report were contoured by first interpreting an action/no action contour boundary based upon the NCDEHNR action level for the particular contaminant. Hydropunch and monitoring well data was viewed at first qualitatively to establish this contour. The isopleths were subsequently calculated inward from the interpreted contour interval, using Type II monitoring well ground water data only. Hydropunches were not included because of the difference in sampling methodology and variance in Hydropunch/monitoring well sampling results.

As specified in the delivery order, the following analyses were utilized to characterize the ground water dissolved contamination at Building AS-410:

- 29 Purgeable Organics- EPA Method 602
- 10 Total Lead - EPA Method 239.2

Monitoring wells (AS410N-2, AS410N-4 through AS410N-19) were sampled for purgeable organic (EPA Method 602) parameters. Table 5.5A summarizes the results of the purgeable organic compounds identified from ground water samples and compares them to the North Carolina ground water standards. Concentrations of purgeable organic compounds were identified in AS410N-2, AS410N-5, AS410N-8, AS410N-9, AS410N-12, AS410N-13, AS410N-14, AS410N-15, AS410N-16, AS410N-17, AS410N-18, and AS410N-19. Ground water quality standards (NCAC T15A:02L) have been established for the maximum allowable concentrations of specific contaminants. Currently, a maximum of 1 ppb benzene, 1,000 ppb toluene, 29 ppb ethylbenzene, 530 ppb of xylenes, 50 ppb chlorobenzene, 620 ppb 1,3-dichlorobenzene, 75 ppb 1,4-dichlorobenzene, and 620 ppb 1,2-dichlorobenzene are allowed in Class GA waters (ground water). Monitoring wells AS410N-2, AS410N-12, AS410N-16, AS410N-18, and AS410N-19 were noncompliant with respect to the established maximum State concentrations. Well AS410N-12 exceeded the established standards for all parameters. Figures 5.4 through 5.8 illustrate the isoconcentrations of individual BTEX compounds and Total BTEX. As shown, the area of highest petrochemical impact appears to be is the former UST basin and immediate vicinity.

Select wells were also sampled and analyzed for total lead concentrations per EPA Method 239.2. Samples AS410N-8, AS410N-9, AS410N-13, AS410N-14, and AS410N-19 all reported lead concentrations in excess of the NCAC T15A:02L standard of 0.015 ppm. Figure 5.9 presents the total lead concentration data and Table 5.5B summarizes the total lead results and compares them to the NCAC T15A:02L standard. The absence or very low levels of petrochemicals in ground water samples taken from AS410N-8 through AS410N-10, AS410N-13, and AS410N-14 indicates that the lead concentrations are the result of a non-petroleum release or the result of sample turbidity. In addition, the sample taken from AS410N-12, adjacent to the former UST basin revealed no evidence of lead.

Trace concentrations of benzene and toluene were reported from Type III wells, AS410N-16, AS410N-17, and AS410N-18. The only noncompliant concentration reported was benzene (1.6 ppb) from AS410N-16. Based on this data, the vertical extent of contamination has been delineated to a depth of 50 feet. However, due to the trace levels reported, the vertical depth of contamination is believed to be at a more shallow depth.

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 (AS410N-4, AS410N-8 and AS410N-13) which did not contain free product. 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. The recovery data was analyzed by methods presented by Hvorslev (1951). The hydraulic conductivity (K) value was calculated as follows:

$$K = \frac{r^2 \ln(L/R)}{2LT_0}$$

Where:

K = Hydraulic conductivity (ft/day)
 r = Well radius
 L = Sandpack length (ft)
 R = Borehole radius (ft)

T_0 = Time required (time lag) for the recovering water level to be within 37 percent of the static water level.

Hydraulic conductivity (K) values ranged from 25 to 38 feet per day (ft/day). 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 in the delivery order, two soil samples were taken 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 from AS410N-12 (10 to 12 feet) and AS410N-15 (10 to 12 feet). Sample AS410N-12 was described as a fine to medium grained sand (SP). Sample AS410N-15 was described as a fine to medium grained sand with a trace of clay (SP-SC). Comparison to published information revealed a K value of 23.78 ft/day for both samples. Refer to Appendix C for grain size analysis report. Refer to Table 5.2 for aquifer parameter summary.

5.6.3 Eight Hour Pumping Test (Refer to Appendix K)

An eight hour pumping test was performed on well AS410N-19. A short term (30 minutes), step down aquifer test was performed initially to determine expected pumping/discharge rates. This test involved pumping well AS410N-19 at three different levels for approximately 10 minutes each, and recording the flow rate at each level. Gauged flow rates ranged from 1.42 gallons per minute (gpm) at the initial level of 10.82 feet to 1.34 gpm at 15.82 feet. Step down data is included in Appendix K.

Performance of the pumping test revealed influence in the majority of the AS-410 North monitoring wells. Wells AS410N-1 through AS410N-3 and all AS-410 South monitoring wells were excluded from the test. The most significant drawdown (0.38 feet) was measured in AS410N-12, approximately 18 feet east of the pumping well (AS410-19). The second most noticeable effect (0.16 feet) was measured in AS410N-7, 78 feet east of the pumping well. These two wells were used for pumping test calculations. Drawdown was also recorded in each of the Type III wells (AS410N-16, AS410N-17, and AS410N-18), suggesting that there is not a continuous aquitard or

aquiclude in the subsurface less than 50 feet deep. Pumping test drawdown results are presented in Appendix K.

In addition to the slug tests performed on-site, hydraulic conductivity (K) was also calculated from the pumping test data using 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; and,
- (2) The flow is horizontal and uniform everywhere in a vertical section.

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

Where: K = Hydraulic Conductivity (feet/day)

Q = Well Discharge (gallons/day)

h_1 = Head in Well AS410N-12 (feet)

h_2 = Head in Well AS410N-7 (feet)

r_1 = Radius from Pumping Well to Well AS410N-12 (feet)

r_2 = Radius from Pumping Well to Well AS410N-7 (feet)

No aquitard or aquiclude was identified during drilling operations. An aquifer thickness of 19.5 feet (total pumping well depth) was assigned for the purposes of these calculations. Hydraulic conductivity was calculated to be 82.81 feet/day.

A distance-drawdown graph was generated using drawdown levels at the end of the pumping test utilizing AS410N-12 and AS410N-7. This plot generated information required to calculate transmissivity (T) and storage coefficient (S) values. Transmissivity was calculated as follows:

$$T = \frac{528 Q}{\Delta s}$$

Where: T = Transmissivity (gpd/ft)

Q = Well Discharge (gpm)

Δs = Slope of the Distance-Drawdown Graph
Expressed as the Change in Drawdown in feet,
Between Any Two Values of Distance on the
Log Scale Whose Ratio is 10.

Transmissivity was determined to be 2,021 gpd/ft.

The storage coefficient (S) was calculated as follows:

$$S = \frac{0.3Tt}{r_0^2}$$

Where: S = Storage Coefficient (unitless)

T = Transmissivity (gpd/ft)

t = Time Since Pumping Started (in days)

r_0^2 = Intercept of Extended Straight line at Zero Drawdown (ft)

The S value for the surficial aquifer below AS-410 was calculated to be 4.17×10^{-3} . All aquifer characteristics are summarized in Table 5.2, with calculations presented in Appendix K.

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 positive gradients of +0.01 for AS410N-2 and AS410N-18, +0.007 for AS410N-3 and AS410N-16, and +0.004 for AS410N-10 and AS410N-17. The positive gradients indicate a slight downward movement of the ground water.

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

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)

$$dh/dl = \text{Hydraulic gradient (ft/ft)}$$

Initial estimates of hydraulic conductivity were determined from published literature for interpretation of grain size distribution analyses of soil samples and from slug tests. Hydraulic gradients were calculated from water level measurements between wells AS410N-1 and AS410N-4 (0.45%).

For a conservative prediction of ground water velocity, the highest K value determined from the slug tests and grain size analyses was used in the calculations. The highest K value was found to be 38 ft/day from the slug test performed on wells AS410N-8 and AS410N-13 (see Appendix C). Calculation of the maximum ground water velocity was determined to be 7.0×10^{-1} ft/day to the southeast (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 from the purgeable organics (EPA Method 602) compounds 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 benzene was found to be 0.26 ft/day.

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 Rinseate Sample Collection Methodology

A rinseate 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 rinseate 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 rinseate samples detected any contamination, a sample of the source rinseate 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 for both on-site and off-site laboratories. 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 unique identification number that was entered on the COC Record.
- The 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*

The goal of soil remediation is to reduce the levels of soil contamination within the estimated plume to acceptable levels established by the NCDEHNR so as not to be a source for continuing contamination. Ground water has been impacted at the site; therefore the following action levels for TPH concentrations apply: 10 ppm for gasoline; 40 ppm for diesel; and 250 ppm for oil and grease.

No petroleum contaminated (TPH-gasoline and TPH-diesel) soils were identified in the vadose zone during this or previous investigations (GSI).

7.1.2 Preliminary Recommendation for Soil Remediation

No recommendations are presented as there was no evidence of soil contamination.

7.2 Ground Water Remediation

7.2.1 Overview and Objectives of Ground Water Remediation

The objectives of ground water remediation are to contain the contaminant plume and to reduce the dissolved contaminant levels. The site rehabilitation levels are those required by NCAC T15A:02L Water Quality standards. As previously mentioned, purgeable organic compounds were identified in concentrations above the established State standards. These concentrations should be remediated to State acceptable levels or other clean up limits specified by the NCDEHNR.

7.2.2 Preliminary Recommendation for Ground Water Remediation

Three alternatives for plume containment and remediation of ground water within the area of investigation are presented:

1) Comprehensive Site Monitoring and Natural Bioremediation

As presented in the November 10, 1993 NCAC T15A:02L guidance document, subsection .0106, natural remediation can be an acceptable means of remediation for sites where low petrochemical concentrations present minimal threat to potential sensitive receptors. As outlined in the referenced document, a comprehensive plume modeling and fate and transport estimate is required to predict that petrochemicals present in the subsurface will not adversely impact any sensitive receptor. A thorough monitoring plan would be required to assure accurate predictions. The monitoring plan would be conducted until either all compounds are found to degrade to levels within State standards, or until a time at which the State releases the site and LANTDIV from further actions. This option does not require remediation system construction/installation or wastewater discharge expenses. The only project costs incurred would be for site monitoring/sampling and reporting, making this a very economically feasible alternative.

Although this option is economically appealing, the presence of municipal wells in the vicinity (± 100 feet north) greatly increases the sensitivity of the site. A more aggressive remediation approach is recommended.

2) *Horizontal or Vertical Air Sparging/Soil Venting*

Field interpretation of the soils and grain size analyses indicate that the ground water plume is within a permeable sand unit along with interfingering units of silts and silty sands. The sand unit appears to be conducive to this type of remediation. Vertical or horizontal sparging points would be constructed within the ground water plume. Air would be injected through the ground water to vacuum lines located in the vadose zone. The action of the air being forced through the subsurface acts to volatilize trapped hydrocarbons. The hydrocarbons dissolved in the ground water should undergo a phase change to air, travel to the vacuum lines located above, and be discharged to the atmosphere. In addition, the oxygen provided to the subsurface will encourage the growth of micro-organisms and enhance the natural bioremediation process. This remediation method has been proven as an effective contaminant reduction approach. However, it is not known if the subsurface would allow for petrochemical plume containment utilizing sparging methods. Costs associated with the air sparging/soil venting approach would include the system equipment construction/installation, monthly equipment maintenance, operation (energy), and monitoring/reporting.

3) *Ground Water Pump and Treat/Air Sparging*

If the subsurface is found to not be conducive to plume containment through sparging alone, a pump and treat system is proposed for the purposes of hydraulic containment only. Recovery wells should be placed along the north and east plume perimeters, preventing migration towards the municipal wells. Removal of the petrochemicals behind the recovery wells should be accomplished using air sparging techniques.

7.3 *Additional Data Needs for Corrective Action Plan Development*

The petrochemical plume within the vicinity of the AS-410 UST basin has been delineated both horizontally and vertically. Pilot tests for soil venting and in-situ air sparging should be performed to determine the appropriate

corrective action strategies.

7.4 Recommendations

This report fulfills the CSA requirements of Section 280.65 of 40 CFR Part 280, Federal Technical Standards for USTs, and Section .0706 of NCAC T15A:02N North Carolina Criteria and Standards Applicable to USTs. It is recommended that a copy of this report be provided to the NCDEHNR-Wilmington Regional office. Ground water contamination in excess of established State standards was identified through this investigation and previous investigations. It is recommended that a Corrective Action Plan (CAP) be prepared and submitted to the NCDEHNR.

8.0 REFERENCES

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TABLES

TABLE 2.1 CONTAMINANT SOURCE INVENTORY BUILDING AS-410 MARINE CORPS AIR STATION NEW RIVER JACKSONVILLE, NORTH CAROLINA					
POTENTIAL SOURCE #	PRODUCT TYPE	SIZE OF TANK (gal)	TANK TYPE	REMOVAL/ ABANDONMENT DATE	TANK STATUS
1	Gasoline	4,000	UST	July 1992	Removed
	Gasoline	4,000	UST	July 1992	Removed
	Gasoline	4,000	UST	July 1992	Removed
	Gasoline	4,000	UST	July 1992	Removed
	Gasoline	4,000	UST	July 1992	Removed
	Gasoline	4,000	UST	July 1992	Removed
2	Heating Oil	550	UST	July 1992	Removed
3	Waste Oil	285	UST	July 1992	Removed
4	Heating Oil	UNK	AST	NA	Active
5	Waste Oil	UNK	AST	NA	Active
6	Gasoline	UNK	UST	NA	Active
	Gasoline	UNK	UST	NA	Active
	Gasoline	UNK	UST	NA	Active
7	Gasoline	NA	PIPING	NA	Active

Notes:

An additional source (PS #7) consists of active product piping and fuel dispensers associated with PS #6.

NA = Not Applicable

TABLE 3.1 WELL INVENTORY SUMMARY BUILDING AS-410 MARINE CORPS AIR STATION NEW RIVER JACKSONVILLE, NORTH CAROLINA	
APPROXIMATE DISTANCE FROM PROJECT SITE (FT)	WELL USAGE
100	SUPPLY
1300	SUPPLY

TABLE 3.2**SUMMARY OF EXPOSURE PATHWAYS****BUILDING AS-410
MARINE CORPS AIR STATION NEW RIVER
JACKSONVILLE, NORTH CAROLINA**

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

Notes:

- (1) No free product detected on site.
- (2) Potential for exposure if subsurface below one to three feet BLS is disturbed.
- (3) Closest water supply well is located approximately 100 feet north of the subject site.
- (4) Closest body of surface water is located approximately two miles east of the subject site.
- (5) Buildings in vicinity of contaminant plume are slab-on-grade construction.

NA = Not Applicable

TABLE 4.1 (PAGE 1 OF 5)
SUMMARY OF HEADSPACE ANALYSIS

BUILDING AS-410
MARINE CORPS AIR STATION NEW RIVER
JACKSONVILLE, NORTH CAROLINA

SAMPLE I.D.	SAMPLE DEPTH (ft)	OVA READING (ppm)	SAMPLE SELECTED FOR TPH ANALYSIS
AS410N-4	2 - 4	<1	*
AS410N-4	4.5 - 6.5	<1	*
AS410N-4	10 - 12	15	
AS410N-5	2 - 4	<1	*
AS410N-5	4.5 - 6.5	<1	*
AS410N-5	10 - 12	80	
AS410N-6	2 - 4	4	*
AS410N-6	4.5 - 6.5	50	*
AS410N-6	10 - 12	**	
AS410N-7	2 - 4	<1	*
AS410N-7	4.5 - 6.5	<1	*
AS410N-7	10 - 12	**	
AS410N-8	2 - 4	<1	*
AS410N-8	4.5 - 6.5	<1	*
AS410N-8	10 - 12	<1	
AS410N-9	2 - 4	4	*
AS410N-9	4.5 - 6.5	2	*
AS410N-9	10 - 12	20	
AS410N-10	2 - 4	4	*
AS410N-10	4.5 - 6.5	6	*
AS410N-10	10 - 12	<1	

Notes:

OVA zeroed on upgradient ambient air

** Insufficient sample quantity to analyze

TABLE 4.1 (PAGE 2 OF 5)

SUMMARY OF HEADSPACE ANALYSIS

BUILDING AS-410
MARINE CORPS AIR STATION NEW RIVER
JACKSONVILLE, NORTH CAROLINA

SAMPLE I.D.	SAMPLE DEPTH (ft)	OVA READING (ppm)	SAMPLE SELECTED FOR TPH ANALYSIS
AS410N-11	2 - 4	2	*
AS410N-11	4.5 - 6.5	3	*
AS410N-11	10 - 12	3	
AS410N-12	2 - 4	1	*
AS410N-12	4.5 - 6.5	0	*
AS410N-12	10 - 12	50	
AS410N-13	2 - 4	RPO	*
AS410N-13	4.5 - 6.5	RPO	*
AS410N-13	10 - 12	RPO	
AS410N-14	2 - 4	10	*
AS410N-14	4.5 - 6.5	7	*
AS410N-14	10 - 12	0	
AS410N-15	2 - 4	1	*
AS410N-15	4.5 - 6.5	1	*
AS410N-15	10 - 12	1	

Notes:

OVA zeroed on upgradient ambient air

** Insufficient sample quantity to analyze

RPO = Rain Prevented OVA

TABLE 4.1 (PAGE 3 OF 5)

SUMMARY OF HEADSPACE ANALYSIS

BUILDING AS-410
MARINE CORPS AIR STATION NEW RIVER
JACKSONVILLE, NORTH CAROLINA

SAMPLE I.D.	SAMPLE DEPTH (ft)	OVA READING (ppm)	SAMPLE SELECTED FOR TPH ANALYSIS
AS410N-16	2.5 - 5.0	10	
AS410N-16	5.0 - 7.5	3	
AS410N-16	7.5 - 10.0	5	
AS410N-16	10.0 - 12.5	6	*
AS410N-16	12.5 - 15.0	15	
AS410N-16	15.0 - 17.5	600	
AS410N-16	17.5 - 20.0	600	
AS410N-16	20.0 - 22.5	70	
AS410N-16	22.5 - 25.0	700	
AS410N-16	25.0 - 27.5	50	
AS410N-16	27.5 - 30.0	600	
AS410N-16	30.0 - 32.5	70	
AS410N-16	32.5 - 35.0	30	
AS410N-16	35.0 - 37.5	15	
AS410N-16	37.5 - 40.0	8	

Notes:

OVA zeroed on upgradient ambient air

** Insufficient sample quantity to analyze

TABLE 4.1 (PAGE 4 of 5)

SUMMARY OF HEADSPACE ANALYSIS

BUILDING AS-410
MARINE CORPS AIR STATION NEW RIVER
JACKSONVILLE, NORTH CAROLINA

SAMPLE I.D.	SAMPLE DEPTH (ft)	OVA READING (ppm)	SAMPLE SELECTED FOR TPH ANALYSIS
AS410N-17	2.5 - 5.0	5	
AS410N-17	5.0 - 7.5	17	
AS410N-17	7.5 - 10.0	30	
AS410N-17	10.0 - 12.5	20	
AS410N-17	12.5 - 15.0	20	
AS410N-17	15.0 - 17.5	4	
AS410N-17	17.5 - 20.0	2	
AS410N-17	20.0 - 22.5	8	
AS410N-17	22.5 - 25.0	6	
AS410N-17	25.0 - 27.5	15	
AS410N-17	27.5 - 30.0	15	
AS410N-17	30.0 - 32.5	10	
AS410N-17	32.5 - 35.0	8	
AS410N-17	35.0 - 37.5	20	
AS410N-17	37.5 - 40.0	11	

Notes:

OVA zeroed on upgradient ambient air

** Insufficient sample quantity to analyze

TABLE 4.1 (PAGE 5 OF 5)

SUMMARY OF HEADSPACE ANALYSIS

BUILDING AS-410
MARINE CORPS AIR STATION NEW RIVER
JACKSONVILLE, NORTH CAROLINA

SAMPLE I.D.	SAMPLE DEPTH (ft)	OVA READING (ppm)	SAMPLE SELECTED FOR TPH ANALYSIS
AS410N-18	2.5 - 5.0	800	
AS410N-18	5.0 - 7.5	850	
AS410N-18	7.5 - 10.0	400	
AS410N-18	10.0 - 12.5	400	*
AS410N-18	12.5 - 15.0	300	
AS410N-18	15.0 - 17.5	140	
AS410N-18	17.5 - 20.0	240	
AS410N-18	20.0 - 22.5	110	
AS410N-18	22.5 - 25.0	40	
AS410N-18	25.0 - 27.5	120	
AS410N-18	27.5 - 30.0	40	
AS410N-18	30.0 - 32.5	40	
AS410N-18	32.5 - 35.0	20	
AS410N-18	35.0 - 37.5	30	
AS410N-18	37.5 - 40.0	30	

Notes:

OVA zeroed on upgradient ambient air

** Insufficient sample to analyze

TABLE 4.2A (Page 1 of 3)

SUMMARY OF LABORATORY ANALYTICAL RESULTS -- SOIL
TPH, FLASHPOINT, AND pHBUILDING AS-410
MARINE CORPS AIR STATION NEW RIVER
JACKSONVILLE, NORTH CAROLINA

SAMPLE I.D.	SAMPLE DEPTH (ft)	LABORATORY RESULTS			
		TPH- 5030 (mg/Kg)	TPH- 3550 (mg/Kg)	FLASHPOINT (Degree C)	pH
AS410N-4	2 - 4	BDL	BDL	NA	NA
	4.5 - 6.5	BDL	BDL	NA	NA
AS410N-5	2 - 4	BDL	BDL	NA	NA
	4.5 - 6.5	BDL	BDL	NA	NA
AS410N-6	2 - 4	BDL	BDL	NA	NA
	4.5 - 6.5	BDL	BDL	NA	NA
	10 - 12	NA	NA	>97	6.16
AS410N-7	2 - 4	BDL	BDL	NA	NA
	4.5 - 6.5	BDL	BDL	NA	NA
	10 - 12	NA	NA	>97	9.34
AS410N-8	2 - 4	BDL	BDL	NA	NA
	4.5 - 6.5	BDL	BDL	NA	NA
	10 - 12	NA	NA	>97	6.32
AS410N-9	2 - 4	BDL	BDL	NA	NA
	4.5 - 6.5	BDL	BDL	NA	NA
	10 - 12	NA	NA	>97	5.68

NA = Not Analyzed

BDL = Below Detection Limits

BQL = Below Quantitation Limits

TABLE 4.2A (Page 2 of 3)

SUMMARY OF LABORATORY ANALYTICAL RESULTS -- SOIL
TPH, FLASHPOINT, AND pHBUILDING AS-410
MARINE CORPS AIR STATION NEW RIVER
JACKSONVILLE, NORTH CAROLINA

SAMPLE I.D.	SAMPLE DEPTH (ft)	LABORATORY RESULTS			
		TPH- 5030 (mg/Kg)	TPH- 3550 (mg/Kg)	FLASHPOINT (Degree C)	pH
AS410N-10	2 - 4	BDL	BDL	NA	NA
	4.5 - 6.5	BDL	BDL	NA	NA
	10 - 12	NA	NA	>97	8.75
AS410N-11	2 - 4	BDL	BDL	NA	NA
	4.5 - 6.5	BDL	BDL	NA	NA
	10 - 12	NA	NA	>97	6.48
AS410N-12	2 - 4	BDL	BDL	NA	NA
	4.5 - 6.5	BDL	BDL	NA	NA
AS410N-13	2 - 4	BDL	BDL	NA	NA
	4.5 - 6.5	BDL	BDL	NA	NA
AS410N-14	2 - 4	BDL	BDL	NA	NA
	4.5 - 6.5	BDL	BDL	NA	NA
	10 - 12	NA	NA	>97	6.65
AS410N-15	2 - 4	BDL	BDL	NA	NA
	4.5 - 6.5	BDL	BDL	NA	NA
	10 - 12	NA	NA	>97	5.63

NA = Not Analyzed

BDL = Below Detection Limits

BQL = Below Quantitation Limits

TABLE 4.2A (Page 3 of 3)

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

**BUILDING AS-410
MARINE CORPS AIR STATION NEW RIVER
JACKSONVILLE, NORTH CAROLINA**

SAMPLE I.D.	SAMPLE DEPTH (ft)	LABORATORY RESULTS			
		TPH- 5030 (mg/Kg)	TPH- 3550 (mg/Kg)	FLASHPOINT (Degree C)	pH
AS410N-16	10 - 12	NA	NA	>97	6.24
AS410N-18	10 - 12	NA	NA	>97	9.00

NA = Not Analyzed

BDL = Below Detection Limits

BQL = Below Quantitation Limits

**TABLE 4.2B
SUMMARY OF LABORATORY ANALYTICAL RESULTS - SOIL***

TCLP 8 RCRA METALS

**BUILDING AS-410
MARINE CORPS AIR STATION NEW RIVER
JACKSONVILLE, NORTH CAROLINA**

	REGULATORY LEVEL (mg/L)	AS410N-12	AS410N-13	AS410N-14	AS410N-16
DATE SAMPLED		10-27-93	10-26-93	10-27-93	10-28-93
ANALYTE					
Arsenic	5.0	BDL	BQL	BDL	BDL
Barium	100.0	BQL	BQL	BQL	BDL
Cadmium	1.0	BQL	BQL	BQL	BQL
Chromium	5.0	BQL	BDL	BQL	BQL
Lead	5.0	BQL	BQL	BQL	BQL
Mercury	0.2	BQL	BQL	BQL	BQL
Selenium	1.0	BDL	BQL	BDL	BDL
Silver	5.0	BQL	BDL	BQL	BQL

*All results in mg/L (ppm)

BDL = Below Detectable Limit

BQL = Below Quantitation Limit

TABLE 5.1 SUMMARY OF MONITORING WELL DEVELOPMENT BUILDING AS-410N MARINE CORPS AIR STATION NEW RIVER JACKSONVILLE, NORTH CAROLINA		
MCB WELL NO.	FINAL TURBIDITY (SUBJECTIVE)*	APPROXIMATE VOLUME OF WATER REMOVED (GAL.)
AS410N-4	1	20
AS410N-5	1	25
AS410N-6	2	20
AS410N-7	1	25
AS410N-8	1	25
AS410N-9	1	20
AS410N-10	2	13
AS410N-11	1	20
AS410N-12	1	18
AS410N-13	1	30
AS410N-14	1	20
AS410N-15	1	30
AS410N-16	1	33
AS410N-17	1	28
AS410N-18	1	33
AS410N-19	1	25

Notes:

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

TABLE 5.2

SUMMARY OF AQUIFER PARAMETER ESTIMATIONS

BUILDING AS-410
MARINE CORPS AIR STATION NEW RIVER
JACKSONVILLE, NORTH CAROLINA

AQUIFER PARAMETER	OBSERVATION WELL					
	AS410N-4	AS410N-8	AS410N-12	AS410N-13	AS410N-15	General Aquifer Characteristics
I. Transmissivity (T) (gpd/ft) by Distance-Drawdown ⁽¹⁾ Diagram Interpretation	--	--	--	--	--	2,021
II. Storage Coefficient (S) by Distance-Drawdown ⁽¹⁾ Diagram Interpretation	--	--	--	--	--	4.17×10^{-3}
III. Hydraulic Conductivity (K) (ft/day) by:						
a) Dupuit Method ⁽²⁾	--	--	--	--	--	83
b) Slug Tests	25	38	--	38	--	--
c) Grain-Size Analysis	--	--	24	--	24	--

Notes: (1) Distance-drawdown values derived utilizing measurements obtained from monitoring wells AS410N-12 and AS410N-7 at the end of the pumping test.

(2) Aquifer thickness assumed to be 19.5 feet thick (total pumping well depth).

TABLE 5.3

SUMMARY OF VERTICAL HYDRAULIC GRADIENT DETERMINATIONS

BUILDING AS-410
MARINE CORPS AIR STATION NEW RIVER
JACKSONVILLE, NORTH CAROLINA

	WELL PAIR					
	TYPE II	TYPE III	TYPE II	TYPE III	TYPE II	TYPE III
	AS410N-2	AS410N-18	AS410N-3	AS410N-16	AS410N-10	AS410N-17
TOCE (ft.)	118.62	118.70	118.73	118.19	118.90	118.01
Approx. Mid-Screen Depth (ft.)	12.50	47.50	12.50	47.50	9.00	47.50
Approx. Mid-Screen Elevation (ft.)	106.12	71.20	106.23	70.69	109.90	70.51
SWLE (ft.)	113.31	112.94	113.32	113.04	113.21	113.05
Difference in SWLE (ft.)	+0.37		+0.28		+0.16	
Difference in Mid-Screen Elevation (ft.)	34.92		35.54		39.39	
Vertical Gradient	+0.01		+0.007		+0.004	

NOTES:

TOCE = Top of Casing Elevation (100 ft. arbitrarily added for convenience)

SWLE = Static Water Level Elevation

Negative gradient indicates upward movement.

Positive gradient indicates downward movement.

TABLE 5.4 (Page 1 of 2)

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

PURGEABLE ORGANICS - EPA METHOD 602

**BUILDING AS-410
MARINE CORPS AIR STATION NEW RIVER
JACKSONVILLE, NORTH CAROLINA**

	N.C. GROUND WATER STANDARD*	HP-1	HP-2	HP-3	HP-4	RINSE BLANK	HP-1 DUP
DATE SAMPLED		10-18-93	10-21-93	10-18-93	10-20-93	10-21-93	10-18-93
ANALYTE							
Benzene	1	BDL	100	BDL	BDL	BDL	BDL
Toluene	1000	9.2	110	BDL	BDL	BDL	BDL
Chlorobenzene	50	BDL	BDL	BDL	BDL	BDL	BDL
Ethylbenzene	29	BDL	36	BDL	BDL	BDL	BDL
Xylenes	530	BDL	170	BDL	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
Total		9.2	416	BDL	BDL	BDL	BDL

* = All results in ug/L (ppb)

BDL = Below Detectable Limits

BQL = Below Quantitation Limits

Shaded areas indicate noncompliant concentrations

TABLE 5.4 (Page 2 of 2)

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

PURGEABLE ORGANICS - EPA METHOD 602

**BUILDING AS-410
MARINE CORPS AIR STATION NEW RIVER
JACKSONVILLE, NORTH CAROLINA**

	N.C. GROUND WATER STANDARD*	HP-5	HP-6	HP-7	HP-8	HP-9	HP-10
DATE SAMPLED		10-21-93	10-20-93	10-21-93	10-20-93	10-18-93	10-21-93
ANALYTE							
Benzene	1	BDL	BDL	16	BDL	BDL	BDL
Toluene	1000	BDL	1.7	BDL	BDL	BDL	BDL
Chlorobenzene	50	BDL	BDL	BDL	BDL	BDL	BDL
Ethylbenzene	29	BDL	BDL	11	BDL	BQL	BDL
Xylenes	530	BDL	BDL	9.2	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
Total		BDL	1.7	36.2	BDL	BDL/BQL	BDL

* = All results in ug/L (ppb)

BDL = Below Detectable Limits

BQL = Below Quantitation Limits

Shaded areas indicate noncompliant concentrations

TABLE 5.5A (Page 1 of 4)

**SUMMARY OF LABORATORY ANALYTICAL RESULTS*
MONITORING WELL GROUND WATER SAMPLES**

PURGEABLE ORGANICS-EPA METHOD 602

**BUILDING AS-410
MARINE CORPS AIR STATION NEW RIVER
JACKSONVILLE, NORTH CAROLINA**

	N.C. GROUND WATER STANDARD*	AS410N-2	AS410N-4	AS410N-5	AS410N-6
DATE SAMPLED		10-21-93	10-25-93	10-25-93	10-25-93
ANALYTE					
Benzene	1	2000**	BDL	BDL	BDL
Toluene	1000	460	BDL	BDL	BDL
Chlorobenzene	50	1.8	BDL	BDL	BDL
Ethylbenzene	29	1100**	BDL	0.7	BDL
Xylenes	530	950	BDL	3.3	BDL
1,3 Dichlorobenzene	620	BQL	BDL	BDL	BDL
1,4 Dichlorobenzene	75	BQL	BDL	BDL	BDL
1,2 Dichlorobenzene	620	BQL	BDL	BDL	BDL
Total		4511.8	BDL	4.0	BDL

* = All results in ug/L (ppb)

** = Exceeds calibration curve >20%

BDL = Below Detection Limits

BQL = Below Quantitation Limits

Shaded areas indicate noncompliant concentrations.

TABLE 5.5 (Page 2 of 4)

**SUMMARY OF LABORATORY ANALYTICAL RESULTS*
MONITORING WELL GROUND WATER SAMPLES**

PURGEABLE ORGANICS-EPA METHOD 602

**BUILDING AS-410
MARINE CORPS AIR STATION NEW RIVER
JACKSONVILLE, NORTH CAROLINA**

	N.C. GROUND WATER STANDARD*	AS410N-7	AS410N-8	AS410N-9	AS410N-10	AS410N-11	AS410N-12
DATE SAMPLED		10-21-93	11-10-93	11-10-93	11-10-93	11-10-93	11-10-93
ANALYTE							
Benzene	1	BDL	BDL	BQL	BDL	BDL	3700**
Toluene	1000	BDL	1.0	6.9	BDL	BDL	1400
Chlorobenzene	50	BDL	BDL	BQL	BDL	BDL	810
Ethylbenzene	29	BDL	BDL	BQL	BDL	BDL	1500
Xylenes	530	BDL	BDL	8.5	BDL	BDL	3700
1,3 Dichlorobenzene	620	BDL	BDL	BQL	BDL	BDL	810
1,4 Dichlorobenzene	75	BDL	BDL	BQL	BDL	BDL	840
1,2 Dichlorobenzene	620	BDL	BDL	BQL	BDL	BDL	710
Total		BDL	1.0	15.4	BDL	BDL	13470

* - All results in ug/L (ppb)

** = Exceeds calibration curve >20%

BDL = Below Detection Limits

BQL = Below Quantitation Limits

Shaded areas indicate noncompliant concentrations.

TABLE 5.5 (Page 3 of 4)

**SUMMARY OF LABORATORY ANALYTICAL RESULTS*
MONITORING WELL GROUND WATER SAMPLES**

PURGEABLE ORGANICS-EPA METHOD 602

**BUILDING AS-410
MARINE CORPS AIR STATION NEW RIVER
JACKSONVILLE, NORTH CAROLINA**

	N.C. GROUND WATER STANDARD*	AS410N-13	AS410N-14	AS410N-15	AS410N-16	AS410N-17	AS410N-18
DATE SAMPLED		11-10-93	11-10-93	11-10-93	11-16-93	11-16-93	11-16-93
ANALYTE							
Benzene	1	BDL	BDL	BDL	1.6	0.9	BDL
Toluene	1000	1.3	0.5	0.7	BDL	BDL	0.5
Chlorobenzene	50	BDL	BDL	BDL	BDL	BDL	BDL
Ethylbenzene	29	BDL	BDL	BDL	BDL	BDL	BDL
Xylenes	530	BDL	BDL	BDL	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
Total		1.3	0.5	0.7	1.6	0.9	0.5

* = All results in ug/L (ppb)

** = Exceeds calibration curve >20%

BDL = Below Detection Limits

BQL = Below Quantitation Limits

Shaded areas indicate noncompliant concentrations.

TABLE 5.5 (Page 4 of 4)

**SUMMARY OF LABORATORY ANALYTICAL RESULTS*
MONITORING WELL GROUND WATER SAMPLES**

PURGEABLE ORGANICS-EPA METHOD 602

**BUILDING AS-410
MARINE CORPS AIR STATION NEW RIVER
JACKSONVILLE, NORTH CAROLINA**

	N.C. GROUND WATER STANDARD*	AS410N-19	AS410N-19 DUP	TRIP BLANK	RINSE BLANK
DATE SAMPLED		10-09-93	11-10-93	11-10-93	10-21-93
ANALYTE					
Benzene	1	5700**	6100**	BDL	BDL
Toluene	1000	2500**	2600**	BDL	BDL
Chlorobenzene	50	BQL	BQL	BDL	BDL
Ethylbenzene	29	1500**	1500**	BDL	BDL
Xylenes	530	4100**	4300**	BDL	BDL
1,3 Dichlorobenzene	620	BQL	BQL	BDL	BDL
1,4 Dichlorobenzene	75	BQL	BQL	BDL	BDL
1,2 Dichlorobenzene	620	BQL	BQL	BDL	BDL
Total		13800	14500	BDL	BDL

* = All results in ug/L (ppb)

** = Exceeds calibration curve >20%

BDL = Below Detection Limits

BQL = Below Quantitation Limits

Shaded areas indicate noncompliant concentrations.

TABLE 5.5B

**SUMMARY OF LABORATORY ANALYTICAL RESULTS*
MONITORING WELL GROUND WATER SAMPLES
TOTAL LEAD - EPA METHOD 239.2**

**BUILDING AS-410
MARINE CORPS AIR STATION NEW RIVER
JACKSONVILLE, NORTH CAROLINA**

	NC GROUND WATER STANDARDS*	AS410N-8	AS410N-9	AS410N-10	AS410N-11	AS410N-12
DATE SAMPLED		11-10-93	11-10-93	11-10-93	11-10-93	11-10-93
ANALYTE						
Lead	0.015	0.087	0.048	0.047	BQL	BQL

	NC GROUND WATER STANDARDS*	AS410N-13	AS410N-14	AS410N-15	AS410N-16	AS410N-19
DATE SAMPLED		11-10-93	11-10-93	11-10-93	11-16-93	11-10-93
ANALYTE						
Lead	0.015	0.077	0.098	BQL	BQL	0.078

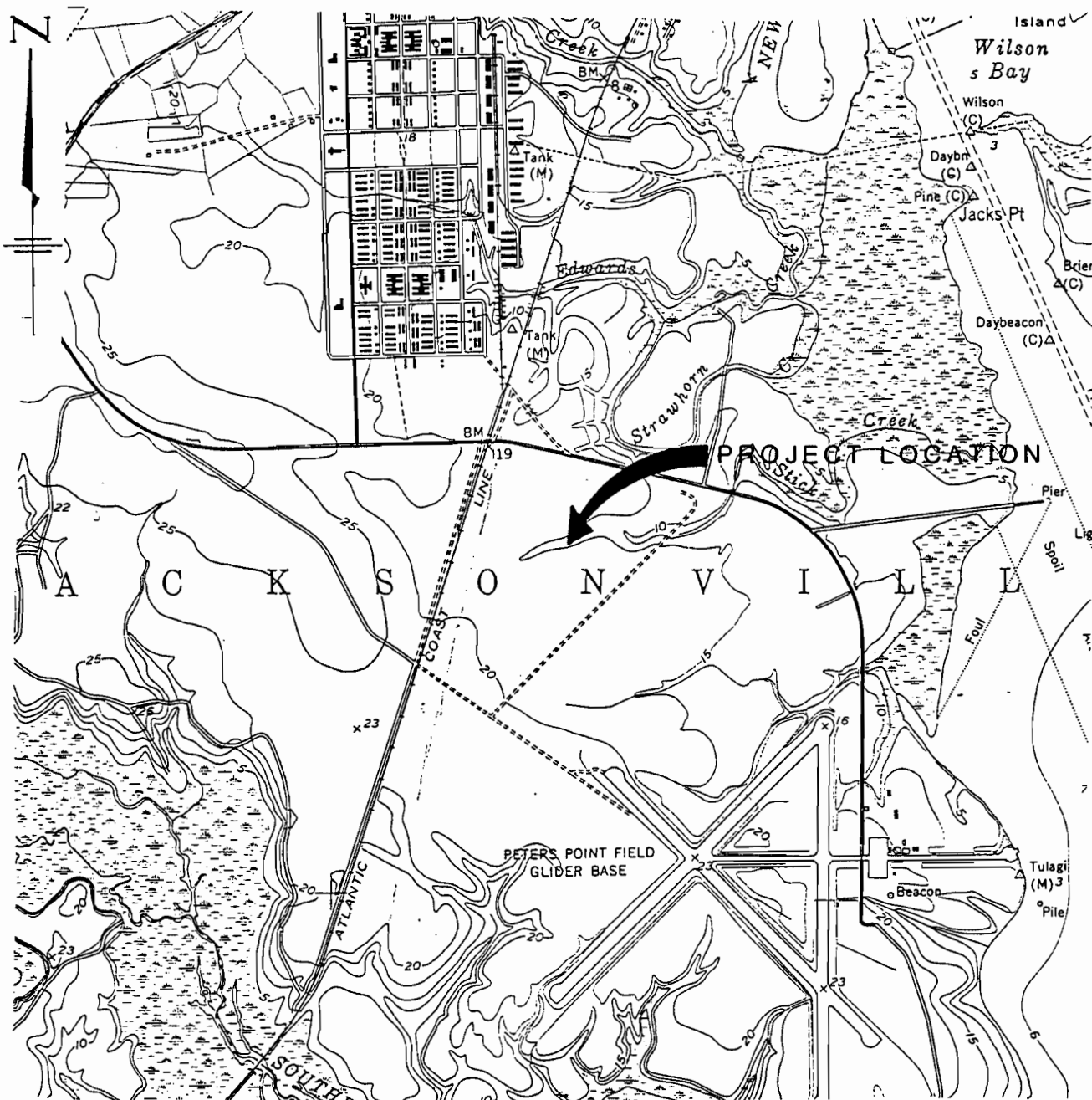
*All results in mg/L (ppm)

BDL = Below Detection Limits

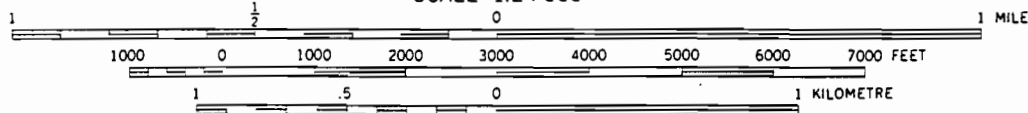
BQL = Below Quantitation Limits

Shaded areas indicate noncompliant concentrations.

FIGURES



SCALE 1:24 000



JACKSONVILLE SOUTH, N. C.

NW/4 NEW RIVER 15' QUADRANGLE
N3437.5—W7722.5/7.5

1952

PHOTOINSPECTED 1971

AMS 5553 III NW—SERIES V 842



QUADRANGLE LOCATION

Richard Catlin & Associates, Inc.
ENVIRONMENTAL ENGINEERS AND HYDROGEOLOGISTS
WILMINGTON, NC CHARLESTON, SC ATLANTA, GA WINSTON-SALEM, NC

PROJECT
BUILDING AS-410
LANTDIV NAVFACENGCOM
MCAS NEW RIVER

TITLE
GENERAL LOCATION
USGS TOPOGRAPHICAL QUADRANGLE

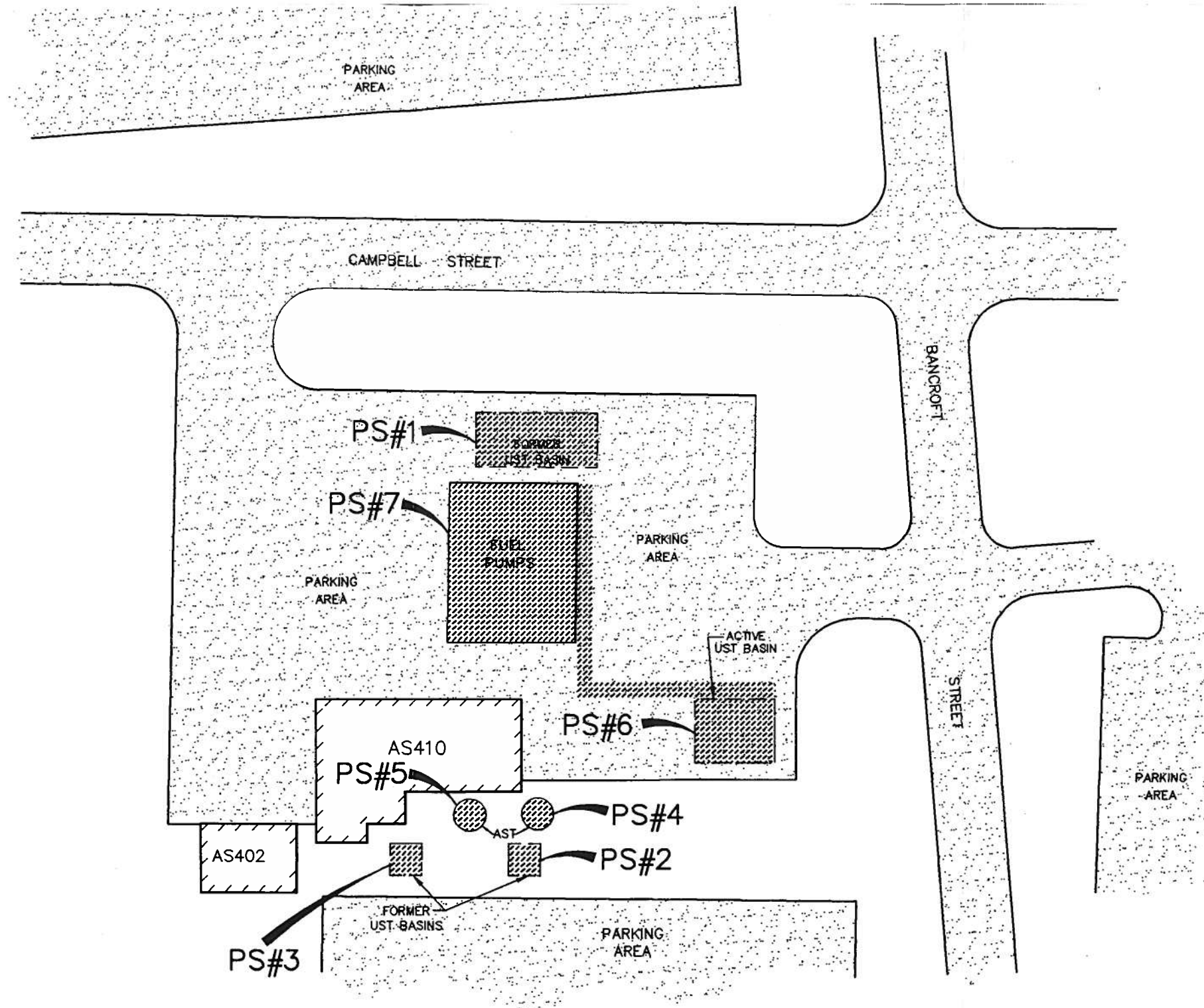
FIGURE

1.1

JOB NO. 93125 DATE JAN. 1995 SCALE AS SHOWN DRAWN BY: WHW CHECKED BY: BW

LEGEND

-  BUILDING
-  POTENTIAL SOURCE



NOTES:

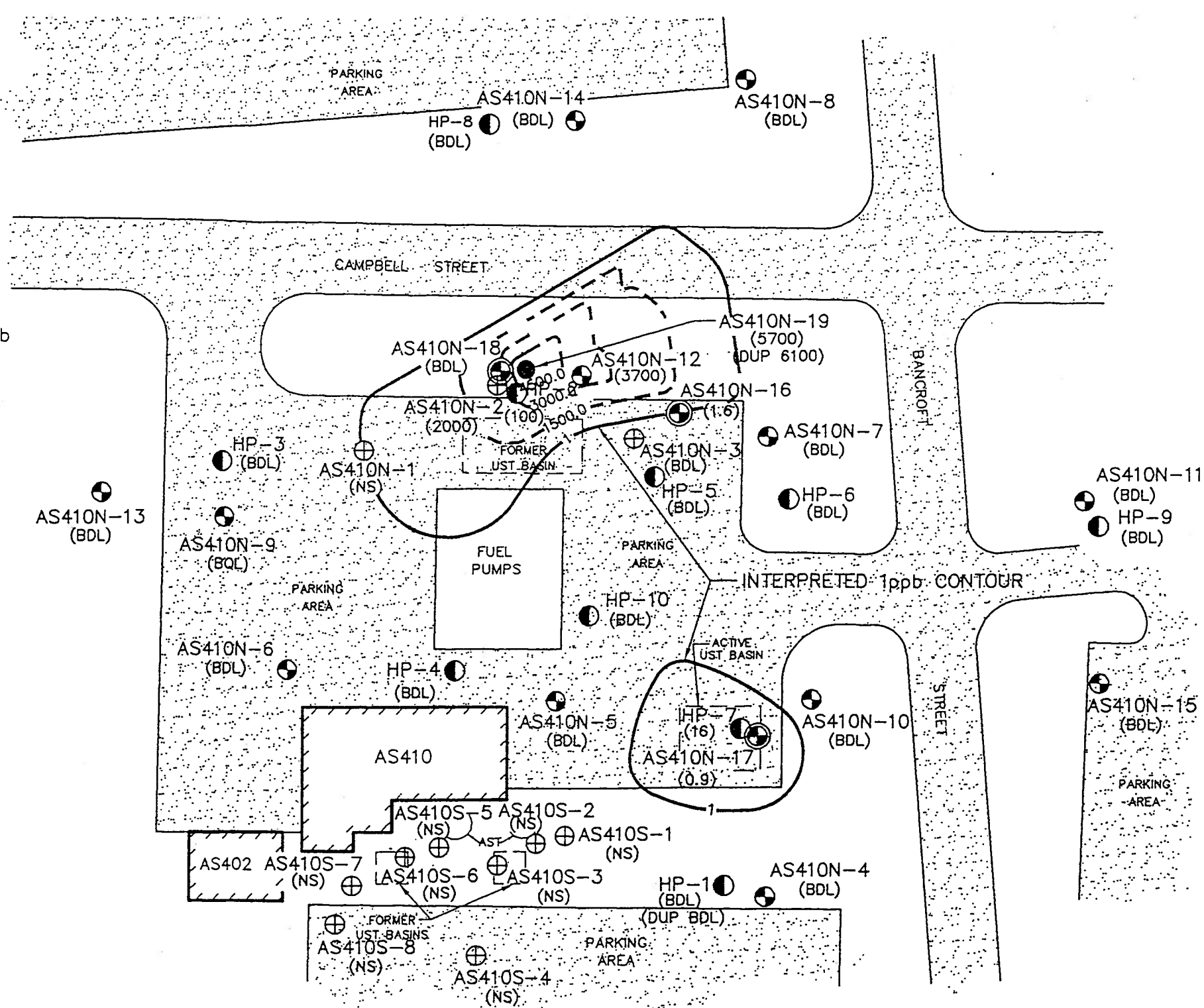
ADAPTED FROM SURVEYED SITE MAP PROVIDED
BY MICHAEL UNDERWOOD & ASSOCIATES, RLS

Richard Catlin & Associates, Inc. ENVIRONMENTAL ENGINEERS AND HYDROGEOLOGISTS WILMINGTON, NC CHARLESTON, SC ATLANTA, GA WINSTON-SALEM, NC	PROJECT BUILDING AS-410 LANTDIV NAVFACENGCOM MCAS NEW RIVER	TITLE CONTAMINANT SOURCE INVENTORY	FIGURE 1.2
JOB NO. 93125-NS	DATE JAN. 1995	SCALE AS SHOWN	DRAWN BY: WW DH SB CHECKED BY: BW

	PRE-EXISTING TYPE II WELL
	TYPE II WELL
	TYPE III WELL
	PUMPING WELL
	HYDROPUNCH

 BUILDING

()	TOTAL BENZENE CONCENTRATIONS IN ppb
BDL	BELOW DETECTABLE LIMITS
BQL	BELOW QUANTATION LIMIT
NS	NOT SAMPLED



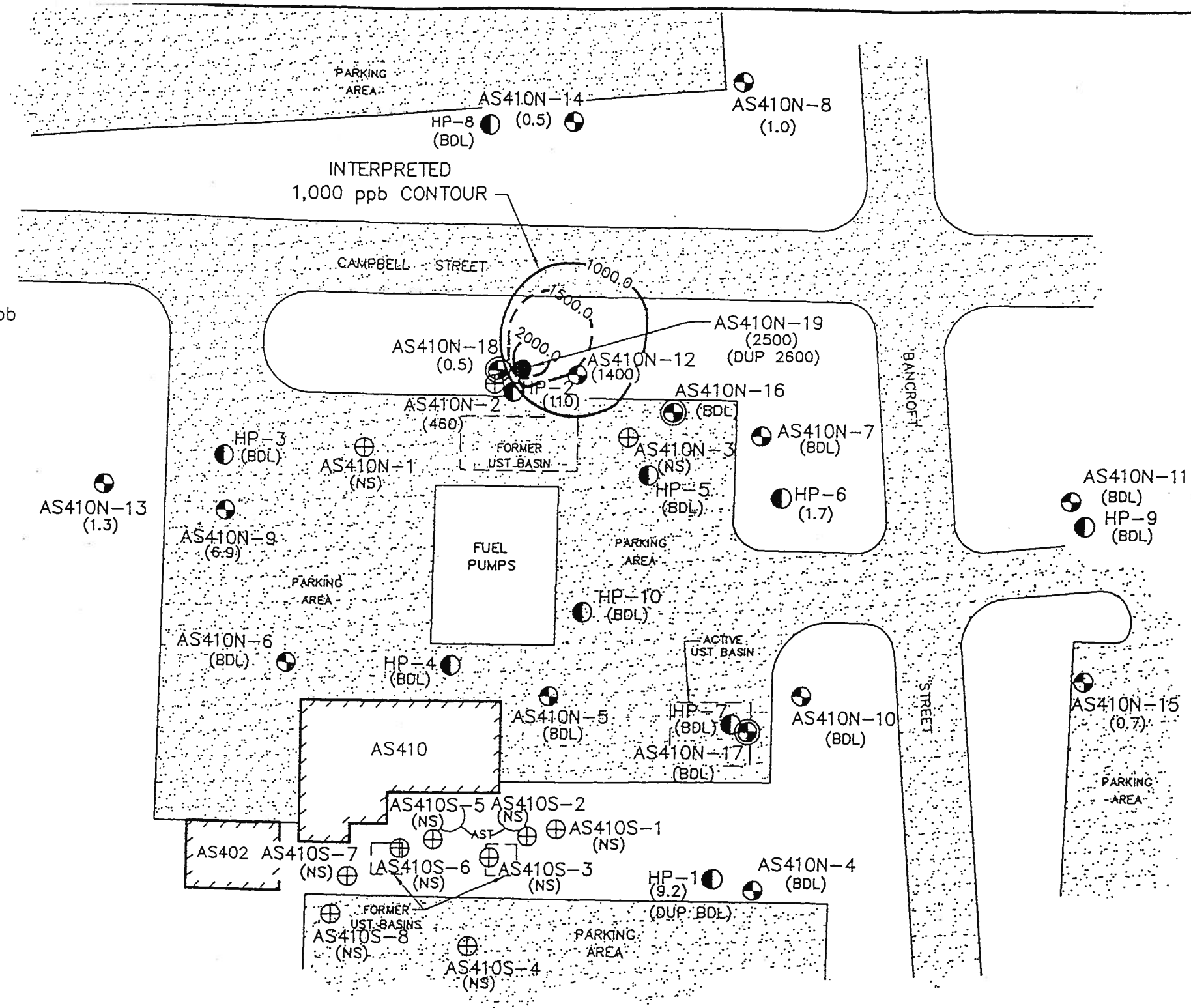
1. ADAPTED FROM SURVEYED SITE MAP PROVIDED BY MICHAEL UNDERWOOD & ASSOCIATES, RLS
2. WHERE DUPLICATE SAMPLES WERE TAKEN, THE HIGHER CONCENTRATION WAS USED FOR CONTOURING.
3. CONTOUR INTERVAL = 1500 ppb



Richard Catlin & Associates, Inc. ENVIRONMENTAL ENGINEERS AND HYDROGEOLOGISTS WILMINGTON, NC CHARLESTON, SC ATLANTA, GA WINSTON-SALEM, NC		PROJECT	TITLE			FIGURE
		BUILDING AS-410 LANTDIV NAVFACENGCOM MCAS NEW RIVER	BENZENE CONCENTRATIONS (WATER) - ISOPLETH MAP			1.3
		JOB NO. 93125-NS	DATE: JAN. 1995	SCALE: AS SHOWN	DRAWN BY: WW DH SB	

LEGEND

- ⊕ PRE-EXISTING TYPE II WELL
- TYPE II WELL
- ⊗ TYPE III WELL
- PUMPING WELL
- HYDROPUNCH
- ▨ BUILDING
- () TOTAL TOLUENE CONCENTRATIONS IN ppb
- NS NOT SAMPLED
- BQL BELOW QUANTITATION LIMITS
- BDL BELOW DETECTABLE LIMITS



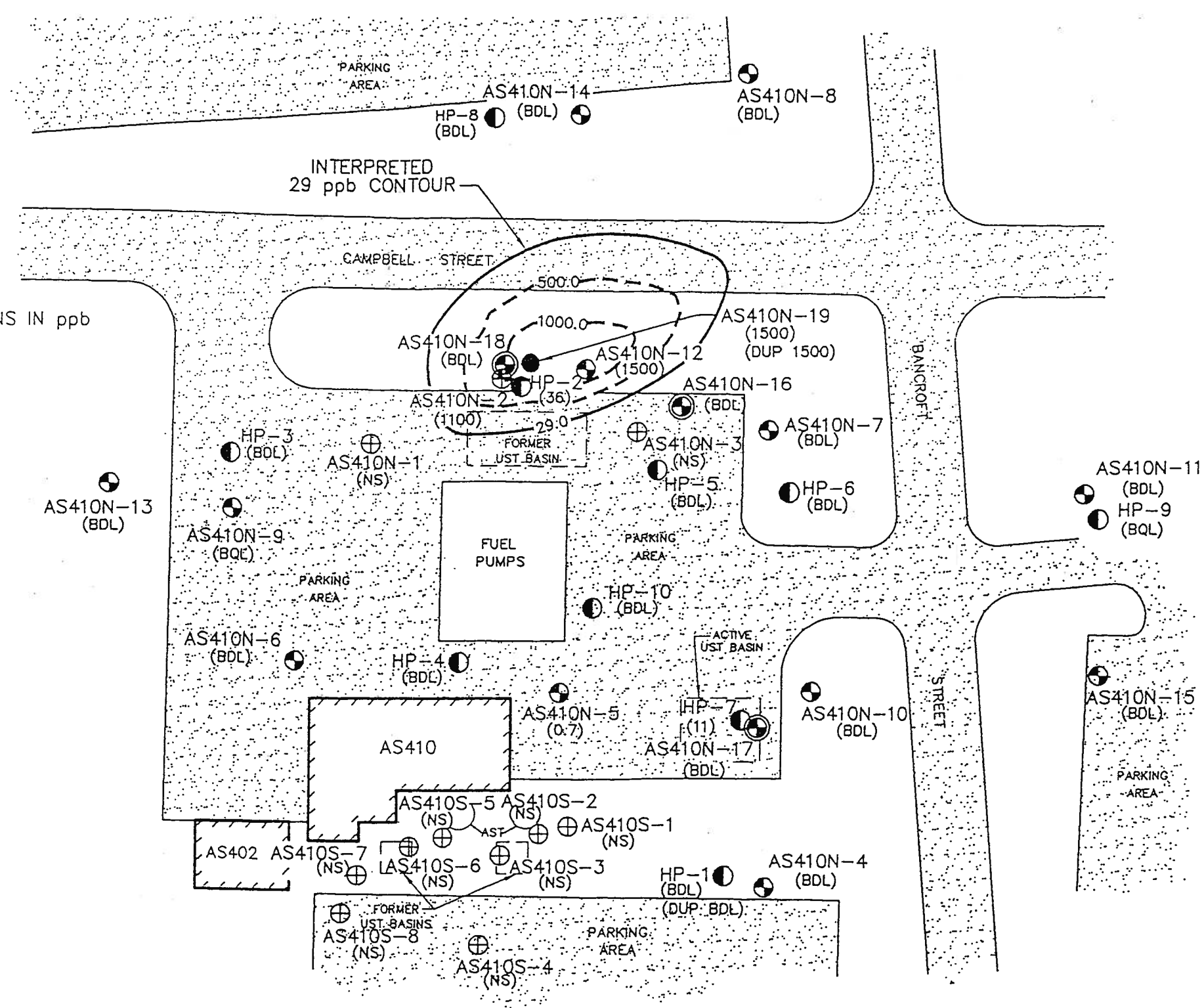
NOTES:

1. ADAPTED FROM SURVEYED SITE MAP PROVIDED BY MICHAEL UNDERWOOD & ASSOCIATES, RLS
2. TYPE III WELLS NOT USED IN CONTOURING
3. CONTOUR INTERVAL = 500 ppb
4. WHERE DUPLICATE SAMPLES WERE TAKEN, THE HIGHEST VALUE WAS USED FOR CONTOURING.

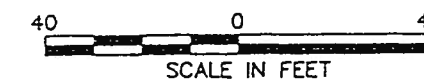
Richard Catlin & Associates, Inc. ENVIRONMENTAL ENGINEERS AND HYDROGEOLOGISTS WILMINGTON, NC CHARLESTON, SC ATLANTA, GA WINSTON-SALEM, NC	PROJECT BUILDING AS-410 LANTDIV NAVFACENGCOM MCAS NEW RIVER JOB NO. 93125-NS DATE JAN. 1995	TITLE TOLUENE CONCENTRATIONS (WATER) ISOPLETH MAP SCALE: AS SHOWN DRAWN BY: WW DH SB CHECKED BY: BW	FIGURE 1.4

	PRE-EXISTING TYPE II WELL
	TYPE II WELL
	TYPE III WELL
	PUMPING WELL
	HYDROPUNCH

()	TOTAL ETHYL BENZENE CONCENTRATIONS IN ppb
BDL	BELOW DETECTABLE LIMITS
BQL	BELOW QUANTITATION LIMITS
NS	NOT SAMPLED



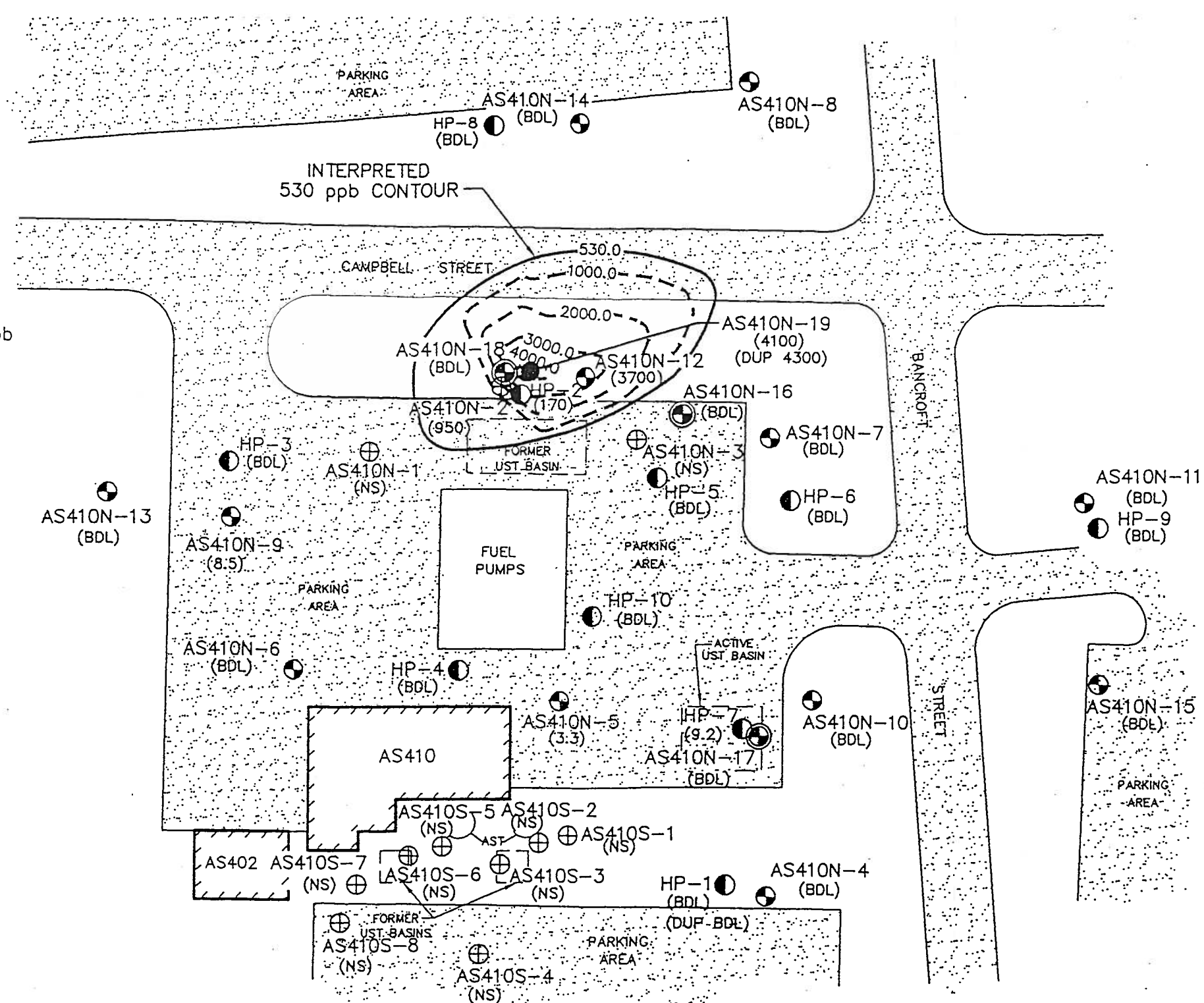
1. ADAPTED FROM SURVEYED SITE MAP PROVIDED BY MICHAEL UNDERWOOD & ASSOCIATES, RLS
2. TYPE III WELLS NOT USED IN CONTOURING
3. CONTOUR INTERVAL = 500 ppb
4. WHERE DUPLICATE SAMPLES WERE TAKEN, THE HIGHEST VALUE WAS USED FOR CONTOURING.



Richard Catlin & Associates, Inc. ENVIRONMENTAL ENGINEERS AND HYDROGEOLOGISTS WILMINGTON, NC CHARLESTON, SC ATLANTA, GA WASHINGTON-SALEM, NC	PROJECT BUILDING AS-410 LANTDIV NAVFACENGCOM MCAS NEW RIVER	TITLE ETHYL BENZENE CONCENTRATIONS (WATER) ISOPLETH MAP	FIGURE
			1.5

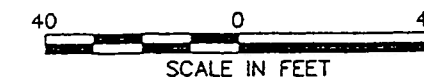
LEGEND

- ⊕ PRE-EXISTING TYPE II WELL
- ⊙ TYPE II WELL
- ⊗ TYPE III WELL
- PUMPING WELL
- ◐ HYDROPUNCH
- ▨ BUILDING
- () TOTAL XYLENES CONCENTRATIONS IN ppb
- NS NOT SAMPLED
- BDL BELOW DETECTABLE LIMITS



NOTES:

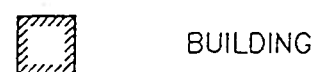
1. ADAPTED FROM SURVEYED SITE MAP PROVIDED BY MICHAEL UNDERWOOD & ASSOCIATES, RLS
2. TYPE III WELLS NOT USED IN CONTOURING
3. CONTOUR INTERVAL = 1,000 ppb
4. WHERE DUPLICATE SAMPLES WERE TAKEN, THE HIGHEST VALUE WAS USED FOR CONTOURING.



Richard Catlin & Associates, Inc. ENVIRONMENTAL ENGINEERS AND HYDROGEOLOGISTS WILMINGTON, NC CHARLESTON, SC ATLANTA, GA WINSTON-SALEM, NC	PROJECT BUILDING AS-410 LANTDIV NAVFACENGCOM MCAS NEW RIVER	TITLE TOTAL XYLENES CONCENTRATIONS (WATER) ISOPLETH MAP	FIGURE 1.6
JOB NO. 93125-NS	DATE JAN. 1995	SCALE AS SHOWN	DRAWN BY: WW DH SB CHECKED BY: BW

LEGEND

- ⊕ PRE-EXISTING TYPE II WELL
- ⊗ TYPE II WELL
- ⊙ TYPE III WELL
- PUMPING WELL

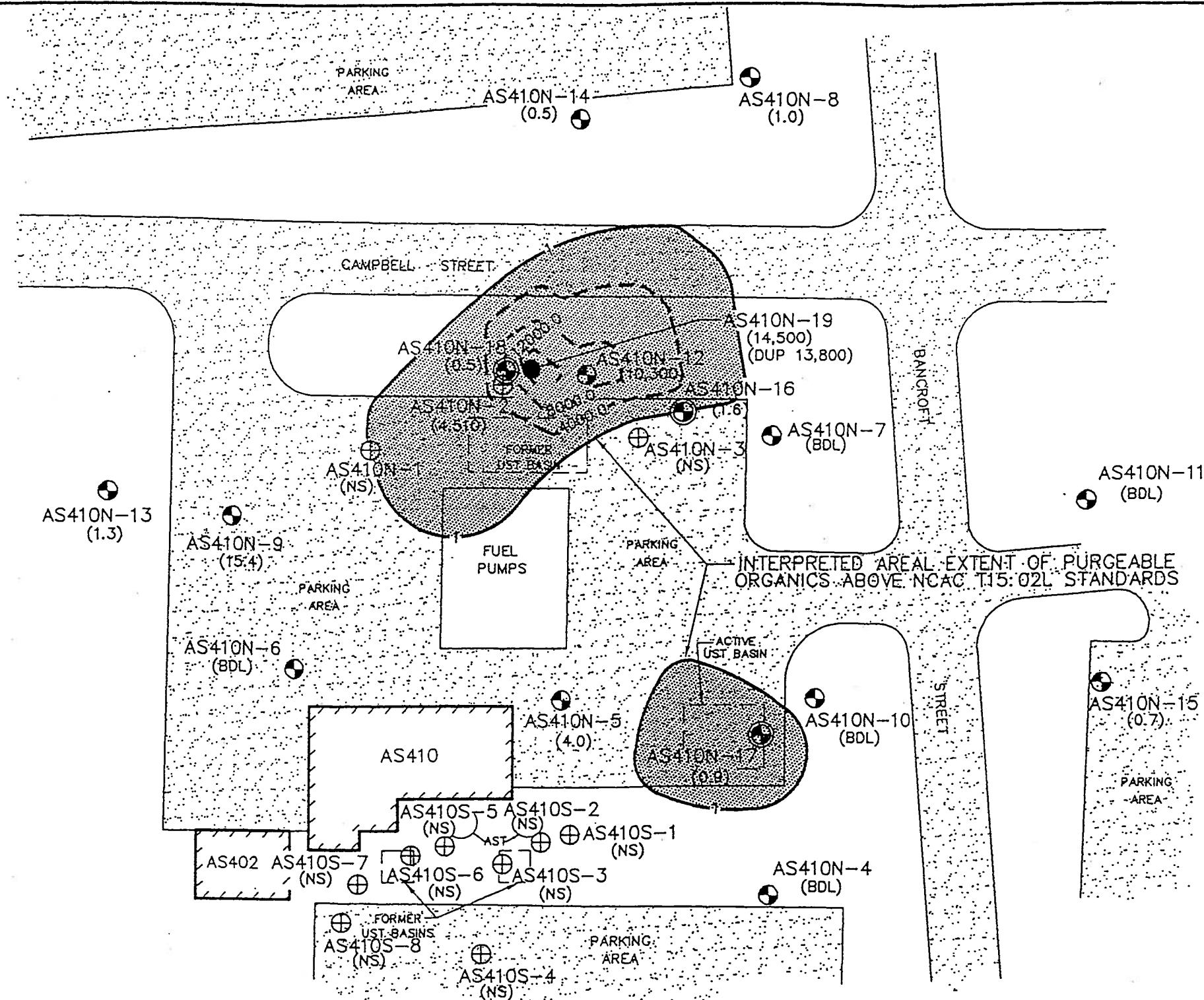


BUILDING

() TOTAL BTEX CONCENTRATIONS IN ppb

NS NOT SAMPLED

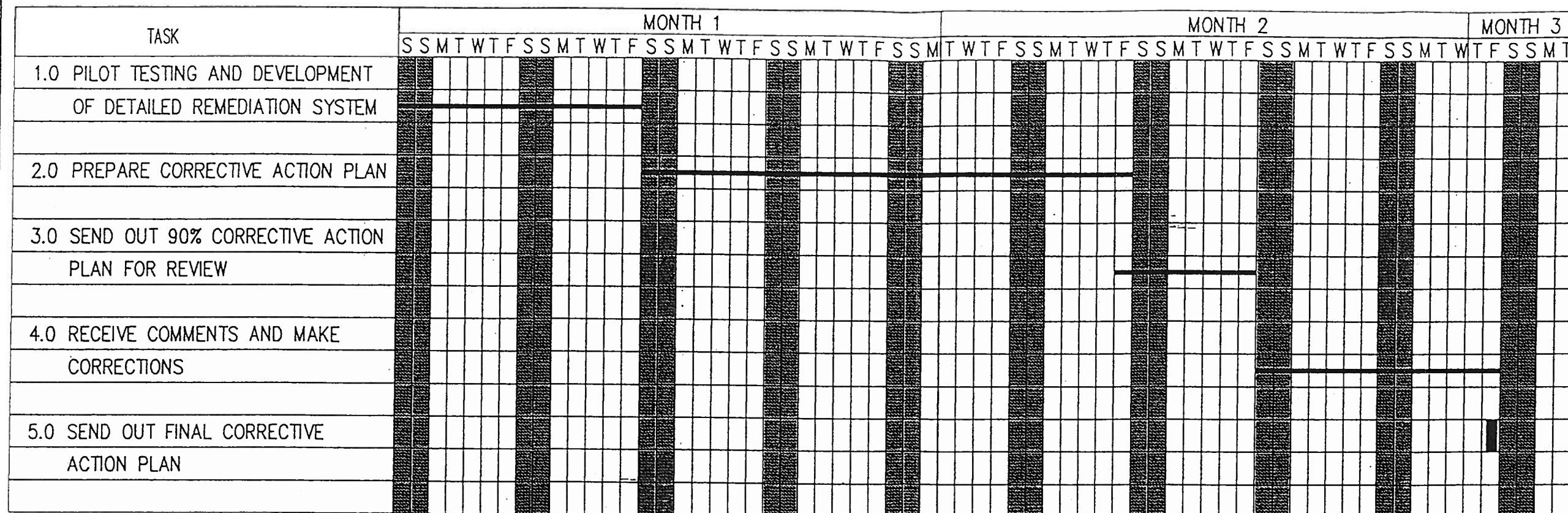
BDL BELOW DETECTABLE LIMITS



NOTES:

1. ADAPTED FROM SURVEYED SITE MAP PROVIDED BY MICHAEL UNDERWOOD & ASSOCIATES, RLS
2. TYPE III WELLS NOT USED IN CONTOURING.
3. CONTOUR INTERVAL = 4,000 ppb
4. WHERE DUPLICATE SAMPLES WERE TAKEN, THE HIGHEST VALUE WAS USED FOR CONTOURING.

Richard Catlin & Associates, Inc. ENVIRONMENTAL ENGINEERS AND HYDROGEOLOGISTS WILMINGTON, NC CHARLESTON, SC ATLANTA, GA WINSTON-SALEM, NC	PROJECT BUILDING AS-410 LANTDIV NAVFACENGCOM MCAS NEW RIVER	TITLE TOTAL BTEX CONCENTRATIONS (WATER) - ISOPLETH MAP	FIGURE 1.7
JOB NO. 93125-NS	DATE: JAN. 1995	SCALE: AS SHOWN	DRAWN BY: WW DH SB CHECKED BY: BW



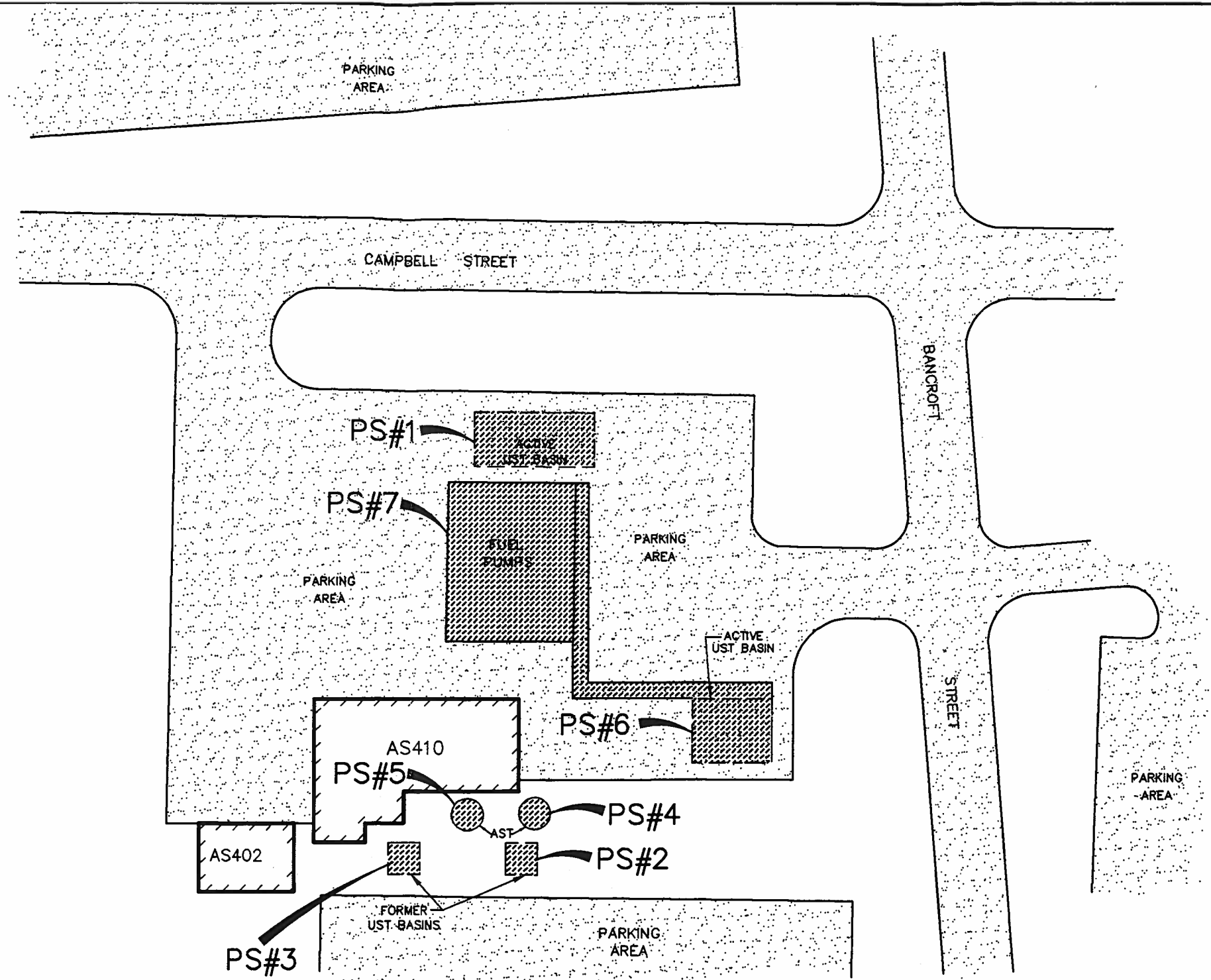
↑
RECEIPT OF STRATEGY LETTER
REVIEW AND COMMENTS

█ DENOTES ACTUAL DAYS EVENT WILL OCCUR
 — DENOTES TIME FRAME WHICH EVENT WILL OCCUR

Richard Catlin & Associates, Inc. ENVIRONMENTAL ENGINEERS AND HYDROGEOLOGISTS WILMINGTON, NC CHARLESTON, SC ATLANTA, GA MOORESVILLE, NC	PROJECT BUILDING AS-410 LANTDIV NAVFACENGCOM MCAS NEW RIVER	TITLE CORRECTIVE ACTION PLAN SCHEDULE		FIGURE 1.8
	JOB NO. 93125-NS DATE JAN 1995	SCALE NTS	DRAWN BY: WHW	CHECKED BY: MEM

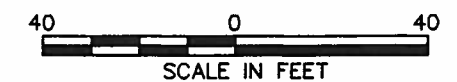
LEGEND

-  BUILDING
-  POTENTIAL SOURCE

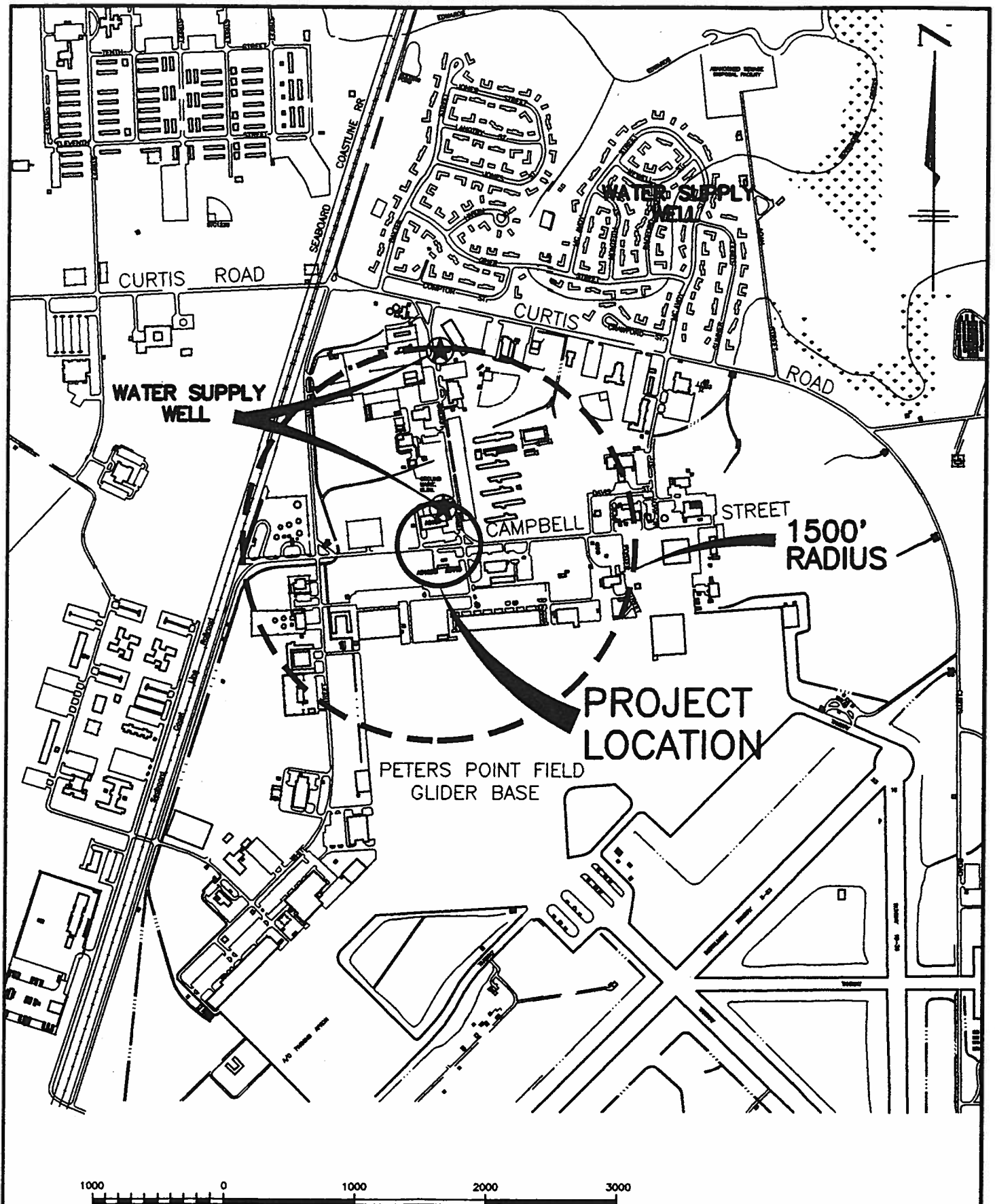


NOTES:

ADAPTED FROM SURVEYED SITE MAP PROVIDED
BY MICHAEL UNDERWOOD & ASSOCIATES, RLS



Richard Catlin & Associates, Inc. ENVIRONMENTAL ENGINEERS AND HYDROGEOLOGISTS WILMINGTON, NC CHARLESTON, SC ATLANTA, GA WINSTON-SALEM, NC	PROJECT BUILDING AS-410 LANTDIV NAVFACENGCOM MCAS NEW RIVER	TITLE CONTAMINANT SOURCE INVENTORY			FIGURE
					2.1
JOB NO. 93125-NS	DATE 14 OCT 93	SCALE AS SHOWN	DRAWN BY: WW DH SB	CHECKED BY: JC	



Richard Catlin & Associates, Inc.
 ENVIRONMENTAL ENGINEERS AND HYDROGEOLOGISTS
 WILMINGTON, NC CHARLESTON, SC ATLANTA, GA WINSTON-SALEM, NC

PROJECT
 BUILDING AS-410
 LANTDIV NAVFACENGCOM
 CAMP LEJEUNE, NC

JOB NO: 93125 DATE: 1 OCT 93

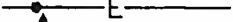
TITLE
 WATER SUPPLY
 WELL LOCATION MAP

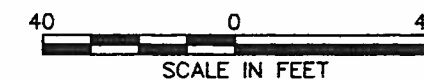
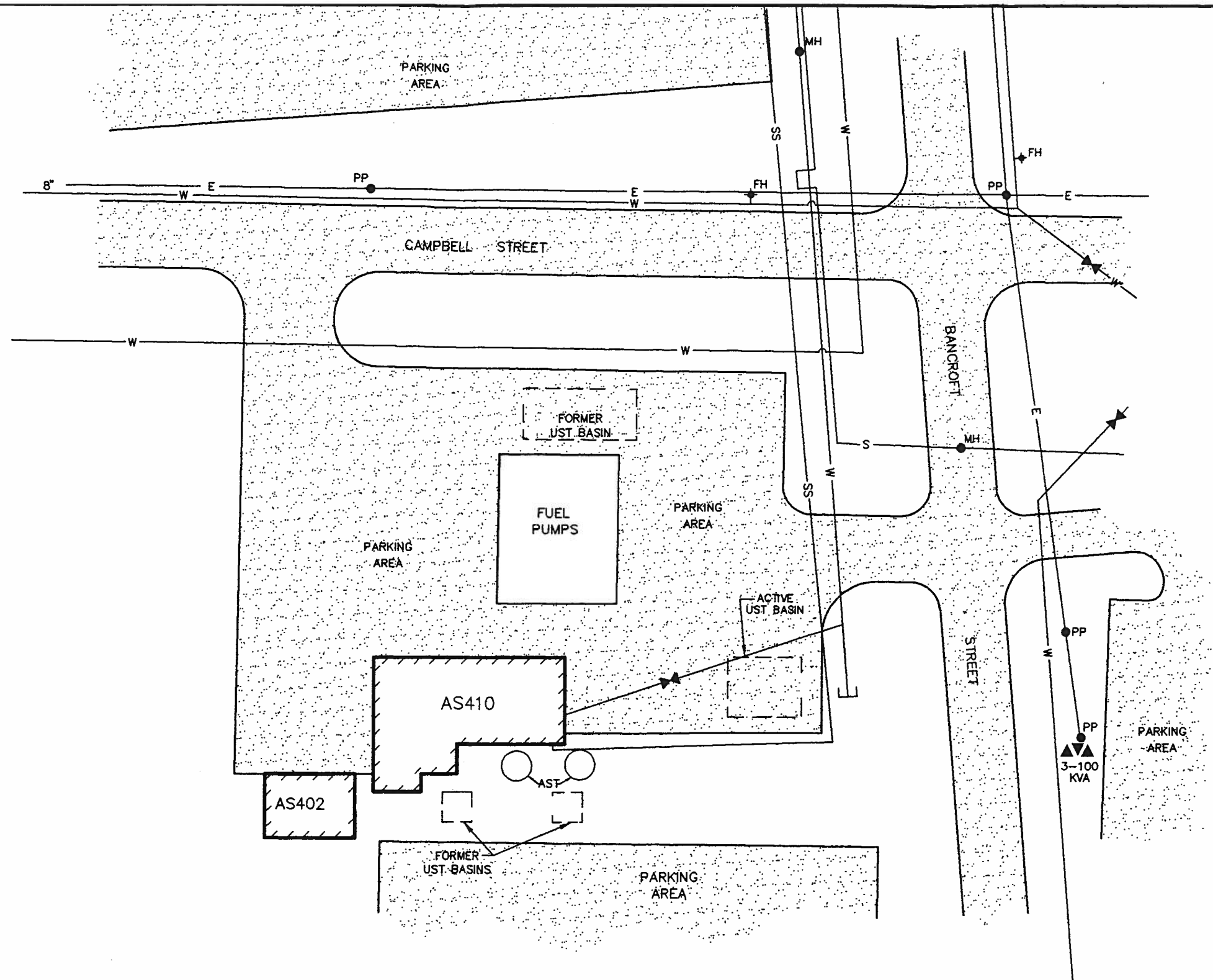
SCALE: AS SHOWN DRAWN BY: WHW CHECKED BY: JC

FIGURE

3.1

LEGEND

-  BUILDING
-  STEAM LINE
-  SANITARY SEWER
-  WATERLINE W/VALVE
-  POWER LINE W/POLE
-  FIRE HYDRANT
-  MANHOLE
-  POWER TRANSFORMER



NOTES:

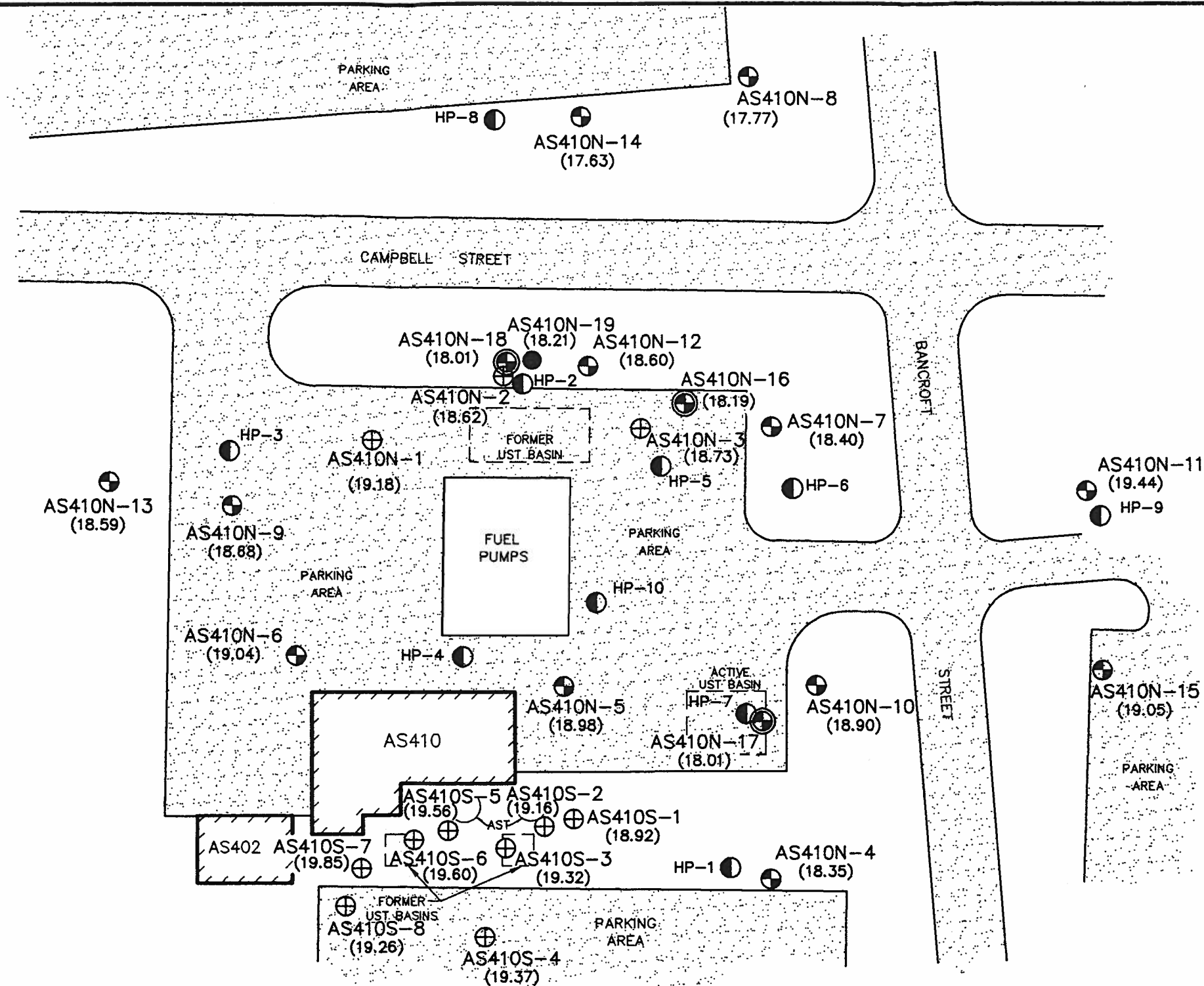
ADAPTED FROM SURVEYED SITE MAP PROVIDED BY MICHAEL UNDERWOOD & ASSOCIATES, RLS

UTILITY LOCATIONS ARE FROM THE AUTOCAD DATABASE FURNISHED BY THE CAMP LEJEUNE ENGINEERING OFFICE. ALL UTILITY LOCATIONS ARE APPROXIMATED AND CURRENT THROUGH 1984. STORM SEWERS ARE FROM MAPS PREPARED BY SIRRINE ENVIRONMENTAL, INC. ARE CURRENT THROUGH 1993.

Richard Catlin & Associates, Inc. ENVIRONMENTAL ENGINEERS AND HYDROGEOLOGISTS WILMINGTON, NC CHARLESTON, SC ATLANTA, GA WINSTON-SALEM, NC	PROJECT BUILDING AS-410 LANTDIV NAVFACENGCOM MCAS NEW RIVER	TITLE SITE UTILITIES LOCATION MAP	FIGURE 3.2
JOB NO. 93125-NS	DATE 14 OCT 93	SCALE AS SHOWN	DRAWN BY: WW DH SB CHECKED BY: JC

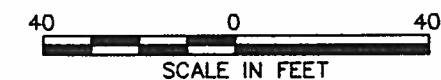
LEGEND

- ⊕ PRE-EXISTING TYPE II WELL
- ⊙ TYPE II WELL
- ⊗ TYPE III WELL
- PUMPING WELL
- ◐ HYDROPUNCH
- ▨ BUILDING
- () TOP OF CASING ELEVATION



NOTES:

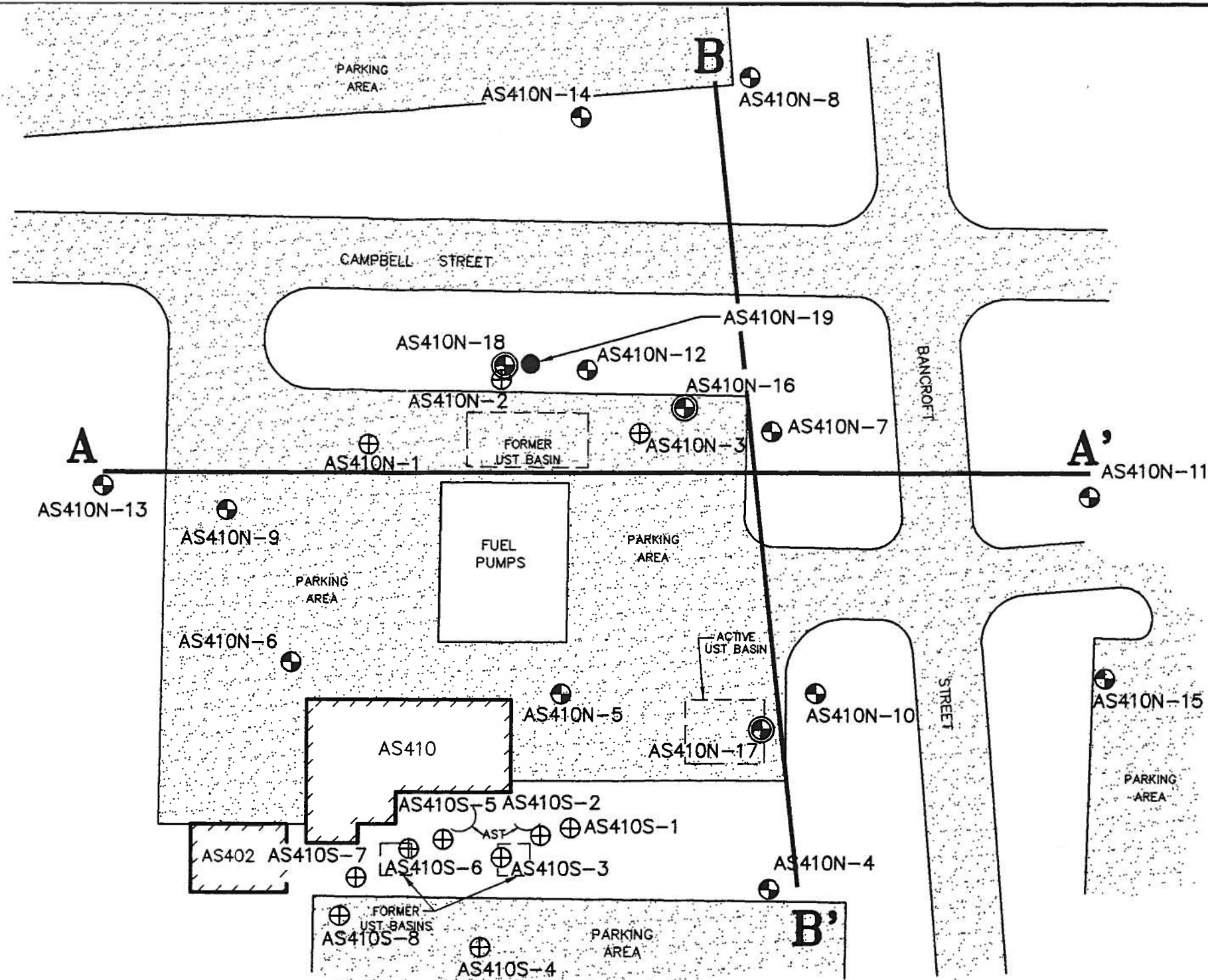
ADAPTED FROM SURVEYED SITE MAP PROVIDED BY MICHAEL UNDERWOOD & ASSOCIATES, RLS



Richard Catlin & Associates, Inc. ENVIRONMENTAL ENGINEERS AND HYDROGEOLOGISTS WILMINGTON, NC CHARLESTON, SC ATLANTA, GA WINSTON-SALEM, NC	PROJECT BUILDING AS-410 LANTDIV NAVFACENGCOM MCAS NEW RIVER	TITLE BORING, MONITORING WELL, AND HYDROPUNCH LOCATION PLAN	FIGURE 4.1
JOB NO. 93125-NS	DATE: 14 OCT 93	SCALE: AS SHOWN	DRAWN BY: WW DH SB
		CHECKED BY: JC	

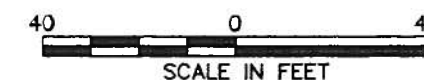
LEGEND

- ⊕ PRE-EXISTING TYPE II WELL
- ⊙ TYPE II WELL
- ⊗ TYPE III WELL
- PUMPING WELL
- ▣ BUILDING

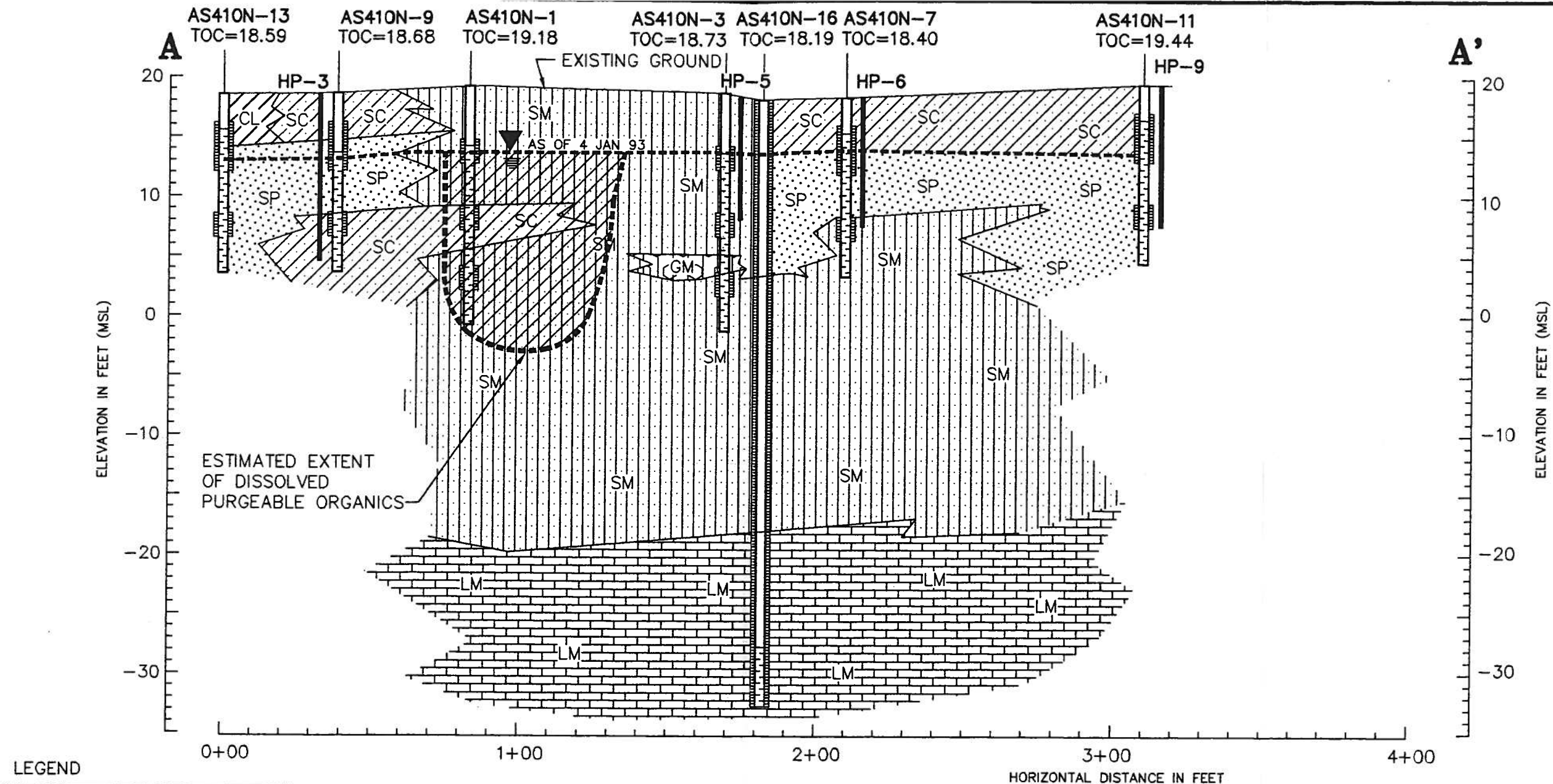


NOTES:

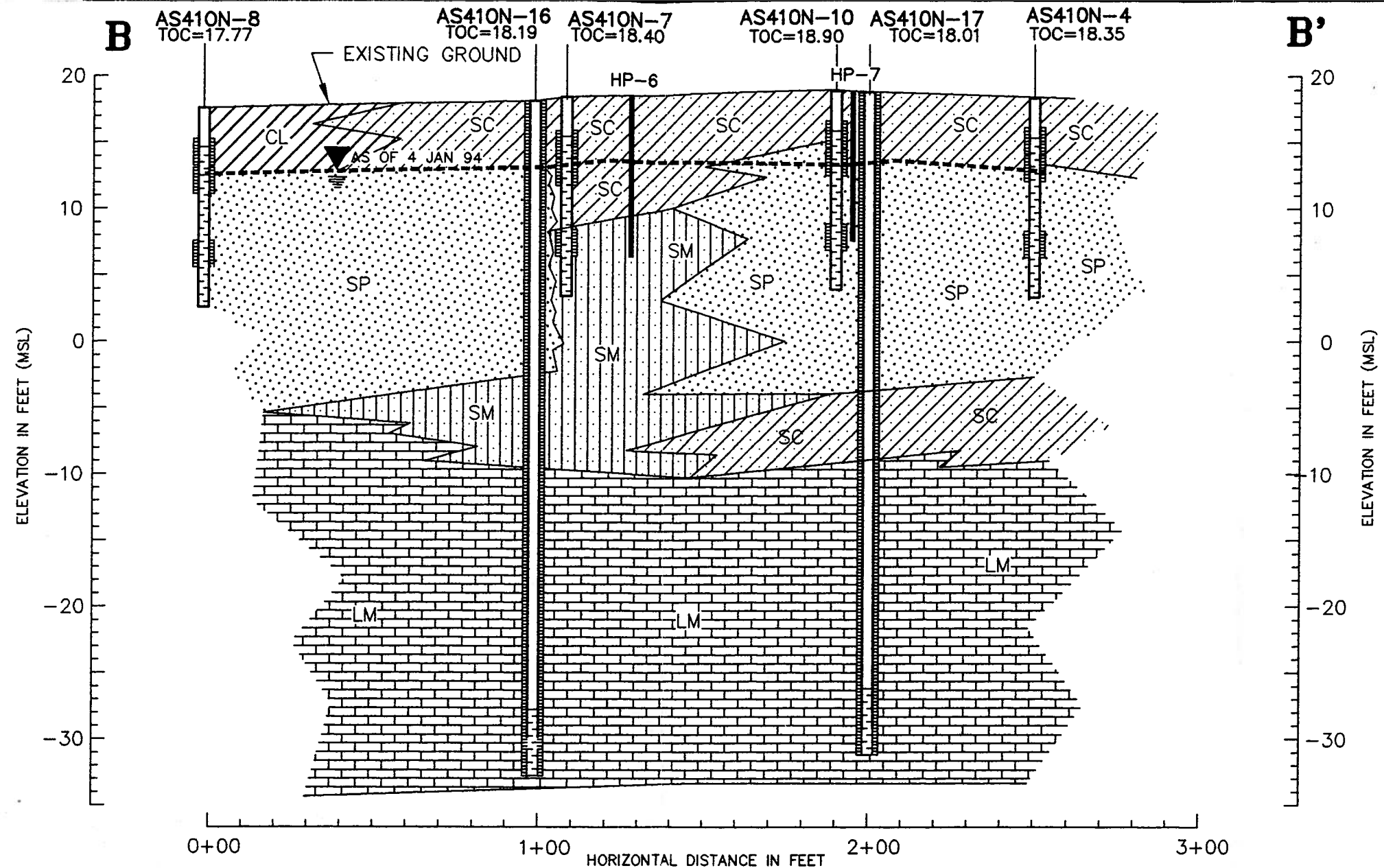
ADAPTED FROM SURVEYED SITE MAP PROVIDED
BY MICHAEL UNDERWOOD & ASSOCIATES, RLS



Richard Catlin & Associates, Inc. ENVIRONMENTAL ENGINEERS AND HYDROGEOLOGISTS WILMINGTON, NC CHARLESTON, SC ATLANTA, GA WINSTON-SALEM, NC	PROJECT BUILDING AS-410 LANTDIV NAVFACENGCOM MCAS NEW RIVER	TITLE CROSS SECTION -- PLAN VIEW	FIGURE 4.2
JOB NO. 93125-NS	DATE 14 OCT 93	SCALE AS SHOWN	DRAWN BY: WW DH SB CHECKED BY: JC



Richard Catlin & Associates, Inc. ENVIRONMENTAL ENGINEERS AND HYDROGEOLOGISTS WILMINGTON, NC CHARLESTON, SC ATLANTA, GA WINSTON-SALEM, NC	PROJECT BUILDING AS-410 LANTDIV NAVFACENGCOM MCAS NEW RIVER	TITLE CROSS SECTION A - A'		FIGURE 4.3
JOB NO. 93125	DATE 14 OCT 93	SCALE AS SHOWN	DRAWN BY: SWB	CHECKED BY: JC



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

WATER TABLE

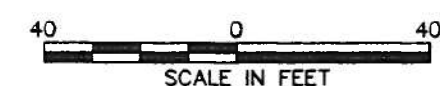
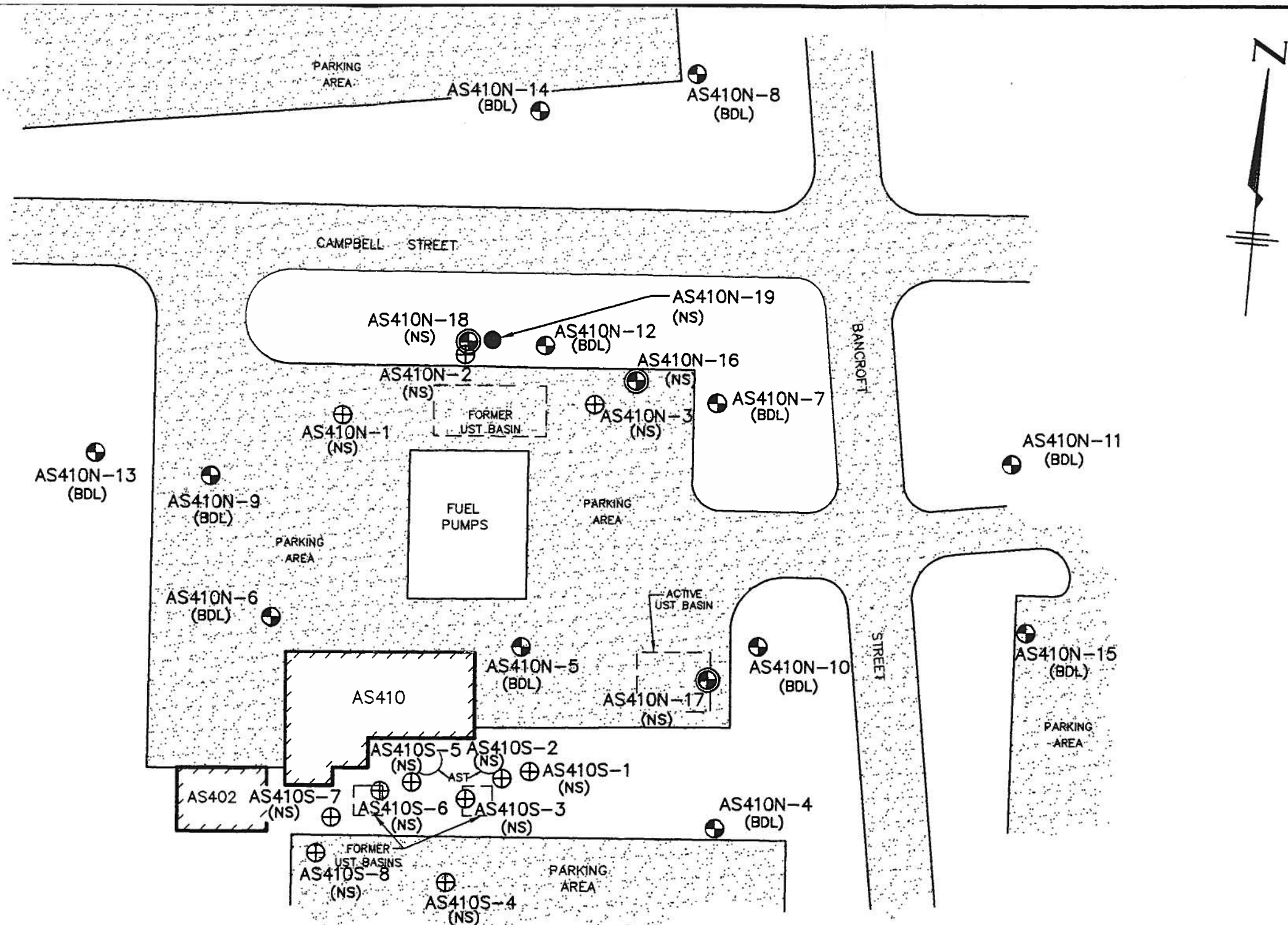
TOC TOP OF CASING

SOIL SAMPLE INTERVAL

Richard Catlin & Associates, Inc. ENVIRONMENTAL ENGINEERS AND HYDROGEOLOGISTS WILMINGTON, NC CHARLESTON, SC ATLANTA, GA WINSTON-SALEM, NC	PROJECT BUILDING AS-410 LANTDIV NAVFACENGCOM MCAS NEW RIVER	TITLE CROSS SECTION B - B'		FIGURE 4.4
	JOB NO. 93125	DATE: 14 OCT 93	SCALE: AS SHOWN	DRAWN BY: SWB

LEGEND

- ⊕ PRE-EXISTING TYPE II WELL
- ⊙ TYPE II WELL
- ⊗ TYPE III WELL
- PUMPING WELL
- ▣ BUILDING
- () TPH CONCENTRATIONS IN ppm
- NS NOT SAMPLED

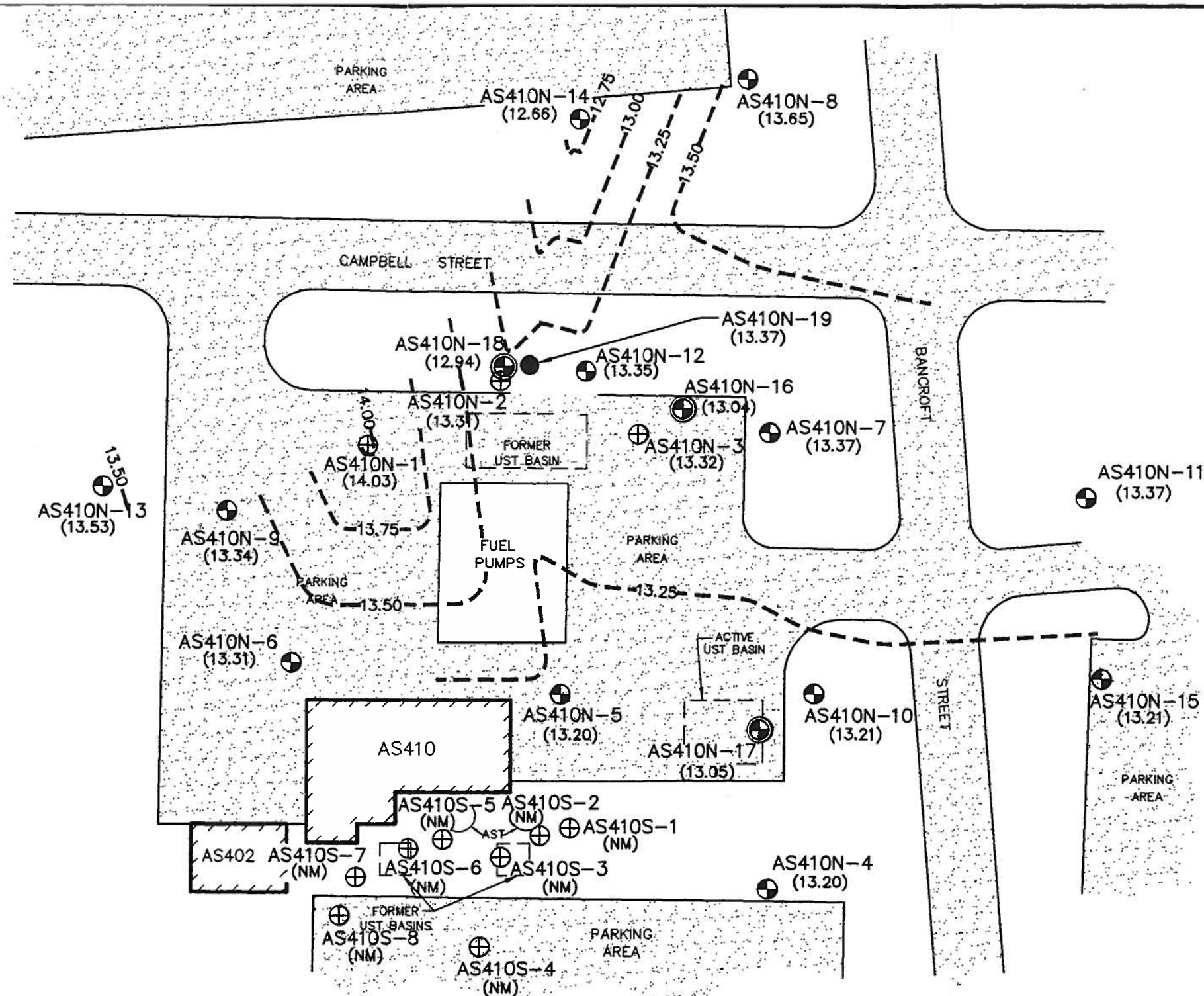


- NOTES:
- ADAPTED FROM SURVEYED SITE MAP PROVIDED BY MICHAEL UNDERWOOD & ASSOCIATES, RLS
 - SAMPLES OBTAINED FROM 2-4 FEET DEEP.

Richard Catlin & Associates, Inc. ENVIRONMENTAL ENGINEERS AND HYDROGEOLOGISTS WILMINGTON, NC CHARLESTON, SC ATLANTA, GA WINSTON-SALEM, NC		PROJECT BUILDING AS-410 LANTDIV NAVFACENGCOM MCAS NEW RIVER		TITLE TPH CONCENTRATIONS (SOIL) - ISOPLETH MAP			FIGURE
							4.5
		JOB NO. 93125-NS	DATE: 14 OCT 93	SCALE: AS SHOWN	DRAWN BY: WW DH SB	CHECKED BY: JC	

LEGEND

- ⊕ PRE-EXISTING TYPE II WELL
- ⊙ TYPE II WELL
- ⊗ TYPE III WELL
- PUMPING WELL
- ▨ BUILDING
- () GROUND WATER TABLE ELEVATION AS OF 4 JAN 94
- NM NOT MEASURED



NOTES:

- ADAPTED FROM SURVEYED SITE MAP PROVIDED BY MICHAEL UNDERWOOD & ASSOCIATES, RLS
- GROUND WATER TABLE ELEVATIONS RELATIVE TO MEAN SEA LEVEL
- TYPE III WELLS NOT CONSIDERED IN CONTOURING



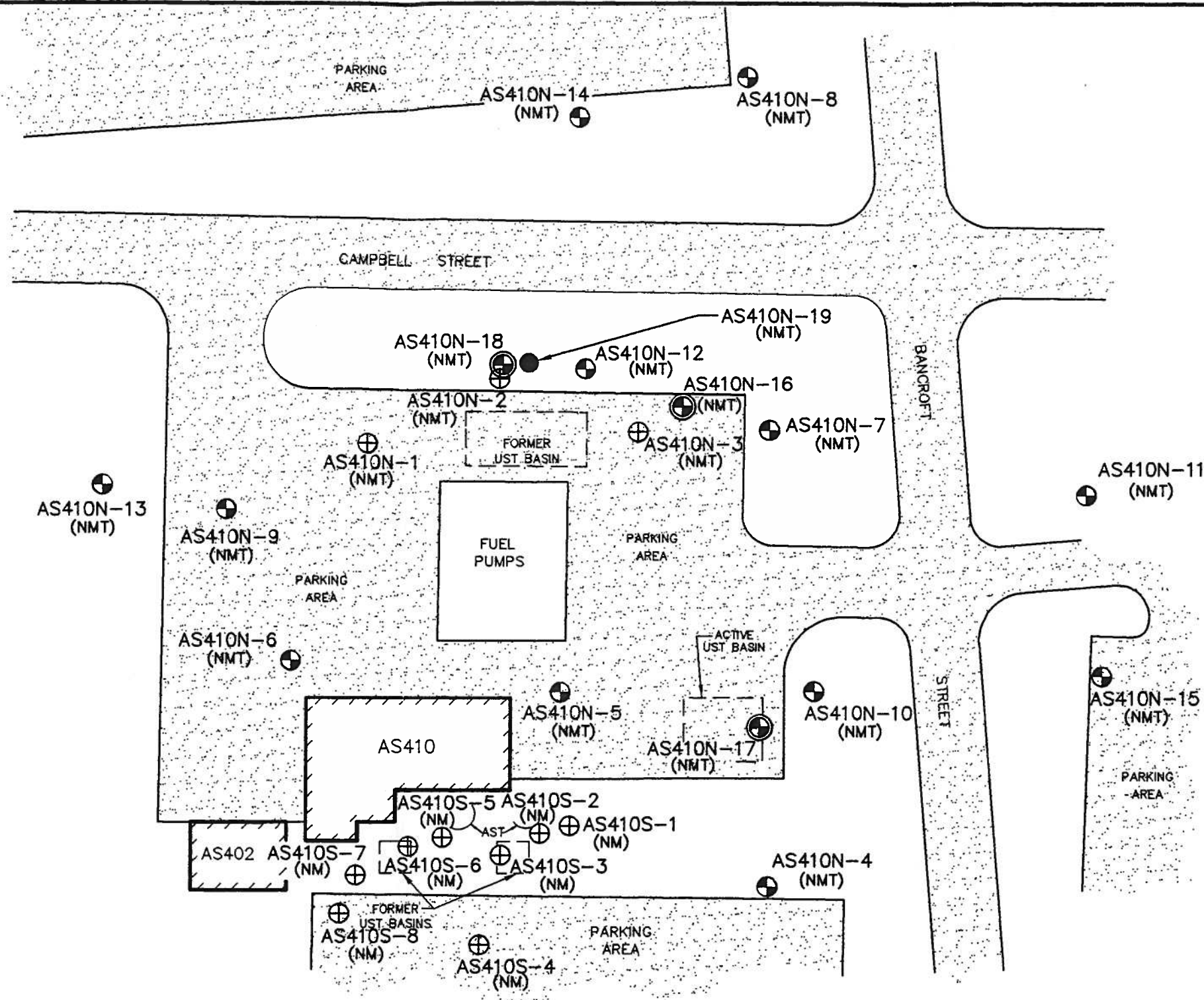
Richard Catlin & Associates, Inc. ENVIRONMENTAL ENGINEERS AND HYDROGEOLOGISTS WILMINGTON, NC CHARLESTON, SC ATLANTA, GA WINSTON-SALEM, NC	BC&A	PROJECT	TITLE	FIGURE
		BUILDING AS-410 LANTDIV NAVFACENGCOM MCAS NEW RIVER	WATER TABLE CONTOUR MAP	5.1
		JOB NO. 93125-NS	DATE 14 OCT 93	SCALE: AS SHOWN

LEGEND

- ⊕ PRE-EXISTING TYPE II WELL
- ⊗ TYPE II WELL
- ⊕ TYPE III WELL
- PUMPING WELL

▨ BUILDING

- () FREE PRODUCT THICKNESS
- NMT NO MEASUREABLE THICKNESS
- NM NOT MEASURED



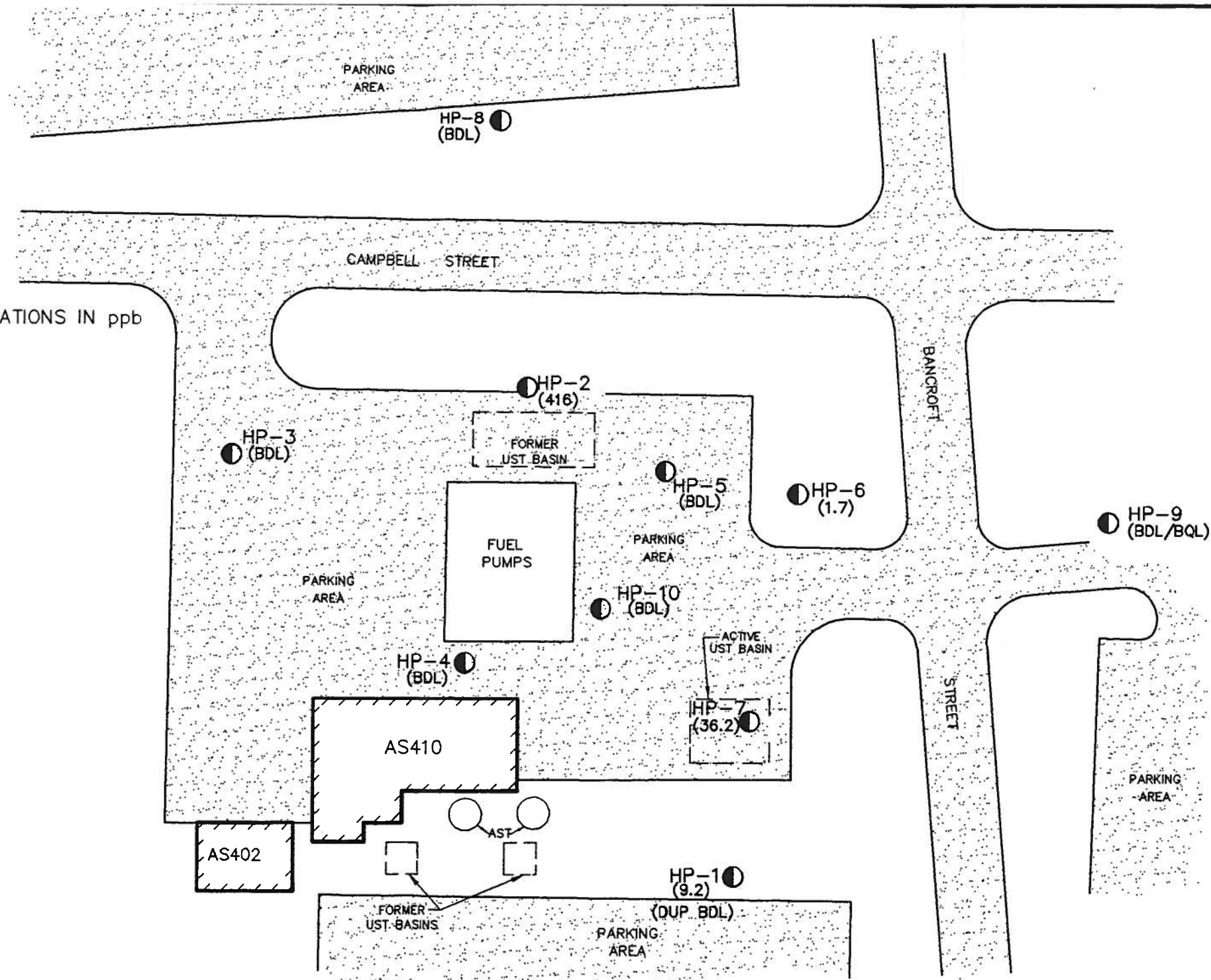
NOTES:

ADAPTED FROM SURVEYED SITE MAP PROVIDED BY MICHAEL UNDERWOOD & ASSOCIATES, RLS

Richard Catlin & Associates, Inc. ENVIRONMENTAL ENGINEERS AND HYDROGEOLOGISTS WILMINGTON, NC CHARLESTON, SC ATLANTA, GA WINSTON-SALEM, NC	PROJECT BUILDING AS-410 LANTDIV NAVFACENGCOM MCAS NEW RIVER	TITLE FREE PRODUCT SPATIAL EXTENT ISOPLETH MAP	FIGURE 5.2
JOB NO. 93125-NS	DATE 14 OCT 93	SCALE AS SHOWN	DRAWN BY: WW DH SB CHECKED BY: JC

LEGEND

- HYDROPUNCH
- ▨ BUILDING
- () TOTAL PURGEABLE ORGANIC CONCENTRATIONS IN ppb
- BQL BELOW QUANTITATIVE LIMITS
- BDL BELOW DETECTABLE LIMITS



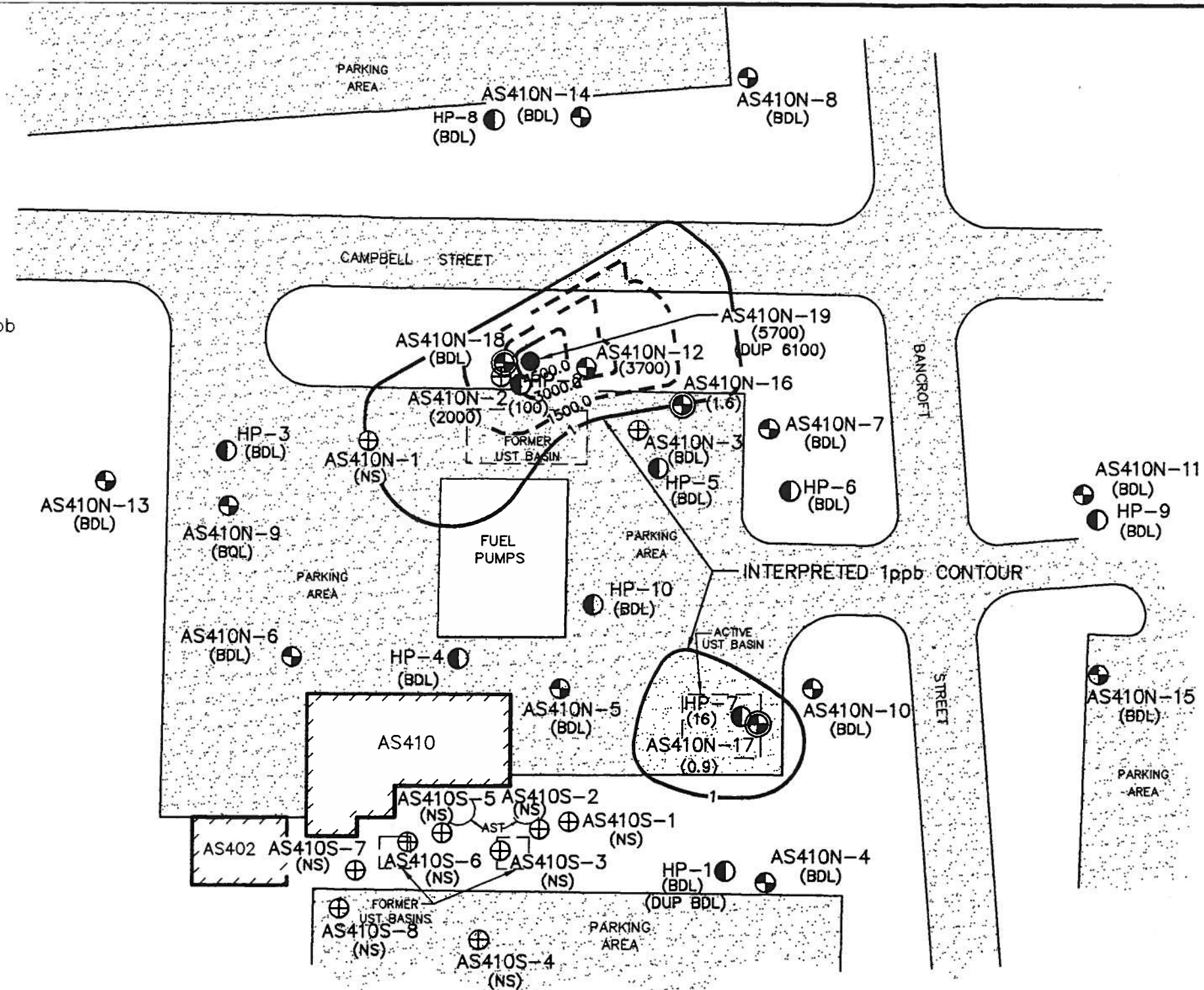
NOTES:

ADAPTED FROM SURVEYED SITE MAP PROVIDED BY MICHAEL UNDERWOOD & ASSOCIATES, RLS



Richard Catlin & Associates, Inc. ENVIRONMENTAL ENGINEERS AND HYDROGEOLOGISTS WILMINGTON, NC CHARLESTON, SC ATLANTA, GA WINSTON-SALEM, NC	PROJECT BUILDING AS-410 LANTDIV NAVFACENGCOM MCAS NEW RIVER	TITLE HYDROPUNCH DATA MAP				FIGURE
						5.3
		JOB NO. 93125-NS	DATE: 14 OCT 93	SCALE: AS SHOWN	DRAWN BY: WW DH SB	CHECKED BY: JC

	PRE-EXISTING TYPE II WELL
	TYPE II WELL
	TYPE III WELL
	PUMPING WELL
	HYDROPUNCH
	BUILDING
()	TOTAL BENZENE CONCENTRATION
BDL	BELOW DETECTABLE LIMITS
BQL	BELOW QUANTATION LIMIT
NS	NOT SAMPLED



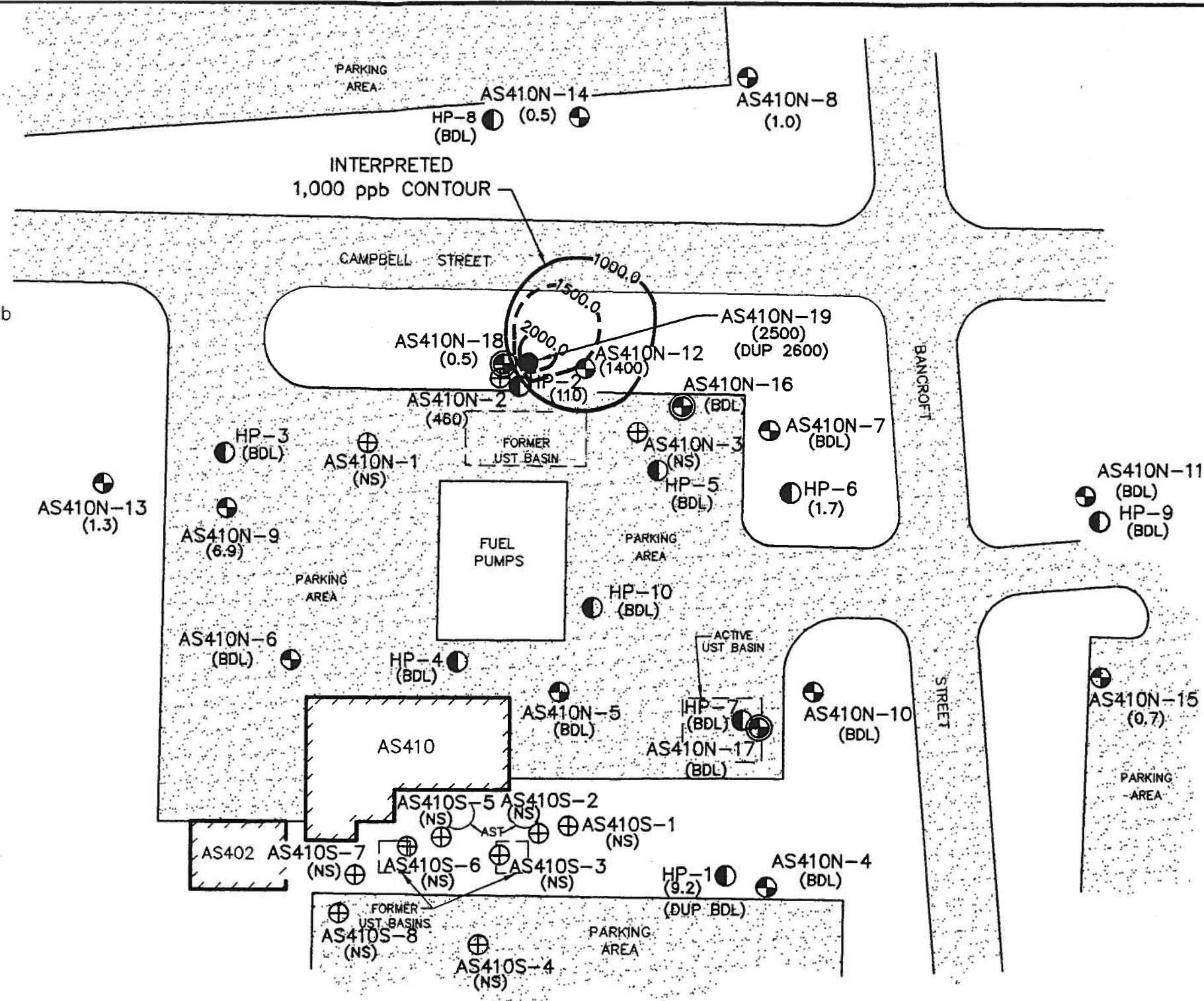
1. ADAPTED FROM SURVEYED SITE MAP PROVIDED BY MICHAEL UNDERWOOD & ASSOCIATES, RLS
2. WHERE DUPLICATE SAMPLES WERE TAKEN, THE HIGHER CONCENTRATION WAS USED FOR CONTOURING.
3. CONTOUR INTERVAL = 1500 ppb



Richard Catlin & Associates, Inc. ENVIRONMENTAL ENGINEERS AND HYDROGEOLOGISTS WILMINGTON, NC CHARLESTON, SC ATLANTA, GA WINSTON-SALEM, NC		PROJECT BUILDING AS-410 LANTDIV NAVFACENGCOM MCAS NEW RIVER	TITLE BENZENE CONCENTRATIONS (WATER) - ISOPLETH MAP	FIGURE 5.4
		JOB NO. 93125-NS DATE: 14 OCT 93	SCALE: AS SHOWN DRAWN BY: WW DH SB CHECKED BY: JC	

LEGEND

- ⊕ PRE-EXISTING TYPE II WELL
- ⊙ TYPE II WELL
- ⊗ TYPE III WELL
- PUMPING WELL
- HYDROPUNCH
- ▨ BUILDING
- () TOTAL TOLUENE CONCENTRATIONS IN ppb
- NS NOT SAMPLED
- BQL BELOW QUANTITATION LIMITS
- BDL BELOW DETECTABLE LIMITS



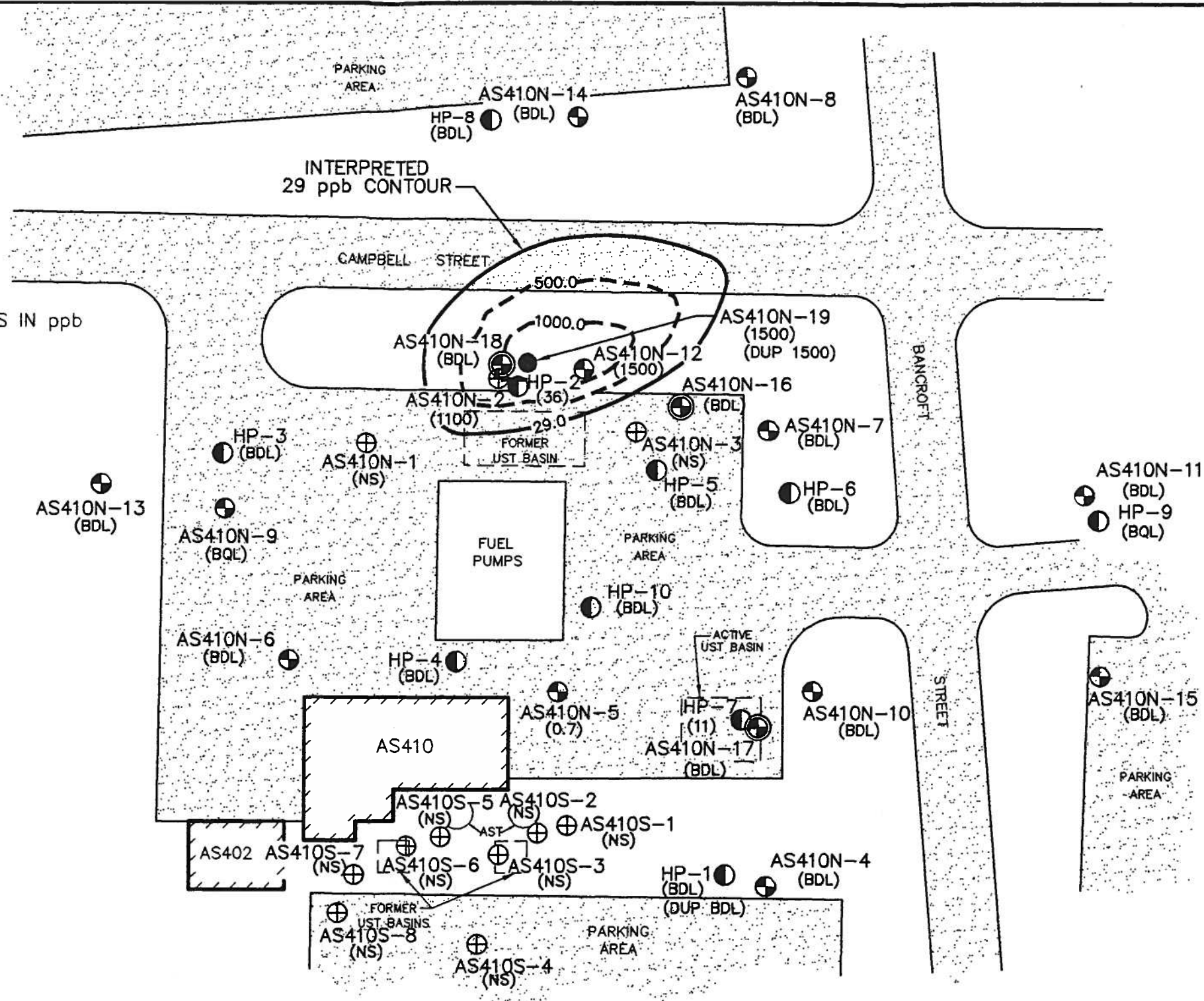
NOTES:

1. ADAPTED FROM SURVEYED SITE MAP PROVIDED BY MICHAEL UNDERWOOD & ASSOCIATES, RLS
2. TYPE III WELLS NOT USED IN CONTOURING
3. CONTOUR INTERVAL = 500 ppb
4. WHERE DUPLICATE SAMPLES WERE TAKEN, THE HIGHEST VALUE WAS USED FOR CONTOURING.

Richard Catlin & Associates, Inc. ENVIRONMENTAL ENGINEERS AND HYDROGEOLOGISTS WILMINGTON, NC CHARLESTON, SC ATLANTA, GA WINSTON-SALEM, NC	PROJECT BUILDING AS-410 LANTDIV NAVFACENGCOM MCAS NEW RIVER	TITLE TOLUENE CONCENTRATIONS (WATER) ISOPLETH MAP	FIGURE 5.5
JOB NO. 93125-NS	DATE 14 OCT 93	SCALE: AS SHOWN	DRAWN BY: WW DH SB CHECKED BY: JC

LEGEND

- ⊕ PRE-EXISTING TYPE II WELL
- ⊙ TYPE II WELL
- ⊗ TYPE III WELL
- PUMPING WELL
- ◐ HYDROPUNCH
- ▨ BUILDING
- () TOTAL ETHYL BENZENE CONCENTRATIONS IN ppb
- BDL BELOW DETECTABLE LIMITS
- BQL BELOW QUANTITATION LIMITS
- NS NOT SAMPLED



NOTES:

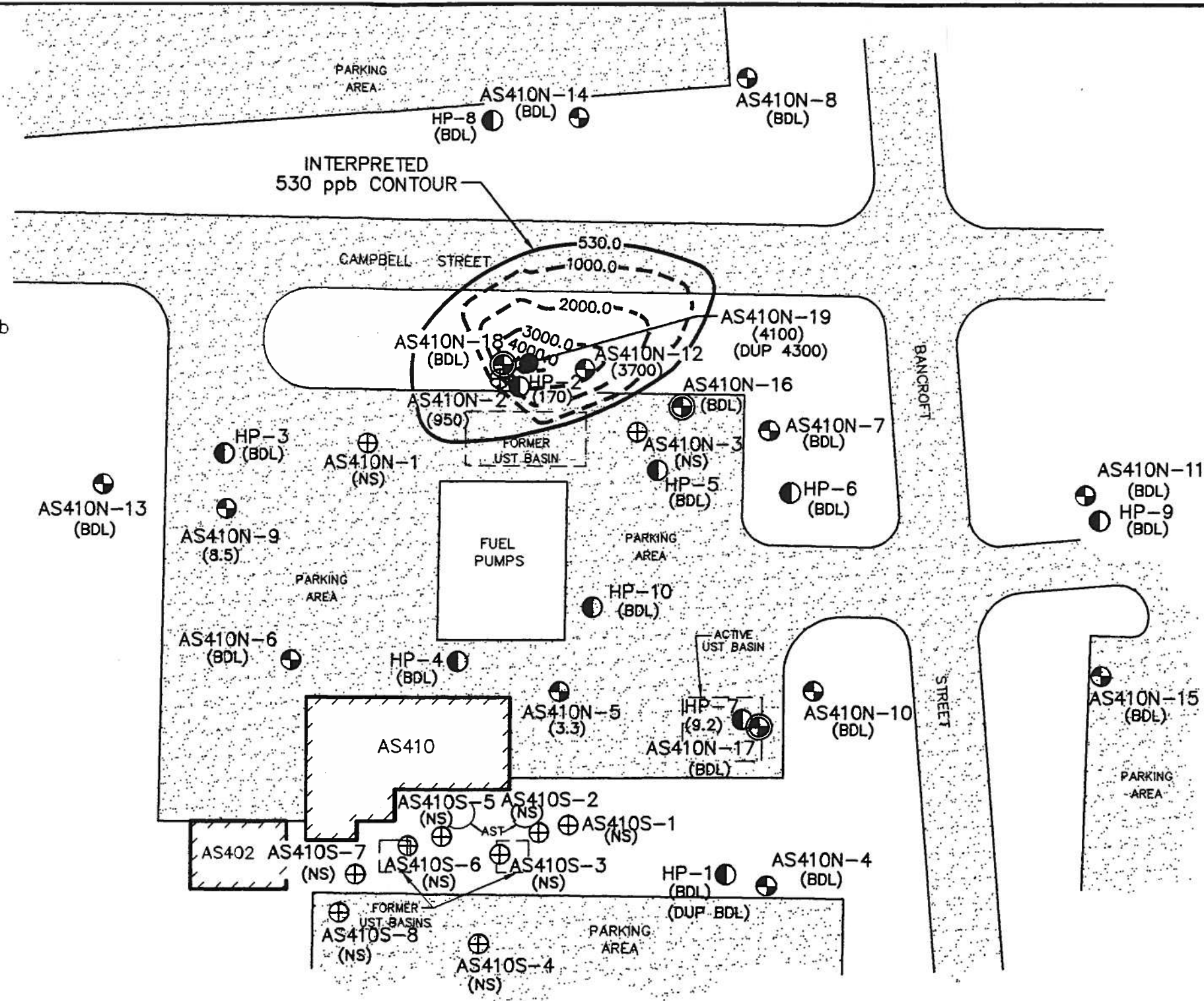
1. ADAPTED FROM SURVEYED SITE MAP PROVIDED BY MICHAEL UNDERWOOD & ASSOCIATES, RLS
2. TYPE III WELLS NOT USED IN CONTOURING
3. CONTOUR INTERVAL = 500 ppb
4. WHERE DUPLICATE SAMPLES WERE TAKEN, THE HIGHEST VALUE WAS USED FOR CONTOURING.



Richard Catlin & Associates, Inc. ENVIRONMENTAL ENGINEERS AND HYDROGEOLOGISTS WILMINGTON, NC CHARLESTON, SC ATLANTA, GA WINSTON-SALEM, NC	BC&A	PROJECT		TITLE				FIGURE
		BUILDING AS-410 LANTDIV NAVFACENGCOM MCAS NEW RIVER		ETHYL BENZENE CONCENTRATIONS (WATER) ISOPLETH MAP				5.6
		JOB NO. 93125-NS	DATE 14 OCT 93	SCALE: AS SHOWN	DRAWN BY: WW DH SB	CHECKED BY: JC		

LEGEND

- ⊕ PRE-EXISTING TYPE II WELL
- ⊗ TYPE II WELL
- ⊙ TYPE III WELL
- PUMPING WELL
- ◐ HYDROPUNCH
- ▨ BUILDING
- () TOTAL XYLENES CONCENTRATIONS IN ppb
- NS NOT SAMPLED
- BDL BELOW DETECTABLE LIMITS



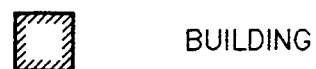
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2. TYPE III WELLS NOT USED IN CONTOURING
3. CONTOUR INTERVAL = 1,000 ppb
4. WHERE DUPLICATE SAMPLES WERE TAKEN, THE HIGHEST VALUE WAS USED FOR CONTOURING.

Richard Catlin & Associates, Inc. ENVIRONMENTAL ENGINEERS AND HYDROGEOLOGISTS WILMINGTON, NC CHARLESTON, SC ATLANTA, GA WINSTON-SALEM, NC	PROJECT BUILDING AS-410 LANTDIV NAVFACENGCOM MCAS NEW RIVER	TITLE TOTAL XYLENES CONCENTRATIONS (WATER) ISOPLETH MAP			FIGURE
					5.7
		JOB NO. 93125-NS	DATE: 14 OCT 93	SCALE: AS SHOWN	DRAWN BY: WW DH SB

LEGEND

- ⊕ PRE-EXISTING TYPE II WELL
- ⊙ TYPE II WELL
- ⊗ TYPE III WELL
- PUMPING WELL

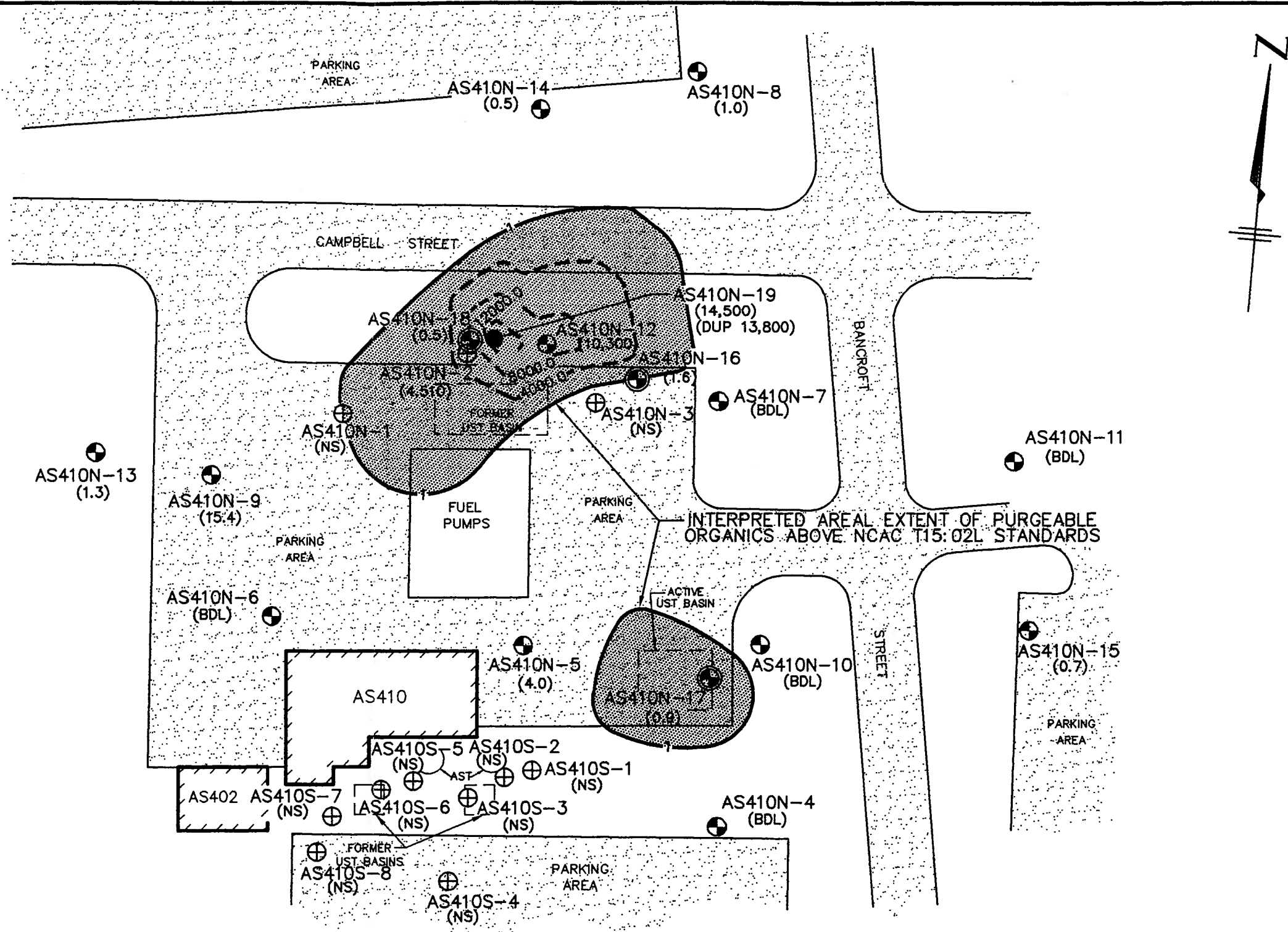


BUILDING

() TOTAL BTEX CONCENTRATIONS IN ppb

NS NOT SAMPLED

BDL BELOW DETECTABLE LIMITS



NOTES:

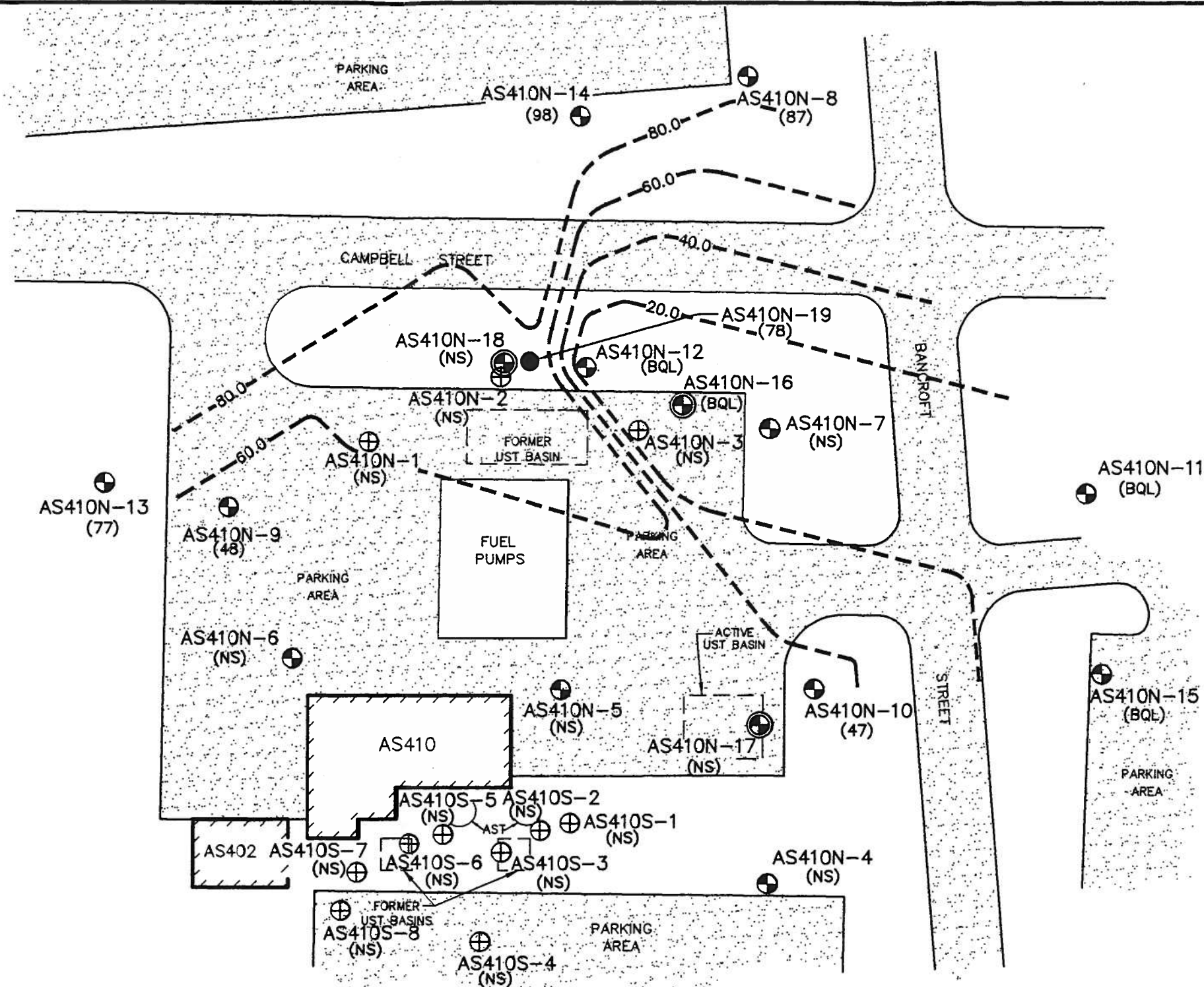
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2. TYPE III WELLS NOT USED IN CONTOURING
3. CONTOUR INTERVAL = 4,000 ppb
4. WHERE DUPLICATE SAMPLES WERE TAKEN, THE HIGHEST VALUE WAS USED FOR CONTOURING.



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		BUILDING AS-410	TOTAL BTEX CONCENTRATIONS (WATER) - ISOPLETH MAP			5.8
		LANTDIV NAVFACENGCOM MCAS NEW RIVER				
JOB NO. 93125-NS DATE: 14 OCT 93		SCALE: AS SHOWN	DRAWN BY: WW DH SB	CHECKED BY: JC		

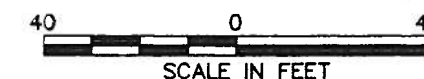
LEGEND

- ⊕ PRE-EXISTING TYPE II WELL
- ⊗ TYPE II WELL
- ⊙ TYPE III WELL
- PUMPING WELL
- ▨ BUILDING
- () TOTAL LEAD CONCENTRATIONS IN ppb
- NS NOT SAMPLED
- BQL BELOW QUANTITATION LIMITS



NOTES:

1. ADAPTED FROM SURVEYED SITE MAP PROVIDED BY MICHAEL UNDERWOOD & ASSOCIATES, RLS
2. TYPE III WELLS NOT USED IN CONTOURING
3. CONTOUR INTERVAL = 20 ppb



Richard Catlin & Associates, Inc. ENVIRONMENTAL ENGINEERS AND HYDROGEOLOGISTS WILMINGTON, NC CHARLESTON, SC ATLANTA, GA WINSTON-SALEM, NC	PROJECT BUILDING AS-410 LANTDIV NAVFACENGCOM MCAS NEW RIVER	TITLE LEAD CONCENTRATIONS (WATER) - ISOPLETH MAP	FIGURE 5.9
JOB NO. 93125-NS	DATE 14 OCT 93	SCALE AS SHOWN	DRAWN BY: WW DH SB CHECKED BY: JC

LEAKING UNDERGROUND STORAGE TANK
COMPREHENSIVE SITE ASSESSMENT

BUILDING AS-410

MARINE CORPS AIR STATION NEW RIVER
JACKSONVILLE, NORTH CAROLINA

OCTOBER 4, 1994

VOLUME II

Contract No. N62470-93-D-4020
Richard Catlin & Associates, Inc. Job No. 93125-F

FINAL



Prepared by:
Richard Catlin & Associates, Inc.
Wilmington, North Carolina

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COMPREHENSIVE SITE ASSESSMENT WORKPLAN

LEAKING UNDERGROUND STORAGE TANK
SITE ASSESSMENT WORKPLAN

BUILDING AS-410 NORTH
MARINE CORPS BASE
CAMP LEJEUNE, NORTH CAROLINA

Issued: October 8, 1993
Contract No. N62470-93-D-4020
Richard Catlin & Associates, Inc. Job No. 93125-F

Prepared by:
Richard Catlin & Associates, Inc.
Wilmington, North Carolina

Under the Direction of:
Law Engineering, Inc.

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LEAKING UNDERGROUND STORAGE TANK
SITE ASSESSMENT WORKPLAN
BUILDING AS-410 NORTH
MARINE CORPS BASE
CAMP LEJEUNE, NORTH CAROLINA

RC&A JOB NO. 93125-F

OCTOBER 8, 1993

1.0 INTRODUCTION

1.1 Purpose and Scope of Investigation

The purpose of this Leaking Underground Storage Tank (LUST) Site Assessment Workplan (Workplan) is to serve as a guidance document and procedural manual for performing tasks to aid in determining the magnitude and extent of soil and groundwater contamination; identifying possible free product accumulation; and assessing potential exposure to possible subsurface petroleum-related contaminants at the former underground storage tank (UST) basin at Building AS-410 New River Marine Corps Air Station (MCAS), Camp Lejeune, North Carolina. The UST basin is located north of Building AS-410. The location of the project site within the base is shown in Figure 1.

This Workplan was prepared in accordance with the Scope of Work (SOW) developed by 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 Comprehensive Site Assessment (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), North Carolina Criteria and Standards Applicable to Underground Storage Tanks.

The project will be conducted in two phases. The first phase involves the advancement of ten Hydropunch penetrometers (Hydropunches) and collection of shallow groundwater samples for on-site laboratory analysis. The on-site laboratory results will be available within 24 to 72 hours to provide data to assist in determining the location of subsequently installed boreholes. The Hydropunches will be located predominantly downgradient of the source, with respect to shallow groundwater flow,

which is reportedly to the north. Previously established information will be used to assist in the placement of the Hydropunches. At least three of the Hydropunches will be used to perimeter the crossgradient and upgradient boundaries of the suspected plume.

The second phase of the investigation will involve the advancement of 16 soil borings, into which 12 Type II and three Type III monitoring wells, and one pumping test well will be installed. Samples will be collected from the soil borings (soil) and monitoring wells (groundwater) for both on-site and off-site analysis. Slug tests will be conducted on three of the monitoring wells to evaluate the hydraulic conductivity of the shallow aquifer system. An eight hour pumping test will be performed on the pumping test well to determine aquifer parameters.

2.0 PREVIOUS INVESTIGATIONS, REMEDIATION AND/OR CLOSURES

Past documents revealed closure information and subsequent soil and groundwater sampling associated with the former gasoline UST basin. On July 28, 1992, six steel, 4,000 gallon capacity gasoline USTs were excavated and removed from the site. One water sample was collected from the water infiltrating the excavation and analyzed for benzene, toluene, ethyl benzene, total xylenes (BTEX), and methyl tertiary butyl ether (MTBE). Analytical results reported concentrations of 6,640 parts per billion (ppb) benzene, less than 125 ppb toluene, 1,990 ppb ethyl benzene, 12,950 total xylenes, and 7,390 ppb MTBE.

Groundwater Technology Government Services, Inc. (GSI) subsequently contracted with the Atlantic Division (LANTDIV) NAVFACENGCOM of the Department of the Navy to conduct a site check with the purpose to identify and/or verify the suspected hydrocarbon impact in the surface soils and groundwater. GSI's services, as part of the site check, were to drill three soil borings, install three monitoring wells into these borings, collect soil and groundwater samples for laboratory analysis for petroleum hydrocarbon concentrations, and determine the groundwater flow gradient in the vicinity of the tank basin. A total of three monitoring wells were installed by GSI in March of 1993 around the UST basin (See Figure 2). The wells were installed to a depth of approximately 20 feet below grade with approximately 15 feet of well screen and five feet of riser. Groundwater was measured between approximately four to five feet below land surface (BLS) in the three wells. Total petroleum hydrocarbon (TPH) analysis of three soil samples, one from each soil boring, revealed no detectable concentrations of TPH gasoline, diesel, mineral spirits, kerosene, fuel oil #6, or lubricating oil. The analysis of groundwater samples for BTEX detected maximum concentrations of 6,900 parts per billion (ppb) benzene, 2,300 ppb toluene, 1,100 ppb ethyl benzene, and 2,500 ppb total xylenes. No free

phase product was noted in any of the wells. Shallow groundwater flow was calculated to be to the north.

3.0 SITE DESCRIPTION

The site description involves the collection of information regarding the history and physical characteristics of the site to identify and evaluate known and/or potential source(s) of contamination and conditions which will assist in determining sample locations. Potential contaminant migration pathways which may influence subsurface contaminant migration characteristics and limit intrusive subsurface investigation will also be identified. These typically include the presence of surface or near surface features, such as asphalt pavement, surface water impoundments, and buried utilities.

3.1 Area of Investigation

The site is located at the New River MCAS in the northern region of the Marine Corps Base (MCB), Camp Lejeune, North Carolina (see Figure 1). The facility is an active service station for the Marine Corps Commissary. Building AS-410 is approximately 2,000 feet north of the MCAS air field. The area immediately adjacent to Building AS-410 is comprised of buildings that house maintenance and support facilities for the base. Site topography is relatively flat with a gentle grade towards the north-northwest. Surface drainage is by sheet flow over the paved surfaces to drainage ditches which empty into a stormwater retention pond west of the site.

3.2 Site History and Operation

Building AS-410 was constructed as a service station/light vehicle maintenance facility. As mentioned previously, six USTs were permanently closed in March of 1993. These USTs were of 4,000 gallon capacity each and held various grades of gasoline. Currently, there are three active gasoline USTs in a new tank basin east of Building AS-410. Facility age is not known at this time.

3.3 Contaminant Source Inventory

A visual survey of the facility revealed the potential for subsurface impact from six sources in addition to the UST basin of interest and include: 1) the current UST basin; 2) former used oil tank basin; 3) former heating oil basin; 4) active used oil above ground storage tank (AST); 5) active heating oil AST; and 6) fuel storage area approximately 300 feet south of Building AS-410. Additional potential sources may exist, but were not

observed during the initial site reconnaissance. Any releases that may have occurred from these potential sources may be encountered during this investigation.

3.4 Water Well Inventory/Water Supply

It is reported that potable water for this area is supplied by wells located approximately 3,000 feet towards the west-northwest. These wells reportedly utilize water from the Castle Hayne aquifer.

3.5 Utility Survey

A site reconnaissance of the area of investigation revealed that underground water, fiber optic communication, sanitary sewer, and possibly electrical lines are in the subsurface beneath the site.

4.0 SITE CHARACTERIZATION

The Site Characterization involves the collection of information to characterize the physical setting of the project area. Information regarding the geology/hydrogeology, topography, and other physical characteristics of the site and vicinity will be evaluated to identify conditions that could potentially affect the migration of petroleum contaminants.

4.1 Regional Geology/Hydrogeology

The following information regarding regional geology/hydrogeology contained in this section is taken directly from the report entitled Three Well Site Check Report, Building AS-410 North prepared by GSI and dated May 21, 1993.

4.1.1 Regional Geology

The Coastal Plain consists of a layered sequence of unconsolidated sand, gravel, silt, and clay deposits of Miocene to Holocene age. These deposits and formations of Lower Cretaceous age, which overlie bedrock of Precambrian age, thicken and dip eastward with a thickness of 1,500 feet in the Camp Lejeune area. The geologic units in the area are divided into six formations: the Castle Hayne Formation of the Eocene Series; the Riverbend Formation of the Oligocene Series; the Belgrade, Pungo River, and Eastover Formations of the Miocene Series; the Yorktown Formation of the Pliocene series and undifferentiated units of the Quaternary Series. The Castle Hayne Formation is composed of limestones and marls.

The Castle Hayne Formation is overlain by the Riverbend Formation. The Belgrade, Pungo River and Eastover Formations are composed of interbedded phosphatic sands, silts and clays, diatomaceous clays, phosphatic and non-phosphatic limestones and silty claystones. The Yorktown Formation is defined as a medium to coarse-grained, poorly sorted, shelly sand. In the Camp Lejeune area, the Yorktown Formation is characterized by fine- to medium-grained quartz sand. The basal unit consists of contiguous clays. The James City Formation unconformably overlies the Yorktown Formation. The James City Formation consists primarily of unconsolidated, calcareous, sandy clays and argillaceous sands. The undifferentiated units, which immediately underlie the site, are composed of fine, well-sorted sand to silty sand.

4.1.2 Regional Hydrogeology

In the eastern part of North Carolina Coastal Plain, groundwater is obtained from the surficial, Yorktown, and Castle Hayne aquifers. The depth to groundwater typically ranges from three to 12 feet below the surface. The surficial unconfined aquifer extends to depths ranging from 50 to 100 feet. This unit is not used as a source of water on the base. The Castle Hayne aquifer, the principle source of water for the base which consists of a series of sand and limestone beds, is 150 to 350 feet thick, and is between 50 and 300 feet below the surface. In the Camp Lejeune area, aquifers below the Castle Hayne consist of a thick sand and clay sequence which contains saltwater. The general groundwater flow is in the direction of lower hydraulic head to discharge areas like the New River or its tributaries or the ocean.

4.2 Site Geology/Hydrogeology and Soils

The information obtained from the GSI May 21, 1993 investigation report revealed the site to be underlain by a silty and clayey fine-grained sand to a depth of approximately 20 feet. Groundwater was measured between approximately four to five feet BLS. Groundwater flow direction was calculated to be towards the north.

4.3 Site Topography and Other Surface Characteristics

The project area is dominated by relatively flat topography. The nearest bodied surface water is the New River, located approximately two miles to the east.

5.0 POTENTIAL RECEPTORS

The information collected in sections 2.0, 3.0, and 4.0 will be evaluated to provide a preliminary listing of potential receptors that could be affected by the known/suspected release of petroleum. Potential receptors of contamination, as defined by the North Carolina Division of Environmental Management, include surface water bodies, groundwater supply wells, and subsurface building structures.

6.0 SUBSURFACE METHODOLOGY INVESTIGATION

The major objectives of the subsurface investigation are to: (1) define the approximate lateral and vertical extent of free product accumulation (if any) and dissolved-phase groundwater contamination resulting from possible discharge of petroleum fuels at the site; and (2) determine the approximate direction and rate of migration of groundwater contaminant constituents at the project site including the identification of preferential pathways of contaminant migration. To accomplish this, ten Hydropunch penetrometers will be advanced at the beginning of the project to provide preliminary information to delineate the extent of contamination in order to assist in the location of the wells. 16 borings will then be advanced to install 12 Type II and three Type III monitoring wells, and one pumping test well. Field activities will be performed in adherence to procedures and guidelines contained in the project Health and Safety Plan (Appendix I). The specific methods to accomplish these objectives are as follows:

6.1 Hydropunch Penetrometer Advancement and Soil Test Borings

6.1.1 Hydropunch Penetrometer Advancement

The proposed Hydropunch penetrometer locations are shown on Figure 3. As specified in the Delivery Order, ten Hydropunch penetrometers will be installed at this site. Nine will be advanced to the shallow water table interface and one will be advanced for deep sample collection. HP-2 will be advanced to approximately 30 feet deep to obtain a deep groundwater sample. HP-1, HP-4, HP-5, and HP-10 will be used to characterize upgradient and on-site potential sources. HP-3 and HP-6 will be used for cross gradient investigation, and HP-7, HP-8 and HP-9 will be used to determine the downgradient plume boundary.

The locations of these sample points were selected based on known/suspected contaminant source locations, and previous subsurface investigative results. The Hydropunch sample locations are intended to provide preliminary information to

delineate the spatial extent of the dissolved and free-phase plume(s). The actual sample locations may change slightly based upon data obtained during the field investigation.

The Hydropunch penetrometer will be advanced by a trailer-mounted drill rig. Depending upon the subsurface conditions at each sample location, the penetrometer will be advanced by hammer blows or by a hydraulic press. If fill material, hard/dense soils, or a deep groundwater table (greater than 10 feet deep) is encountered, a shallow pilot boring will be advanced until a more suitable sampling interval is encountered to avoid damage to the probe.

6.1.2 Soil Test Borings

Sixteen soil borings will be advanced on the site by a trailer-mounted drill rig to install 12 Type II and three Type III monitoring wells, and one pumping test well. Hollow-stem augers will be used to advance the soil borings utilizing a split spoon sampling device for soil sample collection at five foot intervals as described in Section 7.2.

An on-site geologist/engineer will examine the soils from the borings to obtain lithological conditions and continuously monitor soils for evidence of contamination using physical observation and field screening with a flame ionization detector (FID) or photoionization detector (PID). Special emphasis will be placed on physical evaluation of soils by field personnel for evidence of contamination since the presence of heavier hydrocarbons characteristically cannot be entirely detected by a FID or PID. All data will be recorded in a project specific field book.

The soil borings for the Type II monitoring wells will be advanced to approximately five feet below the shallow groundwater table. The soil borings for the Type III wells will be advanced to approximately 50 feet deep. The pumping test well will be advanced to a maximum depth of 40 feet. Boring depths may be modified slightly based on actual hydrogeological characteristics. The final locations of the borings will be subject to subsurface utility clearance.

6.2 Monitoring Well Design, Installation, and Development

A total of sixteen wells will be installed on the site. These will include 12 Type II wells, three Type III (deep) wells, and one pumping test well. The information will be used to obtain data necessary to further define the lithology beneath the project site; develop a water table contour map and determine the direction of groundwater flow across the project site; ascertain the lateral extent and approximate thickness of the free product plume, if present; establish the approximate geometric dimensions (vertical and lateral) of the dissolved-phase contaminant plume(s), if present; and provide for reproducible sampling points in the upper and lower portions of the surficial aquifer. Information will also be obtained to evaluate the hydraulic parameters of the shallow aquifer.

The assigned well identification numbers for this site are as follows:

AS410N-4 through AS410N-19

6.2.1 Monitoring Well Locations

The locations of the monitoring wells will be based on the Hydropunch sampling results, the information obtained from previous subsurface investigations, geologic and hydrologic information, site topography, and visual assessment of the site. At least one Type II well will be located upgradient and two Type II wells located cross-gradient of the suspected/known source of contamination. The remaining Type II wells will be located at downgradient positions to delineate the horizontal extent of contamination. The Type III wells will be paired with selected Type II wells to ascertain vertical components of flow gradient and delineate the vertical extent of contamination. The final locations of the wells will be determined by the information obtained while drilling and installing successive monitoring wells.

6.2.2 Monitoring Well Design and Construction

The Type II monitoring wells will be constructed of two-inch diameter PVC, machine slotted well screens and two-inch diameter, Schedule 40 PVC riser pipe, except in traffic areas, where Schedule 80 PVC pipe will be utilized. Piping will be flush jointed and threaded, and wells will be constructed without the use of glue. Screen slot widths will be 0.010 or 0.020 inches. Sand packs will be constructed of washed silica Torpedo sand (ASTM C190).

The Type III wells will be constructed using six-inch diameter PVC casing and two-inch diameter well screen and riser. All well drilling will be performed by a trailer-mounted rig fully equipped for dry auger drilling.

The pumping test well will be constructed in a manner similar to the Type II wells except six-inch diameter PVC well material and continuously slotted screen will be used.

All wells will be installed by a qualified driller registered in the State of North Carolina. Well installation will be supervised in the field by an experienced staff or project level geologist or engineer specializing in subsurface investigation. No petroleum lubricants will be used on drill pipe joints. However, Teflon tape, vegetable oil, or phosphate-free laboratory detergent such as Liquinox will be used for lubrication, if required.

6.2.3 Detailed Monitoring Well Installation Procedures

The PVC screen and riser pipe used in well construction will be pre-cleaned and packaged by the manufacturer. All well casings and screens will be transported and stored at the site in original packaging. Personnel handling these items will not handle tools or drilling equipment while installing the well. Clean, new disposable latex rubber gloves will be worn when handling well screens or casing. Personnel who are handling the drilling equipment will not be allowed to handle the well screens or casing until a new "clean" pair of gloves are worn.

The Type II monitoring wells will be installed as follows:

- Boreholes will typically be advanced with 4.25-inch inner diameter (ID) hollow stem augers to a depth of approximately 20 to 25 feet BLS to intersect the shallow water table, collect soil samples, and install the well. If heaving or flowing sands are encountered, a 2.5-inch auger may initially be advanced to collect split spoon soil samples followed by the 4.25-inch I.D. hollow stem auger with a bottom plug.
- Soil samples for chemical analysis will be collected via split spoon sampling in accordance with procedures outlined in Section 7.2 of this Workplan.

- At two well locations, a soil sample will be collected and analyzed for grain size distribution to obtain additional information regarding the hydraulic and physical properties of the aquifer material.
- The desired sections of two-inch well screen and riser pipe will be assembled and lowered to the bottom of the augers.
- The lengths of all screen and riser casing sections and bottom plugs will be measured and recorded.
- Washed silica filter sand will be poured into the augers to construct a continuous filter pack within the augers which will extend from approximately one foot below the bottom of the well screen to a maximum of two feet above the slotted section. The depth to the sand pack will be frequently measured through the augers using a decontaminated weighted fiberglass measuring tape while pulling the augers without rotation to maintain the sand inside the augers as the filter pack is constructed.
- A two foot thick bentonite seal will be emplaced above the sand filter pack by pouring bentonite pellets into the augers in the manner described above. Distilled water will be added to the annular space at ten minute intervals to aid in the hydration of the bentonite seal. The bentonite seal will be allowed to hydrate in accordance with manufacturer's recommendations.
- The annular space above the bentonite seal will be tremie grouted from the bottom to within approximately three feet of land surface with neat cement grout.
- After allowing the grout to set, the concrete pad and well head cover will be installed to complete the installation.
- A concrete apron constructed of 3,000 psi concrete and measuring 5.0 feet by 5.0 feet by 0.5 foot will be constructed around each well located in non-traffic areas. In non-traffic areas, each well head will be protected with three Schedule 40, protective steel pipes, three-inch I.D., imbedded in a minimum of 2.5-feet of 3,000 psi concrete. A security pipe with a hinged locking cap, having an embedment depth of 2.5 feet into the concrete, will be installed over the well casing.

The security pipes will extend 3.0 feet above the ground surface and will be filled with concrete and painted day-glow yellow or an equivalent color. All wells will be secured with a brass Master Lock padlock.

- In traffic areas, a flush manhole cover will be built into a three foot square, concrete collar, which will be nine inches thick. If the well is installed through a paved surface, the annular space between the casing and the borehole will be grouted to a depth of at least 2.5 feet and finished with a concrete collar. If the well is not installed through a paved or concrete surface, then a concrete apron, measuring 5.0 feet by 5.0 feet by 0.5 foot will be constructed around each well. The collar and pad will be constructed of 3,000 psi concrete and will be crowned to meet the finished grade of surrounding pavement as required. All wells will be secured with a brass Master Lock padlock. Upon completion, North Carolina Well Construction Records and as-built well diagrams will be prepared to provide site specific well construction information (refer to Appendix II).

The Type III monitoring wells will be installed in two phases, as follows:

- Boreholes will be advanced with hollow stem auger drilling technique to a depth of approximately 40 feet BLS.
- The desired sections of six-inch PVC pipe will be assembled and lowered to the bottom of the borehole.
- The six-inch pipe will be grouted into place and allowed to set for a minimum of 48 hours prior to installation of the two-inch well.
- Utilizing roller cone/dragbit drilling techniques, a five and 7/8-inch hole will be drilled through the grout in the six-inch outer casing to a terminal depth of 50 feet BLS.
- A five foot length of two-inch PVC screen will be installed to a depth of 50 feet BLS with two-inch PVC riser to the surface.
- The lengths of all screen, riser sections and bottom plugs will be measured and recorded.

- Washed silica filter sand will be poured into the augers to construct a continuous filter pack which will extend from below the bottom of the well screen to a maximum of two feet above the slotted section. The depth to the sand pack will be frequently measured using a decontaminated, weighted fiberglass measuring tape.
- A two foot thick bentonite seal will be emplaced above the sand filter pack by pouring bentonite pellets into the borehole in the manner described above.
- The annular space above the bentonite seal will be tremie grouted from the bottom to within approximately three feet of land surface with neat cement grout.
- After allowing the grout to set, the concrete pad and well head cover will be constructed to complete the installation. The well head will be completed in accordance with the specifications for the Type II wells.
- Upon completion, North Carolina Well Construction Records and as-built well details will be prepared to provide site specific well construction information (refer to Appendix II).

The six-inch diameter pumping test well will be of similar construction to the Type II monitoring wells except 20 feet of continuously slotted screen with riser to the surface will be utilized.

6.2.4 Monitoring Well Development

Well development will be performed no sooner than 24 hours after grouting is completed for Type II wells, or 48 hours for Type III wells and the pumping test well. Wells will be developed by continuous low yield pumping or bailing. As the wells are developed, groundwater turbidity will be monitored as an indicator parameter and be noted visually and recorded. Well development will continue until the turbidity stabilizes. Water generated during the well development activities will be handled according to the procedures specified in Section 6.3.

6.2.5 Groundwater Level and Free Product Thickness Measurement

Measurements will be taken in all monitoring wells at the site no sooner than 48 hours after completion of well development activities. All monitoring wells will be measured on the same day. These measurements will be used to calculate hydraulic gradients, determine direction of groundwater flow at the site, and estimate thickness of free product (if present) in the subsurface beneath the site.

Water level and free product thickness measurements will be performed using an electronic interface probe or steel tape with water/product finding pastes. The liquid levels will be measured by slowly lowering the instrument or tape into the well. When the probe reaches the water or free product surface, the circuit is completed and a buzzer is activated. A constant buzzing indicates free product while an intermittent buzzing indicates water. When the tape is inserted into the well, the liquid-specific pastes react with different fluids. The distance from the surveyed marker on the top of the well casing to the free product and/or water level is then measured and recorded. If free product is present, the thickness will be measured to the nearest 0.01 foot. Depth to water will also be measured to the nearest 0.01 foot. The measuring device will be decontaminated between wells by detergent wash and distilled water rinse. A complete set of water level measurements taken on the same day will be tabulated as shown in Table 1.

6.3 Disposal of Borehole Cuttings and Wastewater

Borehole cuttings will be containerized in drums and/or a roll-off box at or near the project site and covered to prevent entry of rainwater and exposure to windblown particles. Ultimate disposal of the material at a permitted facility will be based on analytical results and/or regulatory consultation. Development and purge water will also be containerized and removed to an off-site permitted facility. All soil and groundwater shall be placed in DOT-approved containers and properly labeled prior to any shipment. Manifests will be prepared for all wastes shipped from the site. Wastes generated as part of this investigation will be removed from the site within 48 hours of obtaining the necessary clearances.

6.4 Surveying

Horizontal and vertical locations of all top of casings, soil borings and Hydropunch sampling points will be surveyed in reference to mean sea level. Surveys will be supervised by a registered land surveyor.

7.0 **SAMPLE COLLECTION METHODOLOGY**

The following sections describe the methods that will be utilized to collect soil and groundwater samples for this project. All samples will be collected by personnel who are trained and experienced in sample collection procedures.

7.1 Hydropunch Groundwater Sample Collection

Collection of the shallow groundwater samples (less than 10 feet deep) will be accomplished by driving the Hydropunch through the unsaturated zone into the water-bearing zone as described in Section 6.1.1. The Hydropunch will then be opened by pulling back on the body of the tool to allow groundwater to enter into the screened portion of the sample chamber. Samples will then be collected by lowering a small-diameter, decontaminated Teflon bailer into the sample chamber.

Deep groundwater samples will be obtained directly from the sampling tool in the following manner. When the desired depth for collection of the sample is reached, the Hydropunch screen is opened by pulling back on the body of the tool, allowing groundwater to enter into the sample chamber. After allowing the sample chamber to fill, the sample is transported to the surface within the body of the Hydropunch tool as the tool is extracted. Lower and upper check valves close to retain the sample. At the surface, the sample is decanted into laboratory provided sample containers.

One water sample will be collected at every Hydropunch location. All groundwater samples collected will be immediately placed on ice and submitted to the on-site laboratory as described in Section 7.5. Groundwater will be collected and placed in containers in accordance with the type of analyses scheduled for that sample as follows:

Analytical Method	Bottle Size and Type	Total Number of Bottles per Samples, On-Site Lab	Preservative
602	Glass Vial/40 ml	2	<4°C

See Section 8.0 for the specific type and quantity of analyses that will be conducted for this project.

7.2 Test Boring Soil Sample Collection and Field Screening Methodology

Field screening will be conducted during drilling of the monitoring well borings to determine if organic vapors are present in the unsaturated zone and to identify areas of suspected near surface releases. Soil samples for general site characterization will be obtained from the borings at regular intervals starting at 0.0 to 1.5 feet. The soil samples will be obtained using a split spoon sampler driven in accordance with ASTM D-1586. Soil samples will be 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 will be classified in accordance with the Unified Soils Classification System (USCS) and a boring record of each borehole will be produced. A sample boring log used for final presentation is provided in Appendix II.

Each sample will be removed from the split spoon, divided, and placed in two pre-labeled, airtight, plastic bags. One bag will be immediately placed on ice pending selection of the appropriate laboratory sample depth. The second bag will be left undisturbed for several minutes to allow the organic vapors to reach equilibrium. The gas contained in the headspace of the bag will be tested with a PID or an OVA. The first laboratory sample will be taken from two to five feet deep, and the second from within five feet of the water table. Approximately 50% of the first soil samples will be sent to the on-site laboratory and the remainder will be sent to the off-site laboratory. Samples that are selected for on-site laboratory analysis will be handled and analyzed in accordance with procedures outlined in Section 7.5.2 of this Workplan. No change in screening or on-site laboratory instrumentation will occur during the site investigation in order to enhance consistency of results unless the equipment is damaged and/or needs replacement.

All soil samples collected for laboratory analyses will be immediately placed on ice. Soil will be collected and placed into containers in accordance with the type of analyses scheduled for that sample as follows:

Analytical Method	Bottle Size and Type	Total Number of Bottles per Sample, On-site/Off-Site Lab	Preservative
TPH 5030/3550	Glass Separate Jar Amber Glass Wide Mouth/2 oz.	2/2 2/2	<4°C <4°C
TCLP 8 RCRA Metals	Plastic/1,000 ml	NA/1	NR
Grain Size	Glass Wide Mouth/32 oz.	NA/32 oz. total	NR
Flash Point	Amber Glass Wide Mouth/8 oz.	NA/1	<4°C
pH	Glass or Plastic/8 oz.	NA/1	<4°C

* NA = Not Applicable. Analysis not scheduled for on-site laboratory.
NR = Not Required.

See Section 8.0 for the specific type and quantity of analyses that will be conducted for this project.

7.3 Monitoring Well Groundwater Sample Collection

The groundwater sampling program has been developed to determine the magnitude and extent of contamination that may be present as a result of a petroleum fuel release at the project site. The sampling program will consist of purging the monitoring wells, and then collecting one groundwater sample from each of the newly constructed wells. Purging and sampling will proceed from the least contaminated areas to the highest contaminated areas based on observations made during the well installations, measurement of free phase product, and distance from the known source of contamination. The sampling program will include collection of samples for both on-site and off-site laboratory analysis; static groundwater level measurements, and product thickness measurements.

The RC&A Well Sampling Worksheet will be used to record all measurements made during well purging and sampling (see Appendix II). This form was designed to be used as a checklist and as documentation for each all groundwater sampling activities for each individual well.

Each well will be purged prior to sample collection to draw new water into the well in an effort to collect samples that are representative of the surrounding aquifer. Three standing well volumes of water will be removed from each well. Wells that can be purged to dryness while purging less than three well volumes will be sampled as soon as the well has recovered to yield sufficient water volume for a sample. All purge water removed from the wells will be disposed in accordance with procedures for disposal of development water as described in Section 6.3 of this Workplan.

Well purging will be accomplished using pre-sterilized, disposable, Teflon bailers. New nylon rope will be used at each monitoring well location. Care will be taken to prevent contact between the rope and the ground during well purging and sample collection. Purging techniques will be performed in accordance with recommended practices described in the North Carolina Water Quality Monitoring Guidance Document for Solid Waste Facilities (Solid Waste Section, 1987). The volume of water to be purged is calculated using the following equation:

$$V = \pi r^2 h$$

where:

$$\pi = 3.14159$$

r = Radius of well casing

h = Height of water column in well (total well depth - depth to groundwater prior to purging)

V = Volume of water in well (standing well volume)

$$\text{Minimum purge volume} = V \times 3$$

Samples will be collected immediately upon purging of the well in accordance with the following procedures:

- Chemical preservatives, if applicable, will be added to sample bottles by the laboratory.
- Sample bottles will be labeled prior to sample collection.
- Sample bottles will be filled directly from the Teflon bailer or Hydropunch.

- The pH, temperature, and specific conductance of the sample will be measured and recorded. These measurements will be taken from a sample deposited in a separate container. Visual characteristics of the sample, including insoluble materials, will be recorded.
- Caps will be secured on bottles.
- Sample containers will be placed in plastic bags and the bags sealed.

All monitoring well groundwater samples collected for laboratory analyses will be immediately placed on ice. Groundwater will be collected and placed into containers in the following order based upon the type of laboratory analyses scheduled for that sample:

Analytical Method	Bottle Size and Type	Total Number of Bottles per Sample On-Site/Off-Site Lab	Preservative
602	Clear Glass Vial/40 ml	2/3	<4°C
Total Lead	Plastic/500 ml	NA/1	HNO ₃

NA = Not Applicable. Analysis not scheduled for on-site Laboratory.

See Section 8.0 for the specific type and quantity of analyses that will be conducted for this project.

7.4 Sample Identification

Prior to collecting each soil and groundwater sample, sample bottles will be labeled 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 be added. The sample location number on the label will correspond to the sample location numbers assigned on the field site map.

7.5 Chain of Custody and Transportation Procedures

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

The COC Record will be 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 will not proceed with sample analysis without a correctly prepared COC Record and Analytical Request Form. The laboratory will be responsible for maintaining COC of the sample(s) from time of receipt to disposal. COC procedures will be instituted and followed throughout the investigation.

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

- Samples will be accompanied by a COC Record at all times.
- The COC Record will be initiated in the field by the person collecting the samples. Every sample will be assigned a unique identification number as described in Section 7.4 that is entered on the COC Record.
- The Record will be completed in the field identifying the project, sampler, RC&A assigned project number, etc.
- If the person collecting the sample does not transport the samples to the laboratory or deliver the sample containers for shipment, the first block for "Relinquished By _____" will be signed by the sampler.

- The person transporting the samples to the laboratory or delivering them for shipment will sign the Record as "Relinquished By _____."

7.5.1 Off-Site Laboratory

Collected soil and groundwater samples will be transported on a daily basis by courier to GeoChem, Inc. in Morrisville, North Carolina. Prior to the start of the field investigation, necessary arrangements will be made with the laboratory to assure proper and prompt delivery and log in of the collected samples. Shipment and COC procedures are as follows:

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

7.5.2 On-Site Laboratory

An on-site mobile laboratory will provide expedient analytical data to assist in determining the placement of additional sample locations. The mobile laboratory will be set up at a location central to other projects concurrently being conducted in the area. Relocation of the laboratory will be avoided once it is set up since it will involve a recalibration of instrumentation and set-up logistics which may delay the project schedule. Base personnel will pre-approve the proposed location of the mobile laboratory. Shipment and COC procedures are as follows:

- The samples will be packed properly for transport so that bottles will not dislodge/and or break. The samples will be kept cool using either ice packs or ice in zip-lock bags.

- Once the samples are properly packed, the container will be adequately secured for transport to the laboratory.
- The COC Record will be maintained as described in Section 7.5.

7.6 Equipment Decontamination

Two options for equipment decontamination sites are available in the AS-410 vicinity. An oil/water separator was identified at a fueling station approximately 100 yards west of the site, and ample room is available for a temporary decontamination center on-site. Equipment decontamination sites will be established by the MCB Environmental personnel prior to the initiation of drilling activities. Potable water obtained from on-site sources will be utilized for equipment decontamination. A sample of the decontaminated water will be analyzed at the on-site lab for QA/QC purposes.

7.6.1 Drill Rig

The drill rig will be cleaned in accordance with the following guidelines:

- Drill rigs and all support equipment will be cleaned of excess grease, oils and caked-on soil prior to arrival at the site. Equipment which leaks fuel, coolant, or lubricants will not be used on site.
- Equipment such as pumps and pump lines will be flushed thoroughly with potable water prior to use.

7.6.2 Soil and Groundwater Sample Collection Equipment

Disposable Teflon bailers used for groundwater sampling will be disposed of after the sampling of each well.

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

- Tap water rinse.

- Wash with phosphate-free detergent and tap water using a brush to remove any particulate matter or surface film.
- Tap water rinse.
- Rinse thoroughly with distilled water.
- Rinse with isopropanol.
- Allow to air dry or rinse with distilled water.
- Wrap completely with aluminum foil and seal in airtight plastic bags or place on clean plastic if planned for immediate reuse.

Hollow stem augers, rods, and other drilling equipment will be decontaminated between borings as follows:

- High temperature and pressure water rinse .
- If any noticeable petroleum hydrocarbon film is present, wash with phosphate-free detergent and tap water using a brush.
- High temperature and pressure tap water rinse.
- Allow to air dry.
- Place on and cover with clean plastic until next use.

7.6.3 Rinsate Sample Collection Methodology

Rinsate water samples will be collected for QA/QC purposes. Water from the same brand or batch of distilled water that is used in the decontamination process outlined above will be used to pour over previously decontaminated sampling equipment. The rinsate water will be collected in the sample bottles. The collected samples will be analyzed in accordance with the parameters listed in Section 8.0 to confirm that equipment decontamination is being conducted adequately and that no cross contamination is occurring between sample locations. If the rinsate samples detect any contamination, a sample of the source rinsate water will be collected and analyzed for the same laboratory parameters.

8.0 SAMPLE ANALYSIS

A majority of the samples collected during the investigation will be analyzed by the on-site mobile laboratory. The analytical methods for this project are outlined below and summarized in Tables 2 and 3 for both the off-site and on-site laboratories.

8.1 Off-Site Laboratory

Samples will be analyzed at GeoChem, Inc. in Morrisville, North Carolina. Analytical methods for soils include grain size analysis, TPH (EPA Methods 3550 and 5030), flash point, and pH. Groundwater samples will be analyzed for purgeable aromatics (EPA Method 602). A duplicate sample will also be collected for one soil (TPH) and one groundwater sample (EPA Method 602) for QA/QC purposes. The number and type of samples to be analyzed and the types of analyses to be conducted are summarized in Table 2.

8.2 On-Site Laboratory

Soil samples submitted to the on-site laboratory will be analyzed for TPH (EPA Methods 5030 and 3550). Groundwater samples will be analyzed for purgeable aromatics (EPA Method 602) and total lead (EPA Method 239.2). A duplicate sample will also be collected for one soil (TPH) and one groundwater sample (EPA Method 602) for QA/QC purposes. The number and type of samples to be analyzed and the types of analysis to be conducted are summarized in Table 3.

9.0 COLLECTION AND ANALYSIS OF AQUIFER CHARACTERISTICS DATA

9.1 Slug Tests

Subsequent to development and sampling of the shallow monitoring wells, an attempt will be made to conduct three standard slug tests at three Type II wells which do not contain free product. To perform the test, the static head of groundwater will first be measured. A solid weight (slug) will be inserted into the monitoring well. The weight will remain in the well until the groundwater elevation has stabilized at which time the slug will be removed. Measurements of the water levels will be taken at pre-determined time intervals and recorded. The recovery data will be analyzed by methods presented by Hvorslev (1951). The hydraulic conductivity (K) value will be calculated as follows:

$$K = \frac{r^2 \ln(L/R)}{2LT_0}$$

where: K = Hydraulic conductivity (ft/day)
 r = Well radius (ft)
 L = Sandpack length (ft)
 R = Borehole radius (ft)
 T₀ = Time required (time lag) for the recovering water level to be within 37 percent of the static water level.

9.2 Eight Hour Pumping Test

An eight hour pumping test will be conducted on the six-inch diameter pumping well to determine the performance characteristics of the well and the hydraulic parameters of the aquifer. Yield and drawdown will be recorded so that the specific capacity of the well can be calculated. These data give a measure of the productive capacity of the well and provides information needed during the corrective action phase of the project. The pumping test will also provide data to determine the transmissivity and storage coefficient of the surrounding aquifer in order to predict time-related capture zones around pumping wells.

9.2.1 Pumping Test Procedures

Prior to the actual pumping test, the well will be pumped to determine the approximate well yield. This pre-test data is necessary to select the proper pump and establish the pumping rate to be used during the test. During the eight hour pumping test, a constant yield will be maintained, the drawdown in the surrounding monitoring wells will be accurately recorded at appropriate time intervals, and, after shutting down the pump, recovery data will be collected for comparative purposes. The eight hour pumping test water will be containerized and transported off-site to an approved treatment and disposal facility.

9.2.2 Pumping Well Sampling and Analysis

A water sample will be collected from the pumping test well and analyzed for Purgeable Organics per EPA Method 602 and total lead by EPA Method 239.2. This analytical data will be used to determine the ultimate disposition of the pumping test water.

9.2.3 Aquifer Parameter Determinations

The data collected during the pumping test will be used to calculate the storativity and transmissivity of the surrounding aquifer. These determinations will be made using the modified non-equilibrium equations by Cooper and Jacob after Theis (Driscoll, 1986) where:

$$S = \frac{0.3 T t_0}{r^2}$$

where: S = Storativity (dimensionless)
 T = Transmissivity, in gallons per day per foot
 t_0 = intercept of the straight line at zero drawdown, in days
 r = distance, in feet, from the pumping well to the observation point (monitoring well)

and:
$$T = \frac{264 Q}{\Delta S}$$

where: T = Transmissivity in gallons per day per foot
 Q = pumping rate, in gallons per day
 ΔS = drawdown difference per log cycle of t

10.0 EVALUATION OF ASSESSMENT DATA

An evaluation of the assessment monitoring data will be performed to establish and map the spatial boundaries of contaminant plume(s). Accomplishment of this objective will aid in: (1) identifying contaminant source area(s), migration pathways and potential receptors; and, if necessary, (2) establishing a basis for corrective action strategies.

The initial step in the evaluation process involves data reduction. Analytical results will be reviewed and mapped to their respective sample locations. The following data will be presented in tabular form:

- Sampling point identification number (or quality control designation).
- Sampling date.
- Practical quantitation limit.
- Reported concentration.
- Reported approximate concentration, if below practical quantitation limit.

A quantitative ranking of constituent concentration/sampling point combination will be performed to identify likely source areas, delineate the approximate boundaries of the contamination plume, and establish concentration gradients of detected contaminants within the plume. Based on these results, horizontal and vertical limits of the plume area(s) and contaminant isopleth contours will be calculated for the project area.

11.0 ESTIMATION OF THE RATE OF CONSTITUENT MIGRATION

Groundwater travel time or average linear groundwater flow velocity will serve as the basis for estimating the rate of contaminant migration at the facility. Groundwater 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 sorption processes will be incorporated into rate calculations.

Groundwater flow velocities will be 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)

Estimates of hydraulic conductivity will be determined from results of grain size distribution analyses of soil samples, slug tests, and pumping test calculations. Hydraulic gradients will be calculated from water level measurements obtained as described in Section 6.2.5.

Estimates of bulk density and porosity will be determined from results of visual/manual classification of soils and standard penetration resistance tests as described in Section 6.1.2. Average velocities of contaminant constituents will then be calculated in accordance with the following equation (USEPA, 1985):

$$v_c = v/R$$

where: v_c = Average velocity of contaminant constituent (ft/day)

v = Average linear groundwater flow velocity (ft/day)

R = Retardation factor (unitless)

October 8, 1993

12.0 PROJECT SCHEDULE

A schedule for implementation of the Comprehensive Site Assessment Workplan, along with appropriate milestones, is exhibited in Appendix III. Where possible, one drill rig and Site Manager will be dedicated to the site throughout all of its phases of investigation.

13.0 REFERENCES

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TABLES

TABLE 1

[illegible]

N/A = Not Applicable

NMT = No Measurable Thickness

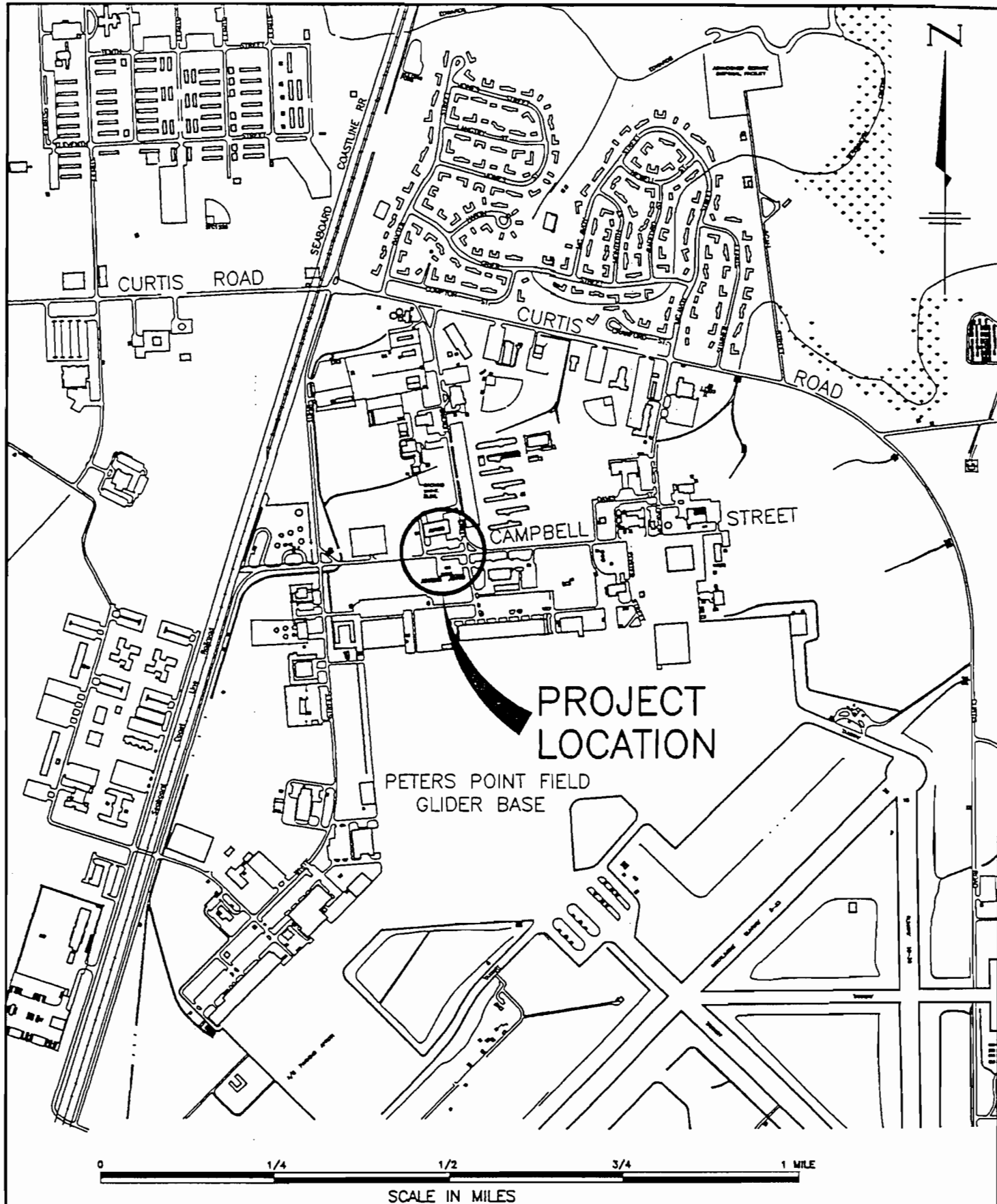
TABLE 2 SAMPLE ANALYSIS SUMMARY TABLE OFF-SITE LABORATORY																		BUILDING AS-410			
DATA POINT	NUMBER OF SAMPLE LOCATIONS	SAMPLE QUANTITY FOR OFF-SITE LAB		TOTAL ANALYSIS QUANTITY								WATER				TOTAL LEAD					
				SOIL				GRAIN SIZE				PH									
		TPH 3550/ 5030	TPH 9071	TPH 8021	TCLP METALS	FLASH POINT	PH	GRAIN SIZE	502.2	601	602	610	8 RCRA METALS								
		Hydropunch Penetrometers	10	0	0	--	--	--	--	--	--	--	--	--	--		--	--	--		
Type II Wells/Borings	12	9*	8*	9*	--	--	3	8	8	2	--	--	8*	--	--	8	--				
Type III Wells/Borings	3	6	3	6	--	--	1	2	2	--	--	--	3	--	--	1	--				
Pumping Well	1	2	0	2	--	--	1	--	--	--	--	--	--	--	--	1	--				
Trip Blank	1	0	1	--	--	--	--	--	--	--	--	--	1	--	--	--	--				

* Includes duplicate or rinsate sample

TABLE 3 SAMPLE ANALYSIS SUMMARY TABLE ON-SITE LABORATORY													BUILDING AS-410		
DATA POINT	NUMBER OF SAMPLE LOCATIONS	SAMPLE QUANTITY FOR ON-SITE LAB		TOTAL ANALYSIS QUANTITY											
				SOIL					WATER						
		SOIL	WATER	TPH 3550/ 5030	TPH 3550	TPH 5030	9071/ 8021	TPH 9071	601	602	610				
Hydropunch Penetrometers	10	0	11*	--	--	--	--	--	--	--	11*	--			
Type II Wells/Boring	12	17*	5	17*	--	--	--	--	--	--	5	--			
Type III Wells/Boring	3	0	0	--	--	--	--	--	--	--	--	--			
Pumping Well	1	0	1	--	--	--	--	--	--	--	1	--			

* Includes one duplicate or rinsate sample

FIGURES

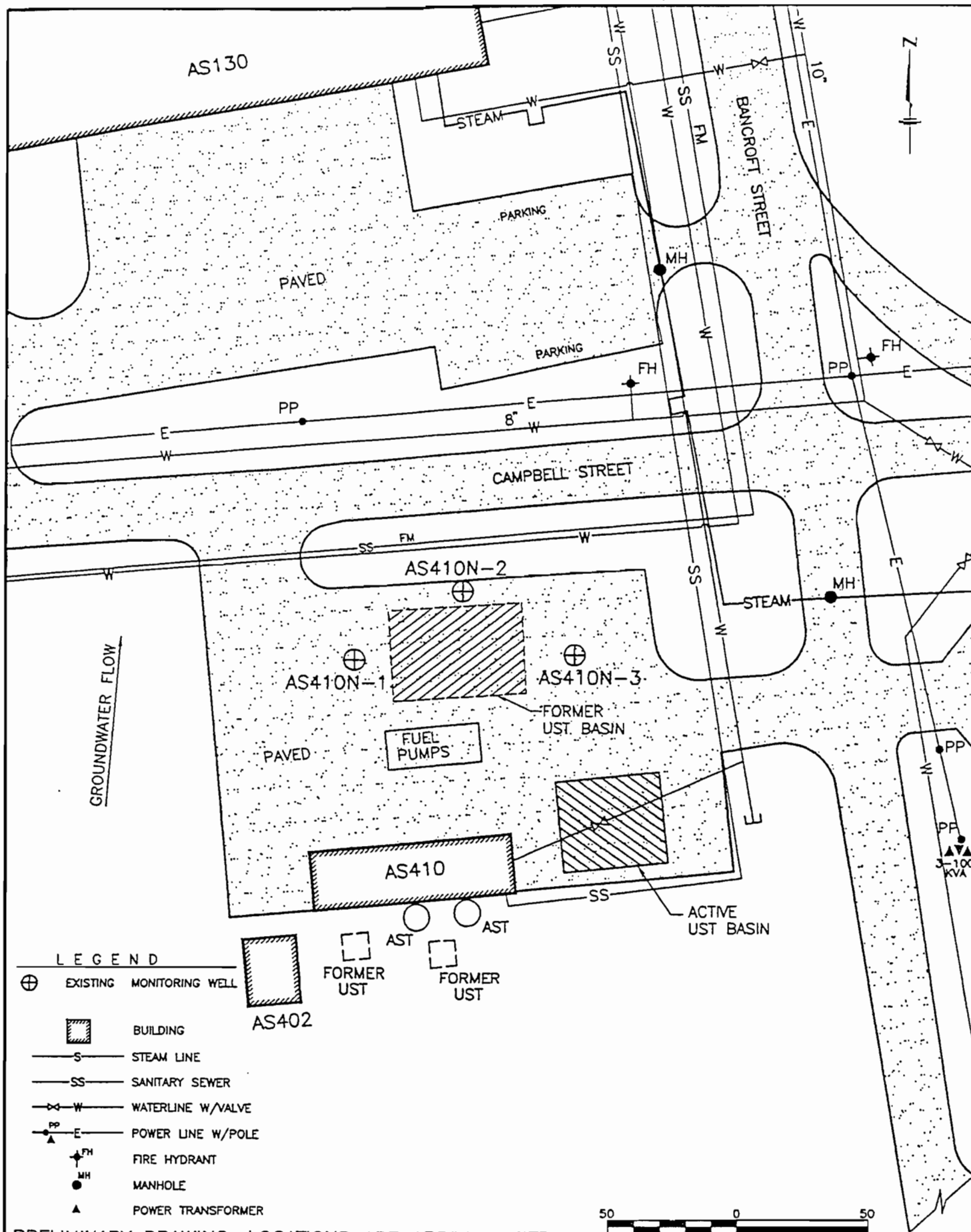


Richard Catlin & Associates, Inc.
 CONSULTING ENGINEERS AND HYDROGEOLOGISTS
 WILMINGTON, NC CHARLESTON, SC ATLANTA, GA WINSTON-SALEM, NC

PROJECT
 BUILDING AS-410
 AS-410 NORTH
 LANTDIV NAVFACENGCOM
 JOB NO: 93125 DATE: 1 OCT 93

TITLE
 VICINITY MAP
 SCALE: AS SHOWN DRAWN BY: WHW CHECKED BY: JC

FIGURE
 1



PRELIMINARY DRAWING, LOCATIONS ARE APPROXIMATED

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AND HYDROGEOLOGISTS

PROJECT
BUILDING AS-410
LANTDIV NAVFACENGCOM

TITLE
SITE MAP
WITH EXISTING
WELL LOCATIONS

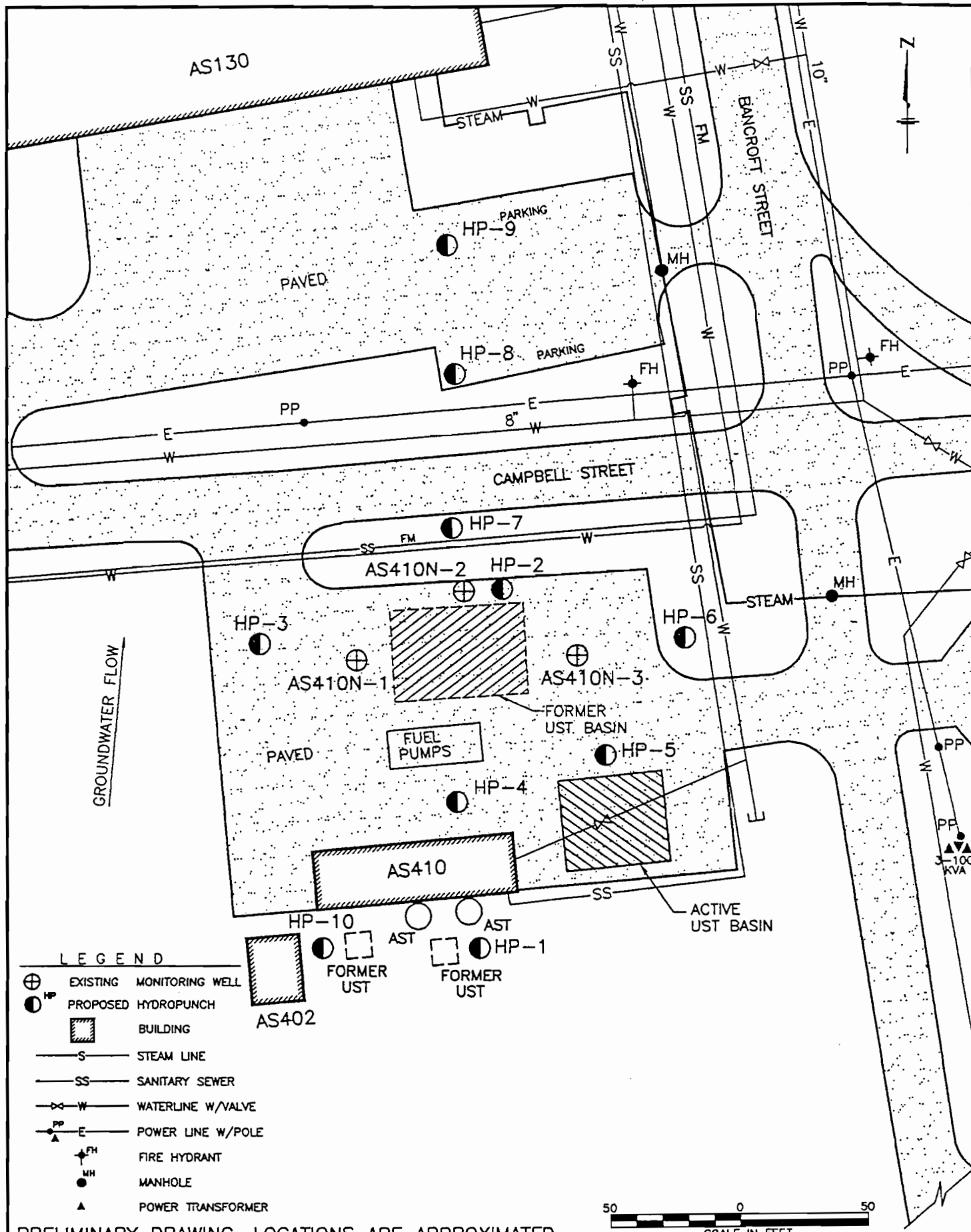
FIGURE

2

WILMINGTON, NC CHARLESTON, SC ATLANTA, GA WINSTON-SALEM, NC

JOB NO: 93125-05 DATE: 1 OCT 93

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



Richard Catlin & Associates, Inc. CONSULTING ENGINEERS AND HYDROGEOLOGISTS WILMINGTON, NC CHARLESTON, SC ATLANTA, GA WINSTON-SALEM, NC	PROJECT BUILDING AS-410 LANTDIV NAVFACENGCOM JOB NO: 93125-0S DATE: 1 OCT 93	TITLE SITE MAP WITH PROPOSED HYDROPUNCH LOCATIONS SCALE: AS SHOWN DRAWN BY: WHW CHECKED BY: JC	FIGURE 3

APPENDICES

APPENDIX I
SITE SPECIFIC HEALTH & SAFETY PLAN

PETROLEUM HYDROCARBON
SITE SPECIFIC HEALTH & SAFETY PLAN

PREPARED FOR:
BUILDING AS-410 NORTH, MARINE CORPS BASE
CAMP LEJEUNE, NORTH CAROLINA

PREPARED BY:
RICHARD CATLIN & ASSOCIATES, INC.

PREPARATION DATE:
OCTOBER 8, 1993

RC&A JOB NO.: 93125-F

COPIES TO: _____	DATE: _____
COPIES TO: _____	DATE: _____
COPIES TO: _____	DATE: _____
COPIES TO: _____	DATE: _____
COPIES TO: _____	DATE: _____
COPIES TO: _____	DATE: _____

The undersigned have read the Site Specific Health and Safety Plan and are familiar with its provisions:

<u>Signature</u>	<u>Date</u>	<u>Signature</u>	<u>Date</u>
_____	_____	_____	_____
_____	_____	_____	_____
_____	_____	_____	_____

AMENDMENTS/REVISIONS MUST BE APPROVED BY PLAN AUTHOR PRIOR TO IMPLEMENTATION OF EACH AMENDMENT.

AMENDMENT NUMBER	EFFECTIVE DATE	SUBJECT
_____	_____	_____
_____	_____	_____
_____	_____	_____

APPROVED: Teri M. Piver DATE: 9/15/93
Health & Safety Officer

PLAN AUTHOR: Teri M. Piver DATE: 9/15/93

PETROLEUM HYDROCARBON
SITE SPECIFIC HEALTH & SAFETY PLAN

BUILDING AS-410 NORTH, MARINE CORPS BASE
CAMP LEJEUNE, NORTH CAROLINA

OCTOBER 8, 1993

1.0 INTRODUCTION

This section of the Site Health and Safety Plan (HASP) document defines general applicability and general responsibilities with respect to compliance with Health and Safety programs.

1.1 *Scope and Applicability of the Site Health & Safety Plan*

The purpose of this Site Health and Safety Plan is to define the requirements and designate protocols to be followed at the Site during investigation and remediation activities. Applicability extends to all employees, contractors, subcontractors, and visitors.

All personnel on site, contractors and subcontractors included, shall be informed of the emergency response procedures and any potential fire, explosion, health, or safety hazards of the operation. This HASP summarizes these hazards and defines protective measures planned for the site.

This plan must be reviewed and an agreement to comply with the requirements must be signed by all personnel prior to entering the exclusion zone or contamination reduction zone.

During development of this plan consideration was given to current safety standards as defined by Environmental Protection Agency/Occupational Safety and Health Administration/National Institute of Occupational Safety and Health (EPA/OSHA/NIOSH), health effects and standards for known contaminants, and procedures designed to account for the potential for exposure to unknown substances. Specifically, the following reference sources have been consulted:

- OSHA 29 CFR 1910.120 and EPA 40 CFR 311
- U.S. EPA, Office of Emergency and Remedial Response, Environmental Response Team (OERR ERT) Standard Operating Safety Guidelines
- NIOSH/OSHA/USCG/EPA Occ. Health and Safety Guidelines
- American Conference of Governmental Industrial Hygienists (ACGIH) Threshold Limit Values

2.0 PROJECT ORGANIZATION/KEY PERSONNEL:

The following personnel are designated to carry out the stated job functions.
(Note: One person may carry out more than one job function.)

RC&A Project Manager: Jim Cornette

RC&A Site Safety Officer: Jim Cornette/ Teri Piver

RC&A Field Team Leader: Jim Cornette

RC&A Field Team Members: Mike Sage, Craig Farrow, Brad Newland, Teri Piver, Jim Cornette, Steve Hudson, Tommy Chalmers, Ira Hines, Bill Miller, Mike Mason, Mike Young

Public Information Officer: Not applicable

Security Officer: Not applicable

Subcontractors: Not applicable

3.0 SITE HISTORY AND DESCRIPTION:

3.1 Location: Refer to Figure 1
Building AS-410 North
Camp Lejeune, North Carolina

3.2 Type of Site:
UST
Former inventory included:
Six 4,000 gallon capacity gasoline USTs, one 550 gallon capacity heating oil, and one 285 capacity used oil.

Current inventory includes:
Three gasoline USTs, one heating oil AST, and one used oil AST.

Description of Site:
Service station/light vehicle maintenance facility.

3.3 Activities Performed on Site Prior to Investigation/Cleanup:
Tank closures were performed on the gasoline, heating oil, and used oil USTs. A site check was performed to identify and/or verify suspected hydrocarbon impact to subsurface. Three monitoring wells were installed as part of the site check.

3.4 Unusual Features (Containers, Buildings, Dikes, Power Lines, Terrain, Bodies of Water, etc.):
Above and below ground utilities; pond.

- 3.5 Results of Previous Surveys:
Concentrations of BTEX in groundwater above State standards. No detectable concentrations of TPH in soil.
- 3.6 Waste Types (Liquid, Solid, Gas Vapor):
Petroleum contaminated soil, groundwater, and potential for vapors.
- 3.7 Characteristics:
Toxic X Flammable/Volatile X Reactive _____
Radioactive _____ Corrosive _____ Ignitable _____
Biological Agent _____
- 3.8 Hazard Evaluation:
- 3.8.1 Substances (known or suspected):

<u>Chemical Name</u>	<u>(PEL/TLV)</u>	<u>Concentrations</u>
Gasoline	300 ppm ACGIH	Not known
Diesel	NE	None known
Kerosene	NE	None known
Benzene	Ca 0.1 ppm NIOSH/OSHA	6,900 ppb (gw)
Ethylbenzene	100 ppm NIOSH/OSHA	2,300 ppb (gw)
Toluene	100 ppm NIOSH/OSHA	1,100 ppb (gw)
Xylenes	100 ppm NIOSH/OSHA	2,500 ppb (gw)
Ethylene Dibromide	Ca 0.045 ppm NIOSH/OSHA	None known
Methyl Tert Butyl Ether	NE	None known
Isopropyl Ether	500 ppm NIOSH/OSHA	None known
Naphthalene	10 ppm NIOSH/OSHA	None known
Petroleum Distillates	87 ppm NIOSH	None known
Total Petroleum Hydrocarbons	NE	None Known
Naptha (coal tar)	100 ppm NIOSH/OSHA	None known

NE= None Established
Ca= Carcinogen

- 3.8.2 Physical Hazards:
Heat X Cold _____ Noise X Radiation _____ Other (specify) X

Comments: Vehicular traffic, exposure to petrochemicals

- 3.9 Weather: Not Applicable

4.0 SITE ORGANIZATION AND CONTROL: Refer to Appendix II

Work Areas Identified: Areas in and surrounding AS-410 North UST basin.

Decontamination Areas Identified: Temporary decontamination area to be established prior to initiation of field activities. The decontamination area will be set up in an area mutually agreed upon by RC&A and MCB personnel.

Support Areas Established: Adjacent to work area.

Site Security Established: Not applicable.

Sketch of Site: Refer to Figure 2

5.0 JOB ACTIVITIES/WORK PLANS:

Types of Activities to be Performed:
Install 12 Type II and three Type III monitoring wells, one pumping test well, advance ten Hydropunch penetrometer probes, develop monitoring wells, collect soil and groundwater samples, conduct slug tests, conduct pumping test, and survey.

6.0 EDUCATION AND TRAINING:

Special Training Required for this Site (yes or no, specify if so):
Yes

Types:
40-hour Hazardous Waste Operations and Emergency Response (HAZWOPER) and 8-hour HAZWOPER refresher in accordance with 29 CFR 1910.120, where required.

7.0 MEDICAL SURVEILLANCE:

Special Medical Monitoring Required:
Yes, RC&A medical monitoring program in accordance with 29 CFR 1910.120.

Avoid frequent or prolonged skin contact with petrochemicals. Monitor skin and eyes for dermatitis, allergic reaction, and eye irritation. If these or other symptoms develop, seek qualified medical attention. Workers with histories of liver, kidney, or nervous system disorders should be advised as to possible increased risk.

Symptoms of acute exposure to volatile organics may include: high vapor levels can cause irritation of the respiratory tract, headaches, nausea and mental confusion. Loss of consciousness occurs with very high concentrations. Liquid contact with skin may cause defatting, drying and irritation. Both vapor and liquid phases are irritating to the eyes.

Heat stress will be monitored in accordance with the contingency plan provided in Appendix III.

8.0 AMBIENT FIELD MONITORING:

8.1 Field Monitoring Equipment Needed for this Site:

Photoionization detector (PID) or flame ionization detector (FID).

8.2 Monitoring Protocol:

Breathing Zone: Ambient air monitoring for the presence of volatile organic compounds (VOCs) will be performed using a PID or FID. Testing will be conducted for approximately three minutes at a minimum of one test per hour or when site conditions warrant. In the event that ambient PID/FID readings exceed a level of 100 ppm for more than one half of any three minute testing interval the work area will be evacuated pending additional testing. The action level of 100 ppm represents permissible exposure limit (PEL) for naphtha and coal tars as established by OSHA. If further testing reveals that ambient air contains VOCs in excess of 100 ppm, respirators will be required. Should concentrations exceed 1,000 ppm, all site work will cease and the site evacuated pending guidance from the Health and Safety Officer (HSO).

9.0 CLOTHING AND PROTECTIVE GEAR

In general, most work will be performed in Level D protective gear unless conditions warrant more protective attire. Level D is the minimum protection clothing as established by OSHA. Typically Level D consists of steel-toe protective work boots, protective eyewear (goggles or glasses), hard hats, nitrile outer gloves, vinyl or latex inner gloves, and hearing protection. Should conditions warrant, full face respirators with proper cartridges, chemical-resistant coveralls (tyvek), and splash suits shall be available.

- Job Activity: Site reconnaissance/Surveying

Level: D

Monitoring Protocol: None required

List of Personal Protective Equipment: steel toe impermeable safety boots, safety goggles, gloves, hard hat.

- Job Activity: Drilling/Well Installation/Hydropunch Installation

Level: D unless conditions warrant, then Level C

Monitoring Protocol: Monitor breathing zone with PID/FID

List of Personal Protective Equipment: steel toe impermeable safety boots, hard hat with face shield or safety goggles, splash suit, outer gloves, inner gloves, tyvek coveralls, hearing protection, full face respirator with proper cartridges.

- Job Activity: Monitoring Well Development/Sampling/Monitoring

Level: D unless conditions warrant, then Level C.

Monitoring Protocol: Monitor breathing zone with PID/FID

List of Personal Protective Equipment: steel toe impermeable safety boots, hard hat with face shield or safety goggles, splash suit (optional), outer gloves, inner gloves, tyvek coveralls, hearing protection. Tyveks may be optional depending on the potential for skin contact with free product and/or contaminated soil, full-face respirator with proper cartridges.

10.0 SAFETY EQUIPMENT LIST:

First Aid: Small - medium industrial First Aid Kit

Fire Fighting: "No Smoking" signs, ABC type Fire Extinguisher

Communications: Barricade tape to keep people out of work area, if necessary.

Personal Protective Equipment: MSHA/NIOSH approved full face air purifying respirator with organic vapor cartridges, hard hats, face shields or safety goggles gloves, steel toe impermeable boots, hearing protection, splash suit (optional), tyvek (optional).

Decontamination Equipment: Potable water, non-phosphate soap, alcohol rinse, steam cleaner

Sanitation: Wash immediately any skin surfaces which come into contact with product and/or contaminated soil or ground water.

11.0 DECONTAMINATION PROCEDURES:

- Work Activities: Drilling/Hydropunch equipment

Level of Protection: D

Decontamination Solutions: Steam cleaner or high pressure wash

Procedures (By Station): Steam wash or pressure wash off dirt and product residue from equipment. May require soapy water wash.

- Work Activities: Personal Decontamination

Level of Protection: D

Decontamination Solutions: Non-phosphate soap, potable water

Procedures (By Station): Wash boots and outer gloves; change product contaminated clothing immediately. Wash contaminated skin surfaces.

12.0 CONTINGENCY PLANS:

Refer to Appendix III

12.1 Local Sources of Assistance:

Hospital (Name, Telephone):

Onslow Memorial Hospital (919) 577-2400

Naval Regional Medical Center Hospital (919) 451-4300

Directions: See Figure 1

Ambulance (Phone): 911

Fire Department (Phone): 911

Local Police (Phone): 911

State Police (Phone): 911

Job Site (Contact and Phone): Debra Pickett (919) 451-5063

12.2 Special First Aid or Evacuation Procedures:

Provide basic first aid procedures as required and note time and circumstances of injuries. In the event of serious injury, the Naval Regional Medical Center Hospital, Brewster Boulevard, will be used (see Figure 1). Minor injuries and non-emergency cases should be treated

off-base at Onslow Memorial Hospital, 317 Western Boulevard in Jacksonville (see Figure 1).

In the event of potential or actual fire or explosion, evacuate the area immediately. Notify fire department. DO NOT attempt to fight the fire. Notify project manager and Ms. Debra Pickett.

EMERGENCY PROCEDURES (Petroleum Products):

Skin	-	Wash with soap and water, rinse well
Inhalation	-	Move to fresh air at least 50 feet upwind from vapor source. Seek qualified medical attention
Eyes	-	Flush for a minimum of ten minutes with clean water while holding eye open. Seek qualified medical attention.
Ingestion	-	Do not induce vomiting. If conscious, give water or milk to drink. Seek qualified medical attention.

12.3 National or Regional Sources of Assistance:

• Richard Catlin & Associates, Inc.	1-919-452-5861 1-800-346-7360
• Debra Pickett, MCB, Environmental Supervisor	1-919-451-5063
• EPA RCRA/Superfund Hotline	1-800-424-9346
• Chemtrec (24 Hours)	1-800-424-9300
• Bureau of Explosives (24 Hours) (Association of American Railroads)	1-202-293-4048
• Communicative Disease Center (Biological Agents)	1-404-633-5313
• National Response Center, NRC (Oil/Hazardous Substances)	1-800-424-8802
• US DOT, Office of Hazardous Operations US DOT, (Regulatory Matters)	1-202-426-0656 1-202-426-9280
• US Coast Guard (Major Incidents)	1-800-424-8802
• Poison Control Center	1-800-672-1697
• National Agricultural Chemical Association	1-513-961-4300

13.0 AMENDMENTS TO SITE SPECIFIC HEALTH & SAFETY PLAN

- 13.1 This Site Specific Health & Safety Plan is based on information available at the time of preparation. Unexpected conditions may arise. It is important that personnel protective measures be thoroughly assessed by the RC&A Field Team Leader prior to and during the planned activities. Unplanned activities and/or changes in the hazard status should initiate a review of and may initiate changes in this plan.
- 13.2 Changes in the hazard status or unplanned activities are to be submitted on "Amendments to Site Specific Health and Safety Plan" which is included.
- 13.3 Amendments must be approved by the HSO prior to implementation of amendment.

SITE SPECIFIC HEALTH & SAFETY PLAN

JOB NAME:
LOCATION:

AMENDMENTS TO SITE SPECIFIC HEALTH AND SAFETY PLAN

Changes in field activities of hazards:

Proposed Amendment:

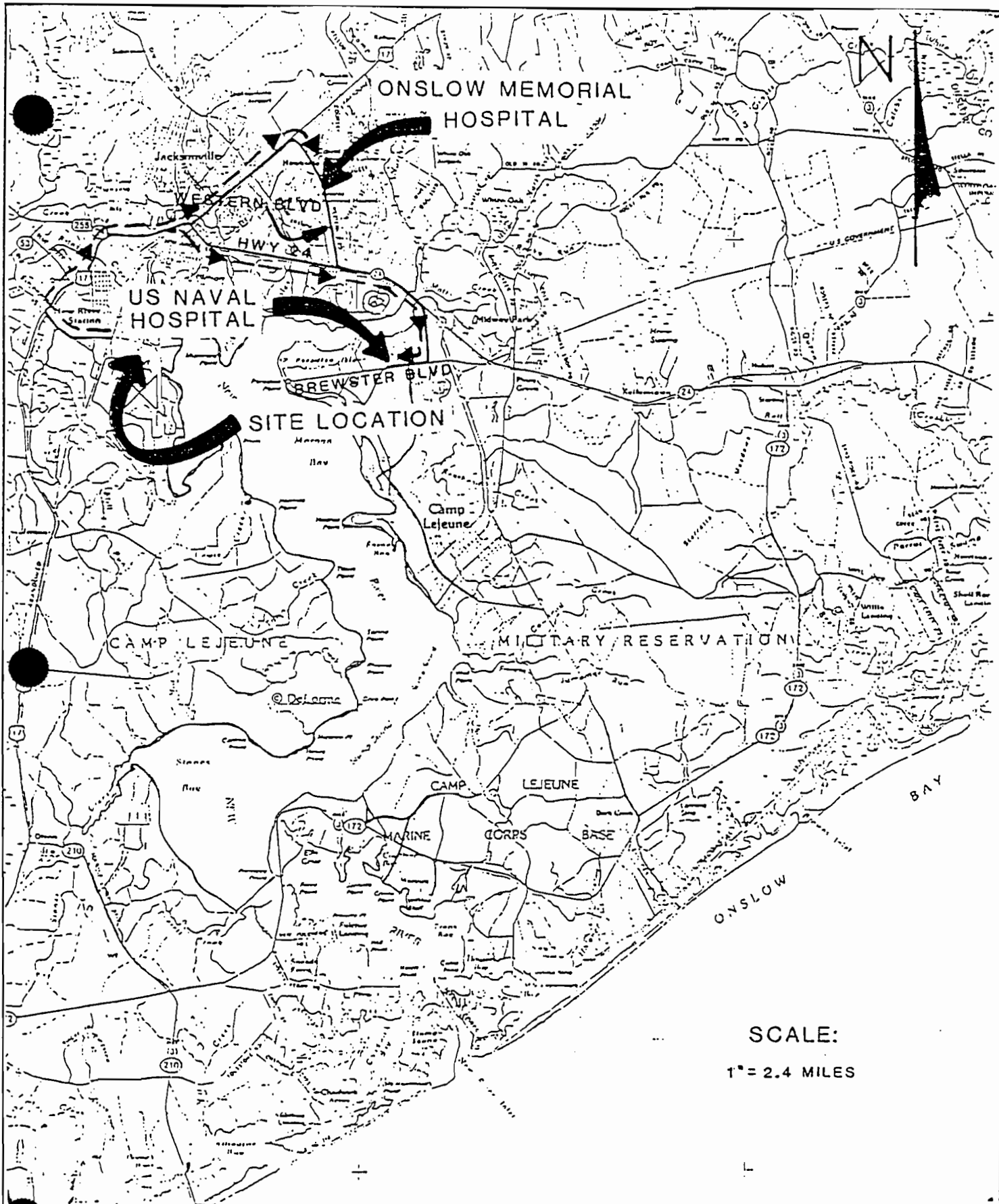
Proposed By:
Date:

Approved By:

Accepted:
Declined:

Amendment Effective Date:

FIGURES



PROJECT:
LANTDIV NAVFACENGCOM
AS-410
MARINE CORPS AIR
STATION, NEW RIVER, NC

TITLE:
HOSPITAL LOCATIONS
AND ROUTES

JOB #:
93125

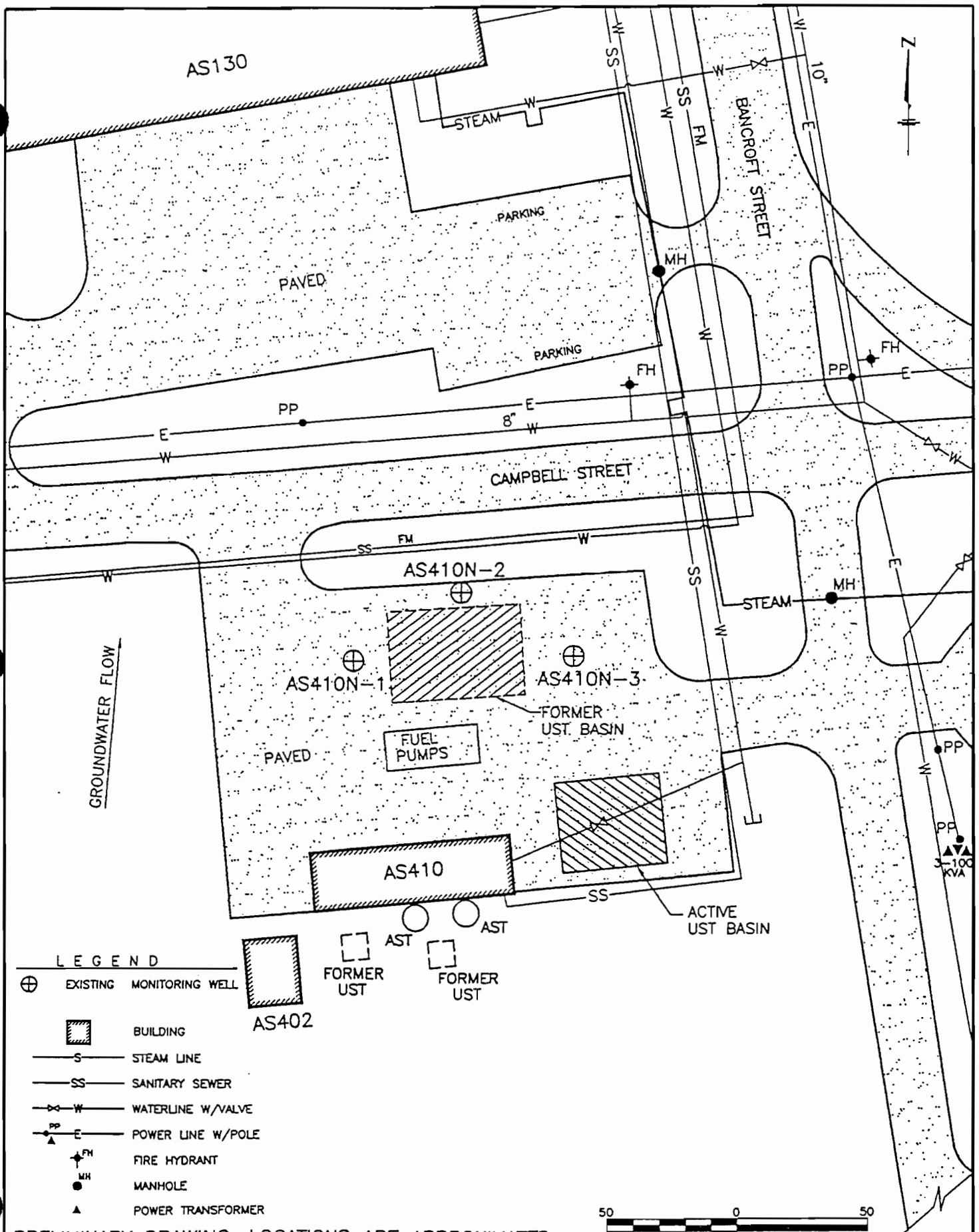
DRAWN BY:
SVH

SCALE:

Richard Catlin & Associates, Inc.
CONSULTING ENGINEERS AND HYDROGEOLOGISTS

FIGURE:

1



PRELIMINARY DRAWING, LOCATIONS ARE APPROXIMATED

Richard Catlin & Associates, Inc.
CONSULTING ENGINEERS
AND HYDROGEOLOGISTS

PROJECT
BUILDING AS-410
LANTDIV NAVFACENGCOM

TITLE
SITE MAP
WITH EXISTING
WELL LOCATIONS

FIGURE

2

NO. 03125 00 DATE: 1 OCT 87 SCALE: AS SHOWN DRAWN BY: WJW CHECKED BY: JP

APPENDIX I

PETROLEUM SUBSTANCES
SUBSTANCE INFORMATION FORMS
MATERIAL SAFETY DATA SHEETS

PETROLEUM SUBSTANCES

INTRODUCTION

During work involving petroleum products, workers may be exposed to petroleum hydrocarbon liquids, vapors or wastes. Petroleum substances in liquid or vapor form are a highly complex mixture of hydrocarbons and additives in varying concentrations. Gasoline for instance, is comprised of over 200 components. Due to the complexity of gasoline and diesel fuel, no firm standards for recommended occupational health and safety have been established. Never the less, health precautions should be taken to minimize exposure to the various petroleum forms.

TOXICITY CONSIDERATIONS

Tests have shown that prolonged or repeated exposures to petroleum substances, in liquid or vapor form, may cause serious illness including cancer in laboratory test animals. High concentrations of inhaled petroleum product components may cause a variety of symptoms including dizziness, intoxication, excitement or unconsciousness (API, 1987). Some petroleum product components may be toxic and care should be exercised to minimize exposure to these substances. When working with or around petroleum substances the ambient air quality should be monitored in the breathing zone by means of an organic vapor detector, oxygen meter, explosimeter and/or colorimetric tubes. However, other aromatic hydrocarbons may become contaminated with benzene during the distillation process and benzene-related health effects should be considered when exposure to any of these agents is suspected (NIOSH, 1985).

The following general health precautions are recommended:

1. Minimize skin contact and breathing of vapors;
2. Keep petroleum projects away from eyes, skin and mouth; and
3. Keep work areas well ventilated.

MATERIAL SAFETY DATA SHEET

GASOLINE, UNLEADED

P. O. BOX 2808 CORPUS CHRISTI, TEXAS 78403
EMERGENCY TELEPHONE NUMBER 1-316-832-6872

PREPARED BY: Dale F. Janes
Industrial Hygienist
DATE: March 1988

SECTION 1. IDENTITY OF MATERIAL

PRODUCT NAME	GASOLINE, UNLEADED		CHEMICAL NAME	None (mixture)	
SYNONYMS	Unleaded; No lead				
FORMULA	See ingredients	CAS NUMBER	8006-61-9	DOT ID NUMBER	1203
HAZARDOUS INGREDIENTS		typical	OSHA PEL	ACGIH TLV	KOCH LIMIT
Paraffins		46	N.D.	N.D.	100 ppm
Olefins		17	N.D.	N.D.	100 ppm
Naphthenes		8	N.D.	N.D.	100 ppm
Benzene* (CAS No. 71-43-2)		1.5	1 ppm	10 ppm	N.A.
Other aromatics		27	N.D.	N.D.	100 ppm

* Listed as a carcinogen in NTP, IARC, and OSHA

SECTION 2. HAZARD SPECIFICATIONS

KNOWN HAZARDS UNDER 29 CFR 1910.1200					
COMBUSTIBLE	NA	IRRITANT	yes	CARCINOGEN	NA
FLAMMABLE (extremely)	yes	MUCOUS MEMBRANE HAZARD	yes	REPRODUCTIVE TOXIN	NA
PYROPHORIC MATERIAL	NA	SKIN HAZARD	yes	BLOOD TOXIN	ND
EXPLOSIVE MATERIAL	NA	EYE HAZARD	yes	NERVOUS SYSTEM TOXIN	yes
UNSTABLE MATERIAL	NA	TOXIC AGENT	NA	LUNG DAMAGING	yes
WATER REACTIVE MATERIAL	NA	HIGHLY TOXIC AGENT	NA	LIVER TOXIN	ND
OXIDIZER	NA	SENSITIZER (possible)	yes	KIDNEY TOXIN	yes
ORGANIC PEROXIDE	NA				
CORROSIVE MATERIAL	NA				
COMPRESSED GAS	NA				
LISTED AS A CARCINOGEN OR A POTENTIAL CARCINOGEN IN: NTP ☐ IARC ☐ OSHA ☐ N.A. ☒					
OSHA PEL = N.D. ACGIH TLV = 300 ppm 8 hr TWA 500 ppm STEL					

SECTION 3. PHYSICAL AND CHEMICAL PROPERTIES

BOILING PT	~ 85°F (29°C)	VAPOR DENSITY AIR = 1	3 - 4	PH	Essentially neutral
VAPOR PRESS MM HG	360 - 720 @ 100°F	SPECIFIC GRAV WATER = 1	0.72 - 0.76	EVAP RATE	Moderately fast
SOLUBILITY IN WATER	Negligible	MELTING POINT	-130°F (-90°C)		
APPEARANCE AND ODOR Clear, colorless liquid. Gasoline odor.					

SECTION 4. FIRE AND EXPLOSION HAZARD DATA

FLASH PT AND METHOD USED	Typical -40°F (-40°C)			AUTOIGNITION TEMPERATURE	536 - 853°F
FLAMMABLE LIMITS	LEL 1.4%	UEL 7.6%	EXTINGUISHING MEDIA	Dry chemical, Water spray, Foam, CO2	
SPECIAL FIRE FIGHTING PROCEDURES Water spray recommended to cool fire-exposed surfaces; to help prevent ignition by dispersing vapors; and to protect personnel attempting shut-off. Avoid using a direct water stream; it may spread the fire over a larger area. Wear self-contained breathing apparatus when fire-fighting in confined spaces.					
UNUSUAL FIRE AND EXPLOSION HAZARDS WARNING! FLAMMABLE. Heat, sparks, open flame, or strong oxidizers may ignite this material. Accumulated vapors can be explosive when ignited. Flowing liquid may ignite by self-generated static electricity; use adequate grounding. Vapors are heavier than air and may accumulate in low areas.					

N.A. = NOT APPLICABLE

N.D. = NOT DETERMINED

~ = APPROXIMATELY

SECTION 5. HEALTH HAZARD DATA

F.3
NATIONAL POISON CENTER 1-412-681-8689

PRIMARY ROUTES OF ENTRY: INHALATION ☒		SKIN ☒	INGESTION ☒
INHALATION EFFECTS ACUTE: Headache, blurred vision, dizziness, nausea, vomiting, coma, respiratory failure, death, depending on the exposure duration and concentration. CHRONIC: May cause kidney damage.			
EFFECTS TO SKIN ACUTE: Can cause skin irritation and is a possible skin allergen. CHRONIC: Prolonged and/or repeated exposures can cause defatting of the skin, which may lead to dryness, cracking, blistering, and dermatitis.			
EFFECTS TO EYES Mist or liquid contact causes immediate eye irritation. Vapor at 160 ppm causes irritation in several hours; at 500 ppm there is irritation in one hour.			
INGESTION EFFECTS Same as above mentioned INHALATION EFFECTS plus capillary hemorrhaging of the lungs and internal organs. Aspiration hazard! Vomiting may allow material to enter the lungs, resulting in severe chemical pneumonia.			
MEDICAL CONDITIONS GENERALLY AGGRAVATED BY EXPOSURE Depending on the severity of the exposure, disorders of the skin, eyes, kidneys, CNS, and respiratory system may be aggravated.			
EMERGENCY AND FIRST AID PROCEDURES			
INHALATION Move person to fresh air. If breathing has stopped, immediately start artificial respiration, mouth to mouth while holding person's nose closed. Get medical attention as soon as possible.			
SKIN Remove contaminated clothing as soon as possible. Wash skin thoroughly with soap and water. Properly decontaminate clothing before rewearing.			
EYES Flush liberally with low pressure water, lifting the lower and upper eyelids occasionally. If irritation persists, get medical attention.			
INGESTION Aspiration hazard! Do <u>NOT</u> induce vomiting. Read INGESTION EFFECTS above in this section. Immediately obtain services of a physician.			

SECTION 6. REACTIVITY DATA

STABILITY	STABLE ☒ UNSTABLE ☐	CONDITIONS TO AVOID	Heat, sparks, and open flame.
INCOMPATIBLE MATERIALS Strong oxidizers such as fluorine, chlorine, nitric & sulfuric acid.			
HAZARDOUS DECOMPOSITION PRODUCTS Combustion/burning can form carbon monoxide, a deadly gas.			
HAZARDOUS POLYMERIZATION	MAY OCCUR ☐ WILL NOT OCCUR ☒	CONDITIONS TO AVOID	None.

NOTICE: Use only nonsparking equipment when in the vicinity of gasoline vapors.

SECTION 7. SAFE HANDLING AND CONTROL MEASURES

CHEMTREC 1-800-424-9300

SPILL OR LEAK CLEANUP PROCEDURES Immediately eliminate all ignition sources; notify spill response personnel; stop leakage; ventilate area if appropriate. Dike a large spill; transfer to tank. Use suitable absorbent for a small spill; shovel into containers.	
WASTE DISPOSAL METHODS The Resource Conservation and Recovery Act as well as other federal, state, and local laws regulate the disposal of chemical wastes.	
HANDLING AND STORING PRECAUTIONS When handling, wear proper protective clothing (see below). Class IA flammable liquid storage required by OSHA. Protect against physical damage; outside or detached storage preferable; separate from oxidizing materials.	
OTHER PRECAUTIONS Extremely flammable! Do not use as a cleaning solvent or charcoal lighter; use only as a motor fuel. Never siphon by mouth or death is a possibility.	
RESPIRATORY PROTECTION Up to 1000 ppm, use half or full mask with organic vapor cartridges. Over 1000 ppm, use SCBA or an air-line respirator with an egress bottle, full mask, and positive pressure.	
VENTILATION Local exhaust and/or dilution ventilation, as needed.	
HAND PROTECTION Wear impervious industrial gloves for prolonged and/or repeated exposures.	
EYE PROTECTION Wear chemical splash goggles for exposures to liquids or mists. In addition, for high pressures, use a face shield.	
OTHER PROTECTION Other impervious clothing may be necessary depending on work situations. This clothing may include boots, pants, coat, and full face protection.	

IMPORTANT NOTICE: The information contained in this Material Safety Data Sheet has been prepared in accordance with the OSHA Hazard Communication Standard, 29 CFR 1910.1200. This information relates specifically to the product designated and may not be valid for the product when used in combination with any other materials or products or in a particular process. The information is, to the best of our knowledge and belief, accurate and reliable as of the date compiled. However, no representation, warranty or guarantee is made as to its accuracy, reliability or completeness. It is the user's responsibility to review this information, satisfy itself as to its suitability and not pass on the information to its employees or customers in accordance with applicable federal, state or local hazard communication regulations. The user accepts responsibility for any loss or damage which may occur from the use of this information.

1A

GASOLINES: AUTOMOTIVE

(< 4.23g lead/gal)

Common Denominators	
Watery liquid	Colorless to pale brown or pink Gasoline odor
Floats on water. Flammable, irritating vapor is produced.	
Stop discharge if possible. Keep people away. Shut off ignition sources and call fire department. Stay upwind and use water spray to "knock down" vapor. Isolate and remove discharged material. Notify local health and pollution control agencies.	
Fire	FLAMMABLE Flashback along vapor trail may occur. Vapor may explode if ignited in an enclosed area. Extinguish with dry chemical, foam, or carbon dioxide. Water may be ineffective on fire. Cool exposed containers with water.
Exposure	CALL FOR MEDICAL AID. VAPOR Irritating to eyes, nose and throat. If inhaled, will cause dizziness, headache, difficult breathing or loss of consciousness. Move to fresh air. If breathing has stopped, give artificial respiration. If breathing is difficult, give oxygen. LIQUID Irritating to skin and eyes. If swallowed, will cause nausea or vomiting. Remove contaminated clothing and shoes. Flush affected areas with plenty of water. IF IN EYES, hold eyelids open and flush with plenty of water. IF SWALLOWED and victim is CONSCIOUS, have victim drink water or milk. DO NOT INDUCE VOMITING.
Water Pollution	HARMFUL TO AQUATIC LIFE IN VERY LOW CONCENTRATIONS Floating to shoreline. May be dangerous if it enters water intakes. Notify local health and wildlife officials. Notify operators of nearby water intakes.
1. RESPONSE TO DISCHARGE (See Appendix Appendixes, CG 4-6-6-1) Issue warning: high flammability Evacuate area Disperse and flush	2. LABEL 
1. CHEMICAL DESIGNATIONS 3.1 Synonyms: Motor spirit Petrol 3.2 Coast Guard Compatibility Classifications: Miscellaneous hydrocarbon mixtures 3.3 Chemical Formula: (Mixture of hydrocarbons) 3.4 IMCO/United Nations Numerical Designation: 111203	4. OBSERVABLE CHARACTERISTICS 4.1 Physical State (as shipped): Liquid 4.2 Color: Colorless to brown 4.3 Odor: Gasoline
5. HEALTH HAZARDS	
5.1 Personal Protective Equipment: Protective goggles, gloves. 5.2 Symptoms Following Exposure: Irritation of mucous membranes and stimulation followed by depression of central nervous system. Breathing of vapor may also cause dizziness, headache, and incoordination or, in more severe cases, anesthesia, coma, and respiratory arrest. If liquid enters lungs, it will cause severe irritation, coughing, gagging, pulmonary edema, and, later, signs of bronchopneumonia and pneumonia. Swallowing may cause irregular heartbeat. 5.3 Treatment for Exposure: INHALATION: maintain respiration and administer oxygen; enforce hot rest if liquid is in lungs. INGESTION: do NOT induce vomiting; stomach should be lavaged (in absence of appreciable quantity is swallowed). EYES: wash with copious quantity of water. SKIN: wipe off and wash with soap and water. 5.4 Toxicity by Inhalation (Threshold Limit Value): ~~300 ppm~~ 300 ppm 5.5 Short-Term Inhalation Limits: 300 ppm for 30 min. 5.6 Toxicity by Ingestion: Grade 2: LD₅₀ 0.5 to 5 g/kg. 5.7 Late Toxicity: None 5.8 Vapor (Gas) Irritant Characteristics: Vapors cause a slight stinging of the eyes or respiratory system if present in high concentrations. The effect is temporary. 5.9 Liquid or Solid Irritant Characteristics: Minimum hazard. If spilled on clothing and allowed to remain, may cause stinging and reddening of the skin. 5.10 Odor Threshold: 0.25 ppm	

6. FIRE HAZARDS	8. WATER POLLUTION																																				
6.1 Flash Point: -16°F C.C. 6.2 Flammable Limits in Air: 1.4% - 7.4% 6.3 Fire Extinguishing Agents: Foam, carbon dioxide, dry chemical 6.4 Fire Extinguishing Agents Not to be Used: Water may be ineffective 6.5 Special Hazards of Combustion Products: None 6.6 Behavior in Fire: Vapor is heavier than air and may travel considerable distance to a source of ignition and flash back. 6.7 Ignition Temperature: 533°F 6.8 Electrical Hazard: Class I, Group D 6.9 Burning Rate: 4 mm/min.	8.1 Aquatic Toxicity: 90 ppm/24 hr/juvenile American shad/ TL₅₀/fresh water 91 mg/l/24 hr/juvenile American shad/ TL₅₀/salt water 8.2 Waterfowl Toxicity: Data not available 8.3 Biological Oxygen Demand (BOD): 8%, 5 days 8.4 Food Chain Concentration Potential: None																																				
7. CHEMICAL REACTIVITY	9. SELECTED MANUFACTURERS																																				
7.1 Reactivity with Water: No reaction 7.2 Reactivity with Common Materials: No reaction 7.3 Stability During Transport: Stable 7.4 Neutralizing Agents for Acids and Caustics: Not pertinent 7.5 Polymerization: Not pertinent 7.6 Inhibitor of Polymerization: Not pertinent	1. Exxon Co. 30 Rockefeller Plaza New York, N. Y. 10020 2. Shell Oil Co. 1 Shell Plaza Houston, Texas 77001 3. Sun Oil Co. St. Davids, Pa. 19087																																				
11. HAZARD ASSESSMENT CODE (See Hazard Assessment Appendixes, CG 4-6-6-3) A-T-U-V-W	10. SHIPPING INFORMATION																																				
12. HAZARD CLASSIFICATIONS	10.1 Grades or Purity: Various octane ratings, military specification 10.2 Storage Temperature: Ambient 10.3 Inert Atmosphere: No requirement 10.4 Venting: Open (flame arrester) or pressure-vacuum																																				
12.1 Code of Federal Regulations: Flammable liquid 12.2 HAS Hazard Rating for Bulk Water Transportation: <table border="1"> <thead> <tr> <th>Category</th> <th>Rating</th> </tr> </thead> <tbody> <tr> <td>Fire</td> <td>3</td> </tr> <tr> <td>Health</td> <td></td> </tr> <tr> <td>Vapor Irritant</td> <td>1</td> </tr> <tr> <td>Liquid or Solid Irritant</td> <td>1</td> </tr> <tr> <td>Poison</td> <td>2</td> </tr> <tr> <td>Water Pollution</td> <td></td> </tr> <tr> <td>Human Toxicity</td> <td>1</td> </tr> <tr> <td>Aquatic Toxicity</td> <td>2</td> </tr> <tr> <td>Anesthetic Effect</td> <td>2</td> </tr> <tr> <td>Reactivity</td> <td></td> </tr> <tr> <td>Other Chemicals</td> <td>0</td> </tr> <tr> <td>Water</td> <td>0</td> </tr> <tr> <td>Self-Reaction</td> <td>0</td> </tr> </tbody> </table> 12.3 NFPA Hazard Classifications: <table border="1"> <thead> <tr> <th>Category</th> <th>Classification</th> </tr> </thead> <tbody> <tr> <td>Health Hazard (Blue)</td> <td>1</td> </tr> <tr> <td>Flammability (Red)</td> <td>3</td> </tr> <tr> <td>Reactivity (Yellow)</td> <td>0</td> </tr> </tbody> </table>	Category	Rating	Fire	3	Health		Vapor Irritant	1	Liquid or Solid Irritant	1	Poison	2	Water Pollution		Human Toxicity	1	Aquatic Toxicity	2	Anesthetic Effect	2	Reactivity		Other Chemicals	0	Water	0	Self-Reaction	0	Category	Classification	Health Hazard (Blue)	1	Flammability (Red)	3	Reactivity (Yellow)	0	13. PHYSICAL AND CHEMICAL PROPERTIES
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Health Hazard (Blue)	1																																				
Flammability (Red)	3																																				
Reactivity (Yellow)	0																																				
	13.1 Physical State at 15°C and 1 atm: Liquid 13.2 Molecular Weight: Not pertinent 13.3 Boiling Point at 1 atm: 140 JyO°F = 40 194°C = 333 472°K 13.4 Freezing Point: Not pertinent 13.5 Critical Temperature: Not pertinent 13.6 Critical Pressure: Not pertinent 13.7 Specific Gravity: 0.7321 at 20°C (liquid) 13.8 Liquid Surface Tension: 19 23 dynes/cm = 0.019 023 N/m at 20°C 13.9 Liquid-Water Interfacial Tension: 29 51 dynes/cm = 0.049 051 N/m at 20°C 13.10 Vapor (Gas) Specific Gravity: 3.4 13.11 Ratio of Specific Heats of Vapor (Gas): (cal.) 1.054 13.12 Latent Heat of Vaporization: 130 150 Btu/lb = 71 81 cal/g = 3.0 1.4 x 10⁵ J/kg 13.13 Heat of Combustion: -18,720 Btu/lb = -10,400 cal/g = -435.1 x 10³ J/kg 13.14 Heat of Decomposition: Not pertinent 13.15 Heat of Solution: Not pertinent 13.16 Heat of Polymerization: Not pertinent																																				
NOTES																																					

APPENDIX II
SITE ORGANIZATION AND CONTROL

SITE ORGANIZATION AND CONTROL

• SITE CONTROL MEASURES

The following section defines measures and procedures for maintaining site control. Site control is an essential component in the implementation of the site health and safety program.

• General

Prior to any site work the following items will be addressed:

- Site reconnaissance
- Obtain drawings of site and/or existing private utilities for the site.
- Contact utility locating services (U-L-O-C-O) and/or local utility companies and request a site inspection.
- Check for physical restraints/obstructions such as overhead utilities, signs, canopies, etc...
- Determine work areas (decontamination, staging, etc...).
- Barricade work areas, as necessary, to isolate from pedestrians and vehicles.

• Site Communications Plan

Successful communications between field teams and contact with personnel in the support zone is essential. The following communications systems should be available during activities at the Site.

- Noise makers (horns, whistle, siren)

<u>Signal</u>	<u>Definition</u>
One long blast	Evacuate area by nearest emergency exit.

Two short blasts	Localized problem. Not dangerous to workers.

Two long blasts	All clear. Resume activities.

- Hand Signals

<u>Signal</u>	<u>Definition</u>
Hands clutching throat	Out of air/cannot breath
Hands on top of head	Need assistance
Thumbs up	OK/I am all right/I understand
Thumbs down	No/negative
Arms waving upright	Send backup support
Grip partners wrist	Exit area immediately

- Buddy System (where necessary):

This system is used in situations where partners provide each other with assistance and observe his or her partner for signs of chemical exposure or for medical emergencies.

- Safe Work Practices:

Standing orders have been developed to maintain a strong safety awareness and to enforce safe procedures at the Site.

- Work Area

No smoking, eating or drinking;
No horse play;
No matches or lighters;
Implement the communications system; and
Wear the appropriate level of protection as defined in this plan.

- Excavations/trenching:

Hazards encountered during soil and test pit excavation or trenching include both chemical and physical agents, and are as follows:

- Exposure to airborne contaminants released during intrusive activities. Flammable atmospheres may also be encountered.
- Excavation cave in.
- Falling during access/egress, while monitoring, or stumbling into excavation.
- Overhead hazard may result from material, tools, rock and/or soil falling into the excavation.
- Congested work area due to too many workers in small area.

Hazard prevention includes:

- Monitor for airborne contaminants. Allow test pits/excavations to purge and/or use PPE.

- Provide adequate shoring and sloping of sides of the excavation. Regularly inspect trenches for changing conditions.
 - Solid rock, cemented sand or gravel = 90 degrees
 - Compact angular gravel = 63 degrees 26 feet deep
 - Compacted sharp sand = 33 degrees 41 feet deep
 - Rounded loose sand = 26 degrees 34 feet deep
- Provide ramps or ladders to trenches to allow safe access and egress.
- Provide an adequate barrier around open pits (barricades, barricade tape, etc...)
- Maintain ample work room between workers.
- Confined Space Entry Procedures (CSEP)

A confined space provides the potential for unusually high concentrations of contaminants, explosive atmospheres, limited visibility, and restricted movements.

General provisions include:

- When possible, confined spaces should be identified with a posted sign which reads: Caution - Confined Space.
- Only personnel trained and knowledgeable of the requirements of the Confined Space Entry Procedures will be authorized to enter a confined space or be a confined space observer.
- Natural ventilation shall be provided for the confined space prior to initial entry and for the duration of the CSEP. Positive/forced mechanical ventilation may be required. However, care should be taken to not spread contamination outside of the enclosed area.
- If flammable liquids may be contained within the confined space, explosion proof equipment will be used. All equipment shall be positively grounded.
- The contents of any confined space shall, where necessary, be removed prior to entry. All sources of ignition must be removed prior to entry.
- Hand tools used in confined spaces shall be in good repair explosion proof and spark proof, and selected according to intended use. Where possible, pneumatic power tools are to be used.

- Hand-held lights and other illumination utilized in confined spaces shall be equipped with guards to prevent contact with the bulb and must be explosion proof.
- Compressed gas cylinders, except cylinders used for a self-contained breathing apparatus, shall not be taken into confined spaces. Gas hoses shall be removed from the space and the supply turned off at the cylinder valve when personnel exit from the confined space.
- If a confined space requires respiratory equipment or where rescue may be difficult, safety belts, body harnesses, and lifelines will be used. The outside observer shall be provided with the same equipment as those working within the confined space.
- A ladder is required in all confined spaces deeper than the employee's shoulders. The ladder shall be secured and not removed until all employees have exited the space.
- Only self-contained breathing apparatus or NIOSH approved airline respirators equipped with a 5-minute emergency air supply (egress bottle) shall be used in untested confined spaces or in any confined space with conditions determined immediately dangerous to life and health.
- Where air-moving equipment is used to provide ventilation, chemicals shall be removed from the vicinity to prevent introduction into the confined space.
- Vehicles shall not be left running near confined space work or near air-moving equipment being used for confined space ventilation.
- Smoking in confined spaces will be prohibited at all times.
- Any deviation from these Confined Space Entry Procedures requires the prior permission of the Site Safety Officer.

APPENDIX III
CONTINGENCY PLAN

CONTINGENCY PLAN

CONTINGENCY PLAN

This section describes contingencies and emergency planning procedures to be implemented at the Site. This plan is compatible with local, state and federal disaster and emergency management plans as appropriate.

- Pre-Emergency Plan

During the periodic site briefings, all employees will be trained in and reminded of provisions of the emergency response plan, communications systems, and evacuation routes. The HASP identifies the hazardous conditions associated with specific site activities. The plan will be reviewed on a regular basis and revised, if necessary, by the HSO. This will ensure that the plan is adequate and consistent with prevailing site conditions.

- Personnel Roles and Lines of Authority

The Site Supervisor has primary responsibility for responding to and correcting emergency situations. This includes taking appropriate measures to ensure the safety of site personnel and the public. Possible actions may involve evacuation of personnel from the site area, and/or evacuation of adjacent residents. He/she is additionally responsible for ensuring that corrective measures have been implemented, appropriate authorities notified, and follow-up reports completed. The HSO may be called upon to act on the behalf of the site supervisor, and may direct responses to any medical emergency. The individual contractor organizations are responsible for assisting the project manager in his/her mission within the parameters of their scope of work.

The Site Supervisor(s): James L. Cornette, RC&A, (919) 452-5861, or (800) 346-7360

The HSO: Teri M. Piver, RC&A, (919) 452-5861, or (800) 346-7360

- Evacuation Routes/Procedures

In the event of an emergency which necessitates an evacuation of the site, the following alarm procedures will be implemented:

Evacuation alarm notification should be made using one long blast on the air horn. All personnel should evacuate upwind of any activities. Insure that a predetermined location is identified off-site in case of an emergency, so that all personnel can be accounted for.

Personnel will be expected to proceed to the closest exit with your buddy, and mobilize to the safe distance area associated with the evacuation route. Personnel will remain at that area until the re-entry alarm is sounded or an authorized individual provides further instructions.

- Emergency Medical Treatment Procedures

Any person who becomes ill or injured in the Exclusion Zone must be decontaminated to the maximum extent possible. If the injury or illness is minor, full decontamination should be completed and first aid administered prior to transport. If the patient's condition is serious, at least partial decontamination should be completed (i.e., complete disrobing of the victim and redressing in clean coveralls or wrapping in a blanket). First aid should be administered while awaiting an ambulance or paramedics. All injuries and illnesses must immediately be reported to the project manager.

Any person being transported to a clinic or hospital for treatment should take with them information on the chemical they have been exposed to at the site.

Any vehicle used to transport contaminated personnel will be treated and cleaned as necessary.

- Heat Stress

One or more of the following measures will be used to help control heat stress:

- Provision of adequate liquids to replace body fluids. Workers must replace water and salt lost from sweating. Employees must be encouraged to drink more than the amount required to satisfy thirst. Thirst satisfaction is not an accurate indicator of adequate salt and fluid replacement.
- Replacement fluids can be commercial mixes, such as Gatorade, or a combination of these with fresh water. Replacement fluids should be cool (50-60° F) but not chilled (40° F).
- Establishment of a work regiment that will provide adequate rest periods for cooling down . This may require additional shifts of workers.
- During the hot season, workers should frequently drink small amounts (i.e. one cup every 15 - 20 minutes).

- Cooling devices such as cooling vests may be worn beneath protective garments.
- All breaks are to be taken in a cool area (77° F is best).
- Employees shall remove impermeable protective garments during rest periods.
- Workers shall not be assigned other tasks during rest periods.
- All employees shall be informed of the importance of adequate rest, acclimation and proper diet in the prevention of heat stress.
- A copy of the "American Red Cross Standard First Aid" will be available on-site.
- Heat Stress Monitoring
 - For workers wearing permeable clothing, refer to the "American Conference of Government Industrial Hygienists' (ACGIH) Threshold Limit Values for Heat Stress".
 - For workers wearing semipermeable or impermeable ensembles the ACGIH standard cannot be used. For these situations, workers should be monitored when the temperature in the work area is above 70° F. Therefore, the following measures should be employed.
 - Heart rate. Count the radial pulse during a 30-second period as early as possible in the rest period.

If the heart rate exceeds 110 beats per minute at the beginning of the rest period, shorten the next work cycle by one third and keep the rest period the same. If the heart rate still exceeds 110 beats per minute at the next rest period, shorten the following work cycle by one-third.

 - Oral temperature. Use a clinical thermometer (3 minutes under the tongue) or similar device to measure the oral temperature at the end of the work period (before drinking replacement fluids).

If the oral temperature exceeds 99.6° F shorten the next work cycle by one-third without changing the rest period. If the oral temperature still exceeds 99.6° F at the beginning of the next rest period, shorten the following work cycle by one-third.

Do not permit a worker to wear a semipermeable or impermeable garment when his/her oral temperature exceeds 100.6° F.

- Body water loss. If possible, measure weight at the beginning of each work day to see if enough fluids are being taken to prevent dehydration. The body water loss should not exceed 1.5 percent of the total body weight loss in a work day.

- Fire or Explosion

In the event of a fire or explosion, the local fire department should be summoned immediately. Upon their arrival, the project manager or designated alternate will advise the fire commander of the location, nature, and identification of the hazardous materials onsite.

If it is safe to do so, site personnel may:

- Remove or isolate flammable or other hazardous materials which may contribute to the fire.

- Spill or Leaks

In the event of a spill or a leak, site personnel will:

- Inform their supervisor immediately;
- Locate the source of the spillage and stop the flow if it can be done safely; and
- Begin containment and recovery of the spilled materials.

APPENDIX II
BORING LOG
AS-BUILT WELL DETAILS
NC WELL CONSTRUCTION RECORD
WELL SAMPLING WORKSHEET
CHAIN OF CUSTODY RECORD
IN-SITU PERMEABILITY (SLUG) TEST

BORING LOG

BORING NUMBER _____
TOTAL DEPTH _____

SITE LOCATION _____

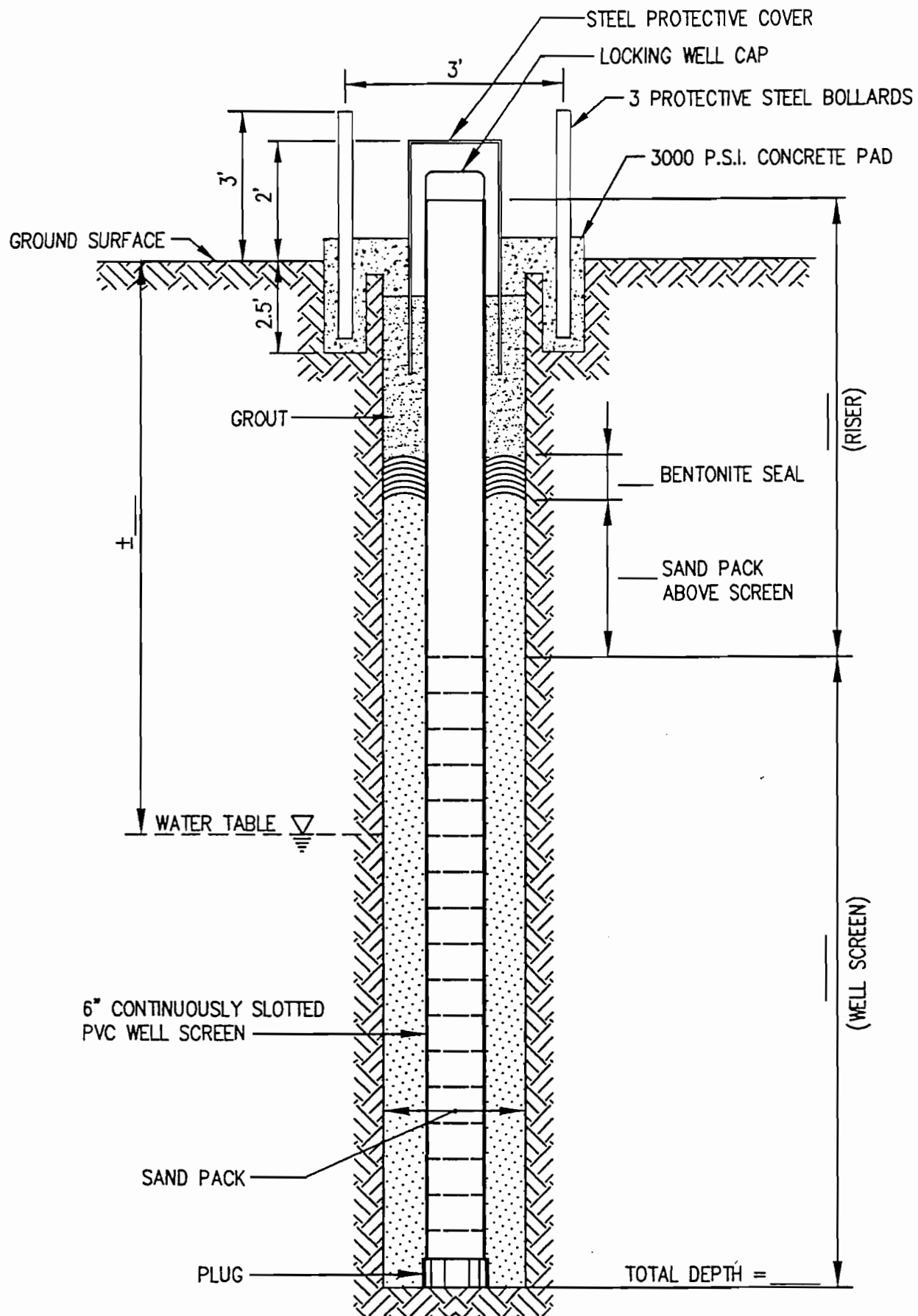
DRILLED BY _____
LOGGED BY _____

DRILLING DATE _____

[illegible]

REMARKS _____

PAGE__ OF__



PROJECT

MARINE CORPS BASE
CAMP LEJEUNE, N.C.
LANTDIV NAVFACENGCOM

TITLE

ABOVE GROUND
PUMPING WELL DETAIL

JOB NO.

TRAINING RT.

SCALE:

NTS

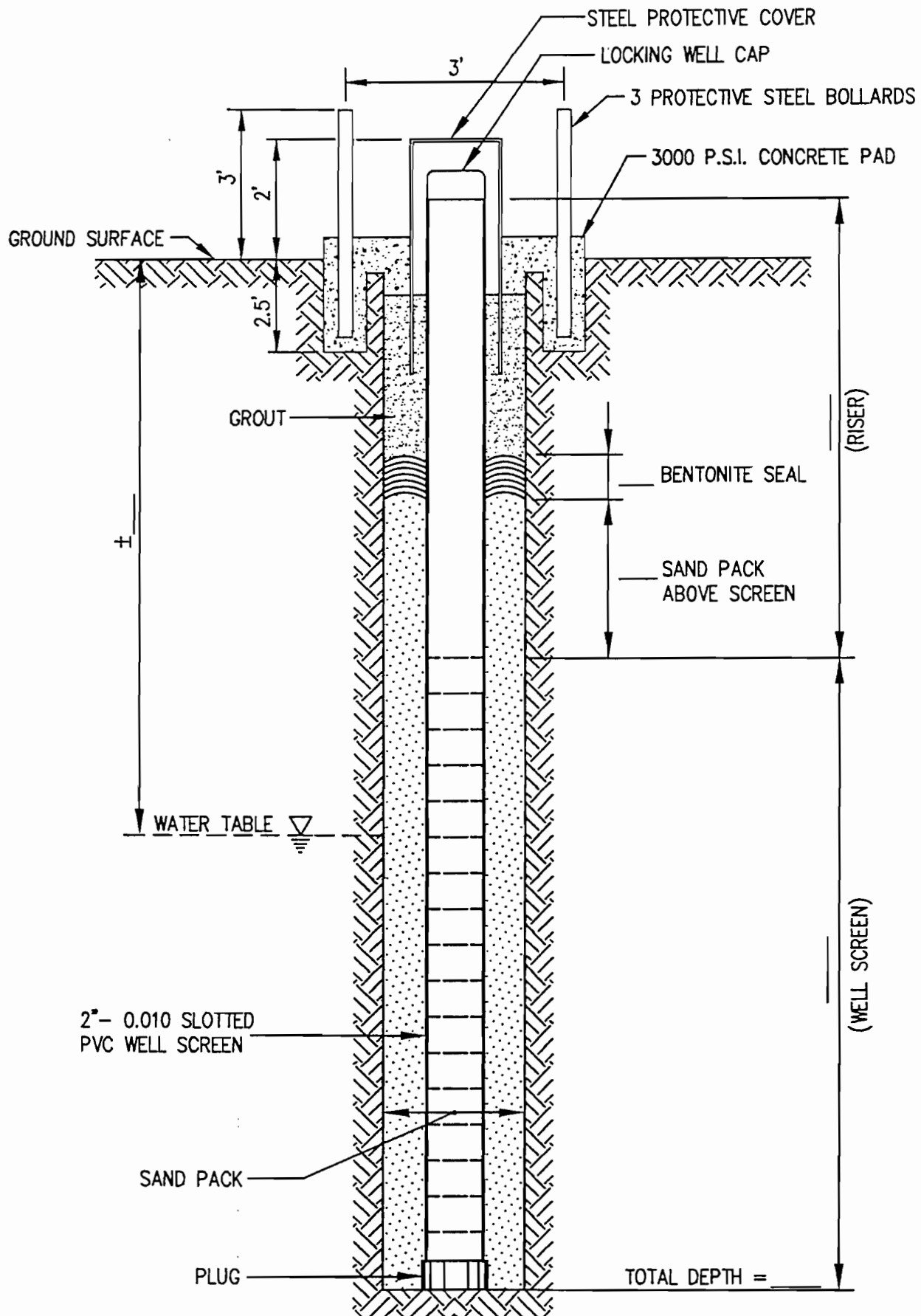
DATE:

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CONSULTING ENGINEERS
AND HYDROGEOLOGISTS

WILMINGTON, NC CHARLESTON, SC ATLANTA, GA
HOUSTON, TX MIAMI, FL ST. PETERSBURG, FL

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FIGURE



PROJECT

MARINE CORPS BASE
CAMP LEJEUNE, N.C.
LANTDIV NAVFACENGCOM

TITLE

ABOVE GROUND TYPE II
MONITORING WELL DETAIL

JOB NO.

SCALE

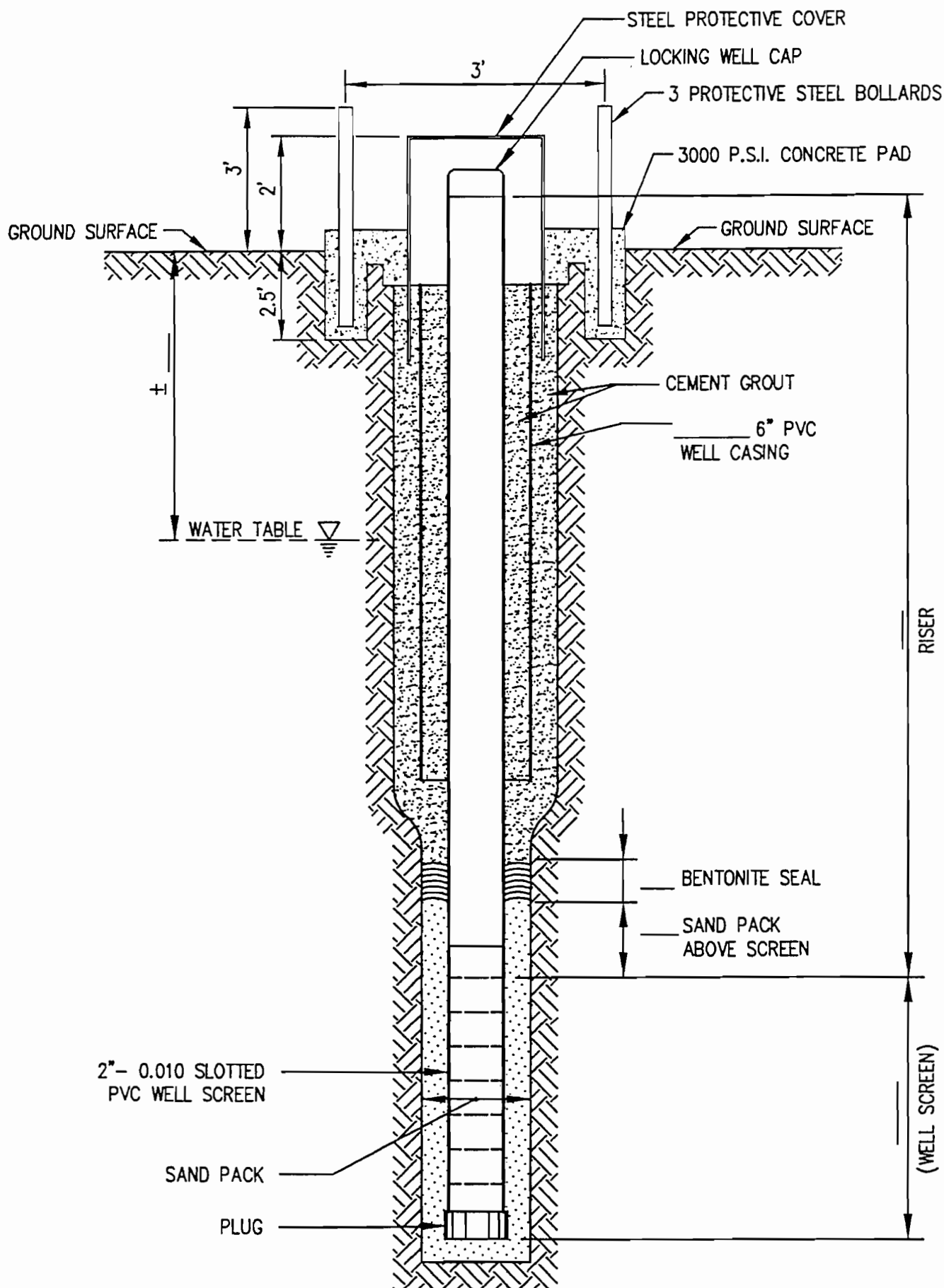
NTS

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THE WASHINGTON FIELD OFFICE OF THE U.S. ARMY

FIGURE

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PROJECT

MARINE CORPS BASE
CAMP LEJEUNE, N.C.
LANTDIV NAVFACENGCOM

TITLE

ABOVE GROUND TYPE III
MONITORING WELL DETAIL

JOB NO.

SCALE:

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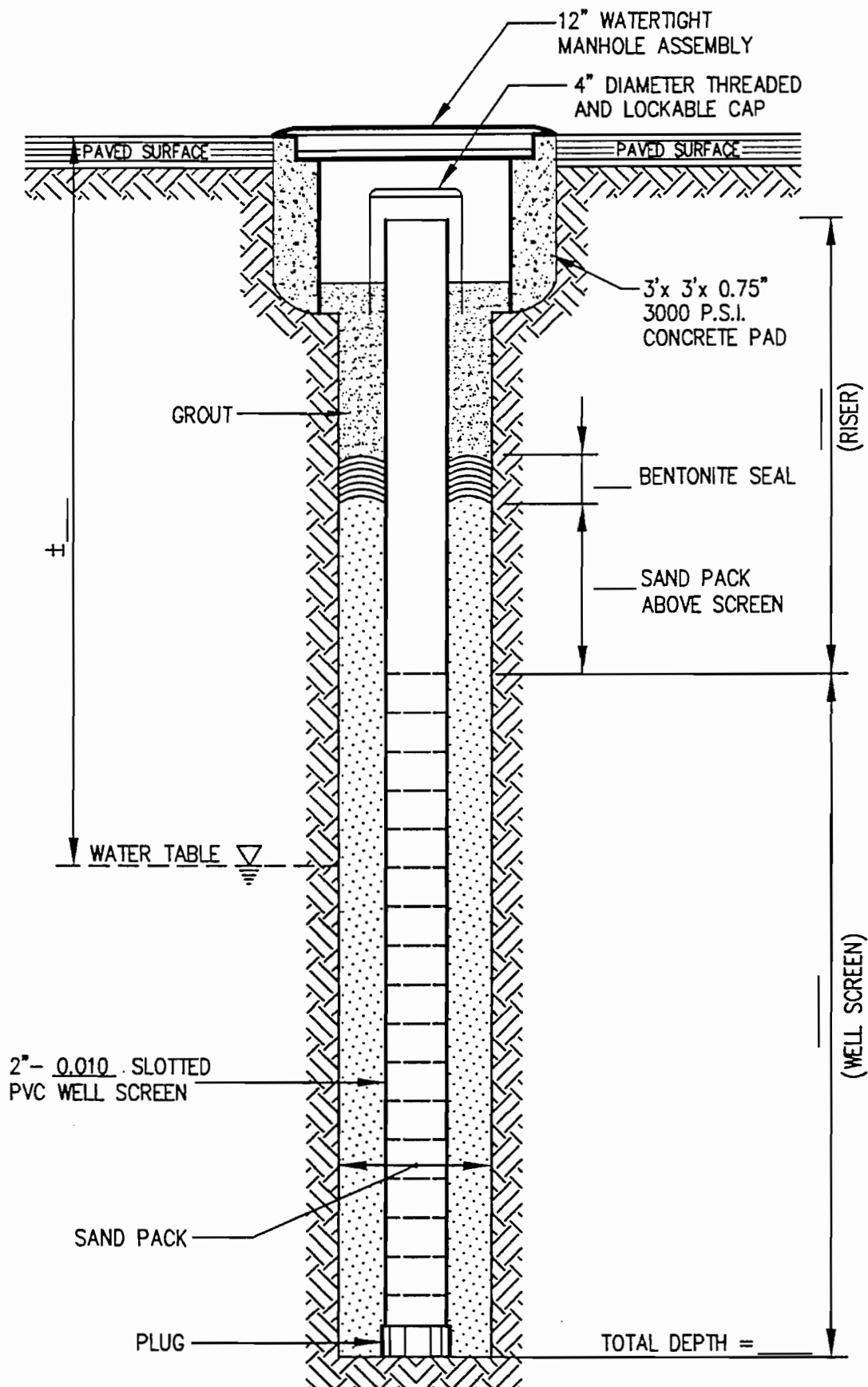
DATE:

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FIGURE



PROJECT
MARINE CORPS BASE
CAMP LEJEUNE, N.C.
LANTDIV NAVFACENGCOM

TITLE
PAVED SURFACE TYPE II
MONITORING WELL DETAIL

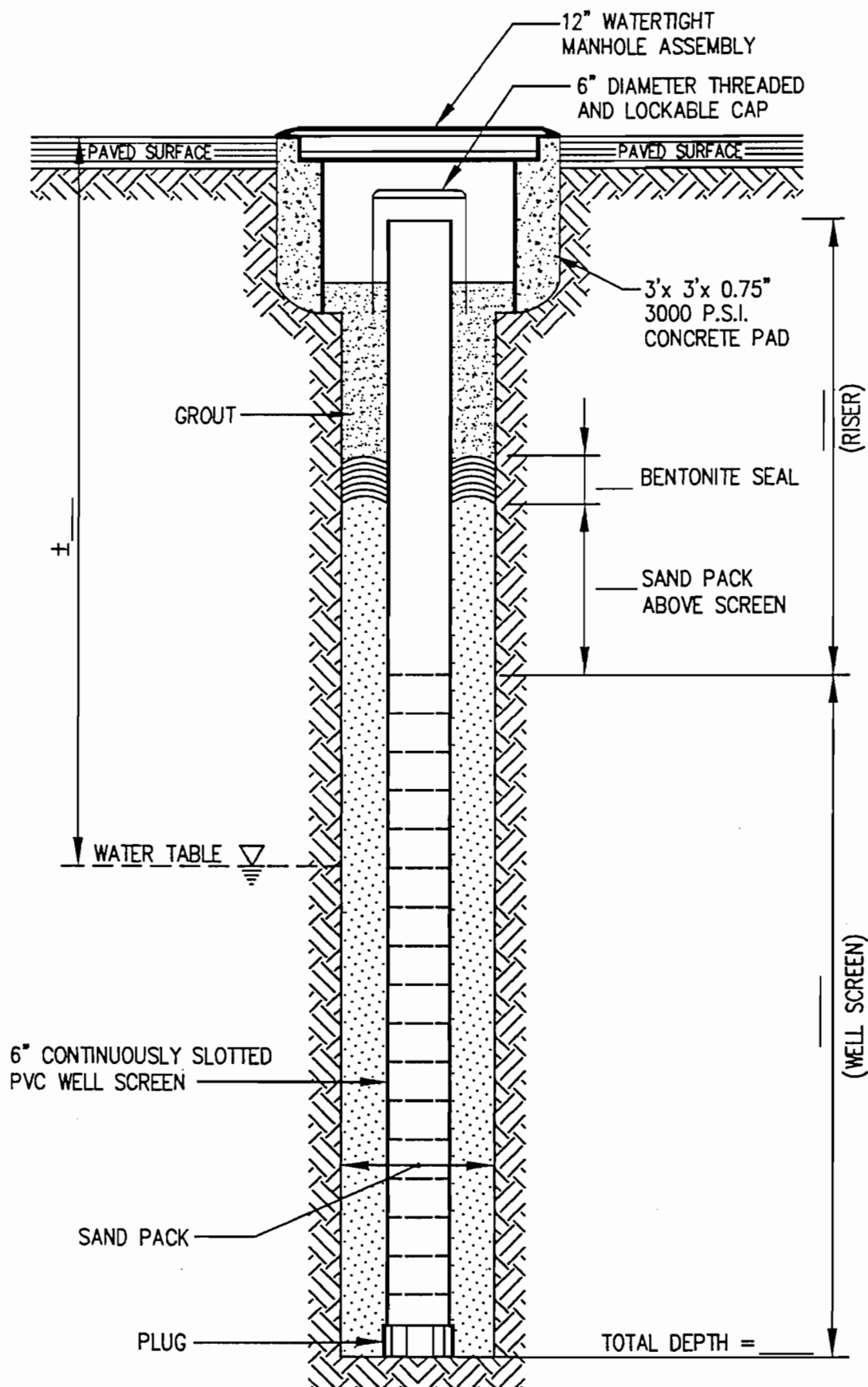
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DRAWN BY: DATE:

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FIGURE

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PROJECT

MARINE CORPS BASE
CAMP LEJEUNE, N.C.
LANTDIV NAVFACENGCOM

TITLE

PAVED SURFACE
PUMPING WELL DETAIL

JOB NO.

SCALE:

NTS

DRAWN BY:

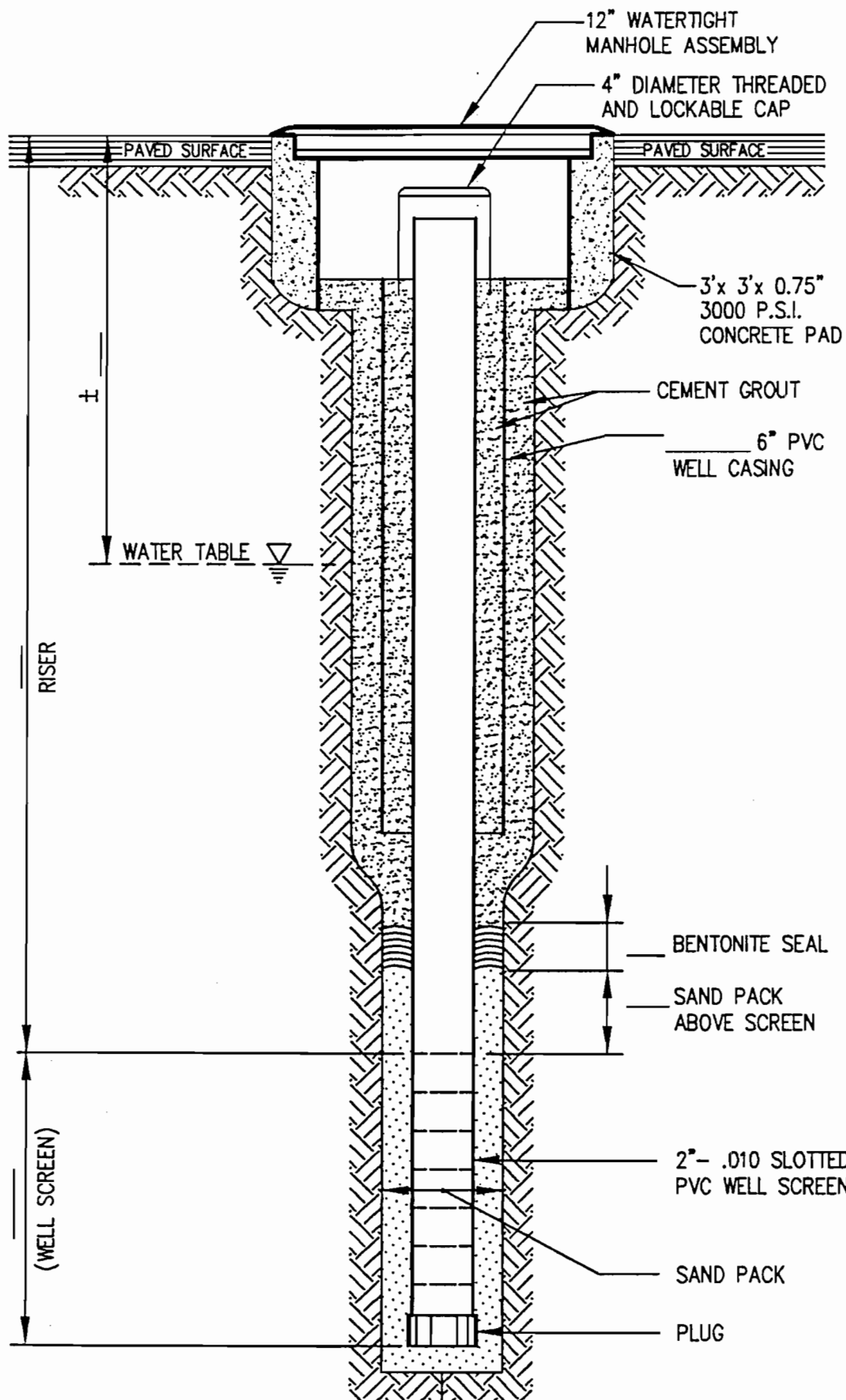
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FIGURE



PROJECT
MARINE CORPS BASE
CAMP LEJEUNE, N.C.
LANTDIV NAVFACENGCOM

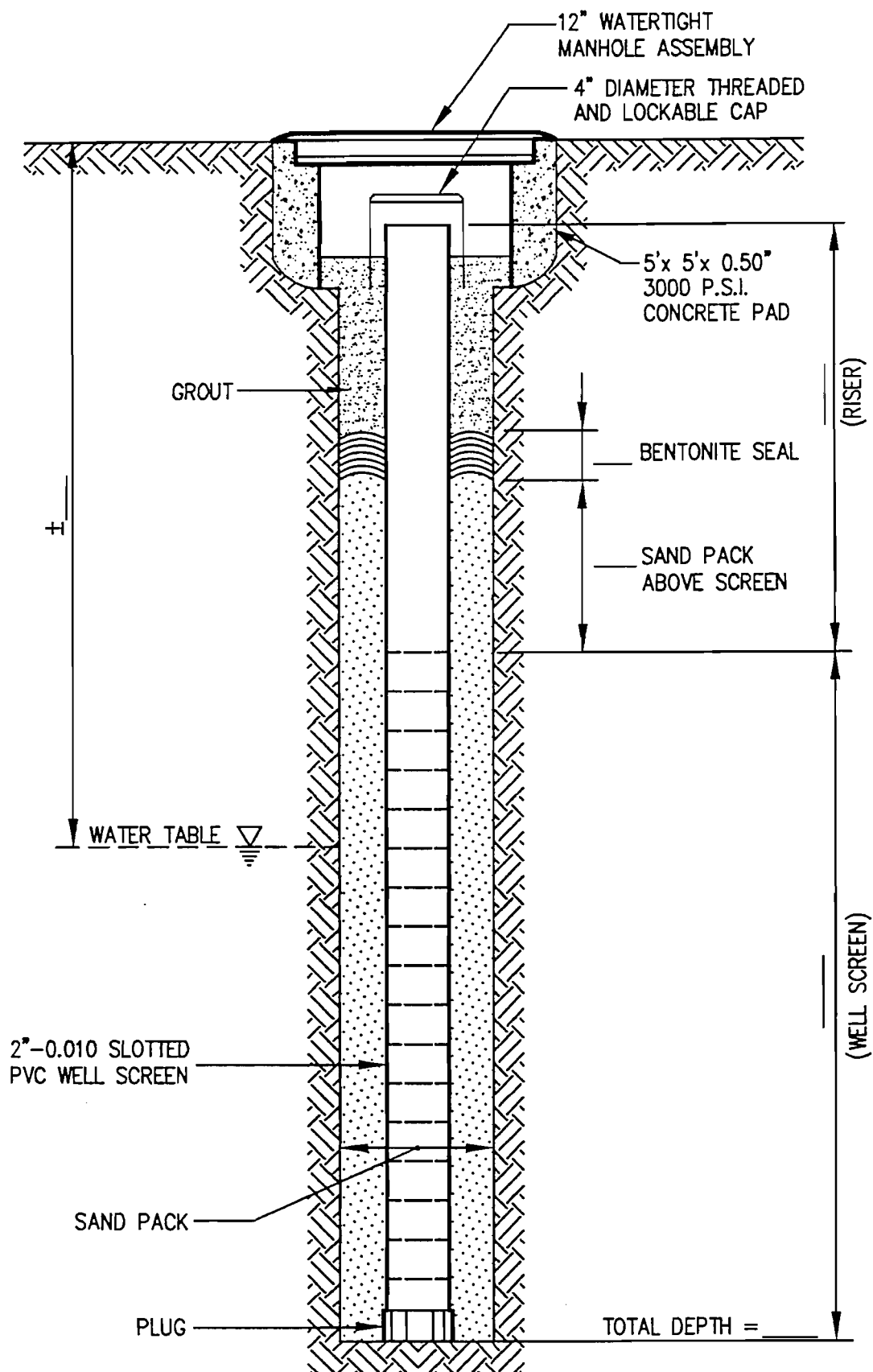
TITLE
PAVED SURFACE TYPE III
MONITORING WELL DETAIL

JOB NO. SCALE: NTS
DRAWN BY: DATE:

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FIGURE

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PROJECT
MARINE CORPS BASE
CAMP LEJEUNE, N.C.
LANTDIV NAVFACENGCOM

TITLE
UNPAVED SURFACE TYPE II
MONITORING WELL DETAIL

JOB NO.

SCALE:

NTS

DRAWN BY:

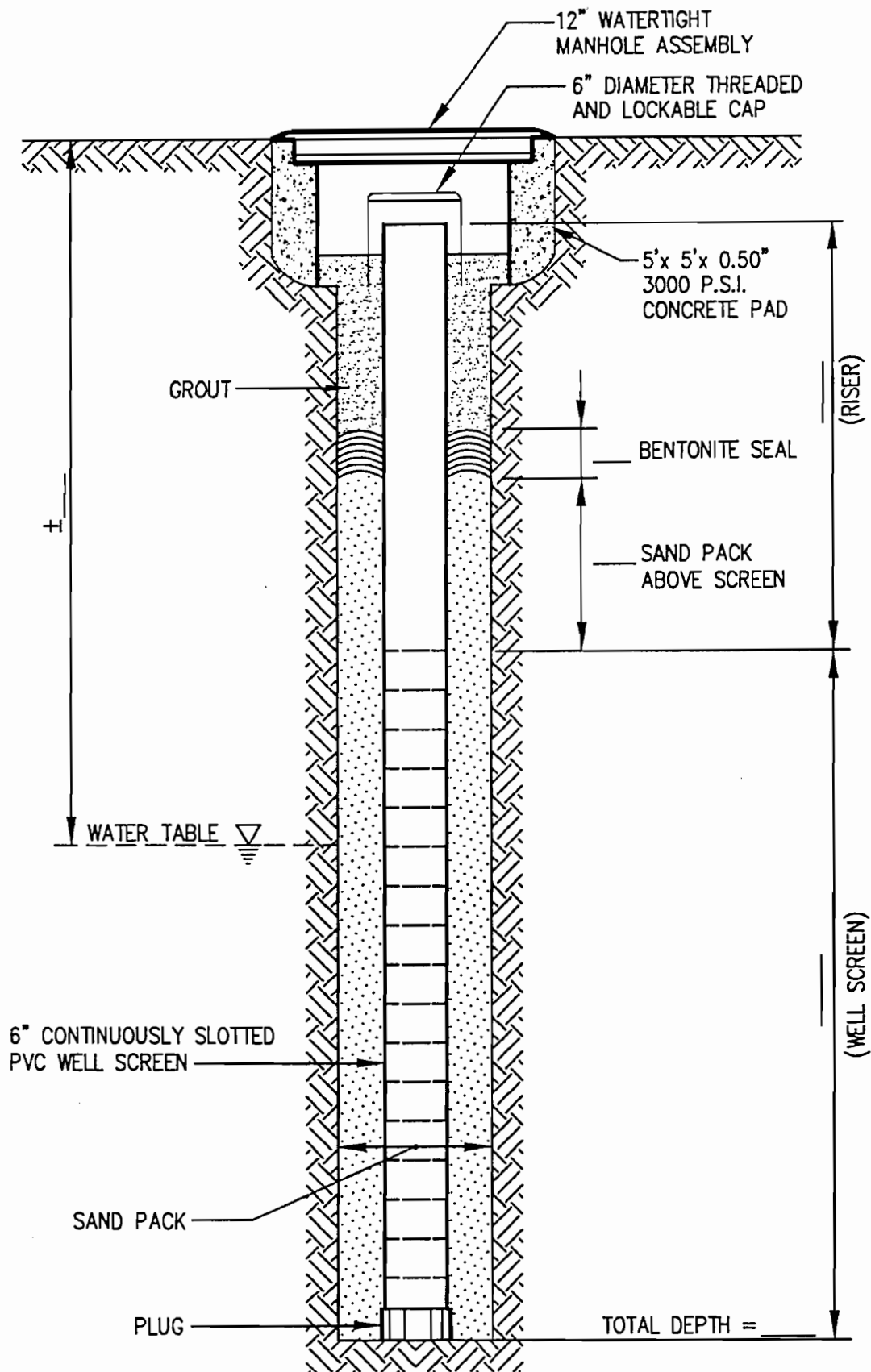
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FIGURE



PROJECT

MARINE CORPS BASE
CAMP LEJEUNE, N.C.
LANTDIV NAVFACENGCOM

TITLE

UNPAVED SURFACE
PUMPING WELL DETAIL

JOB NO.

DRAWN BY:

SCALE:

NTS

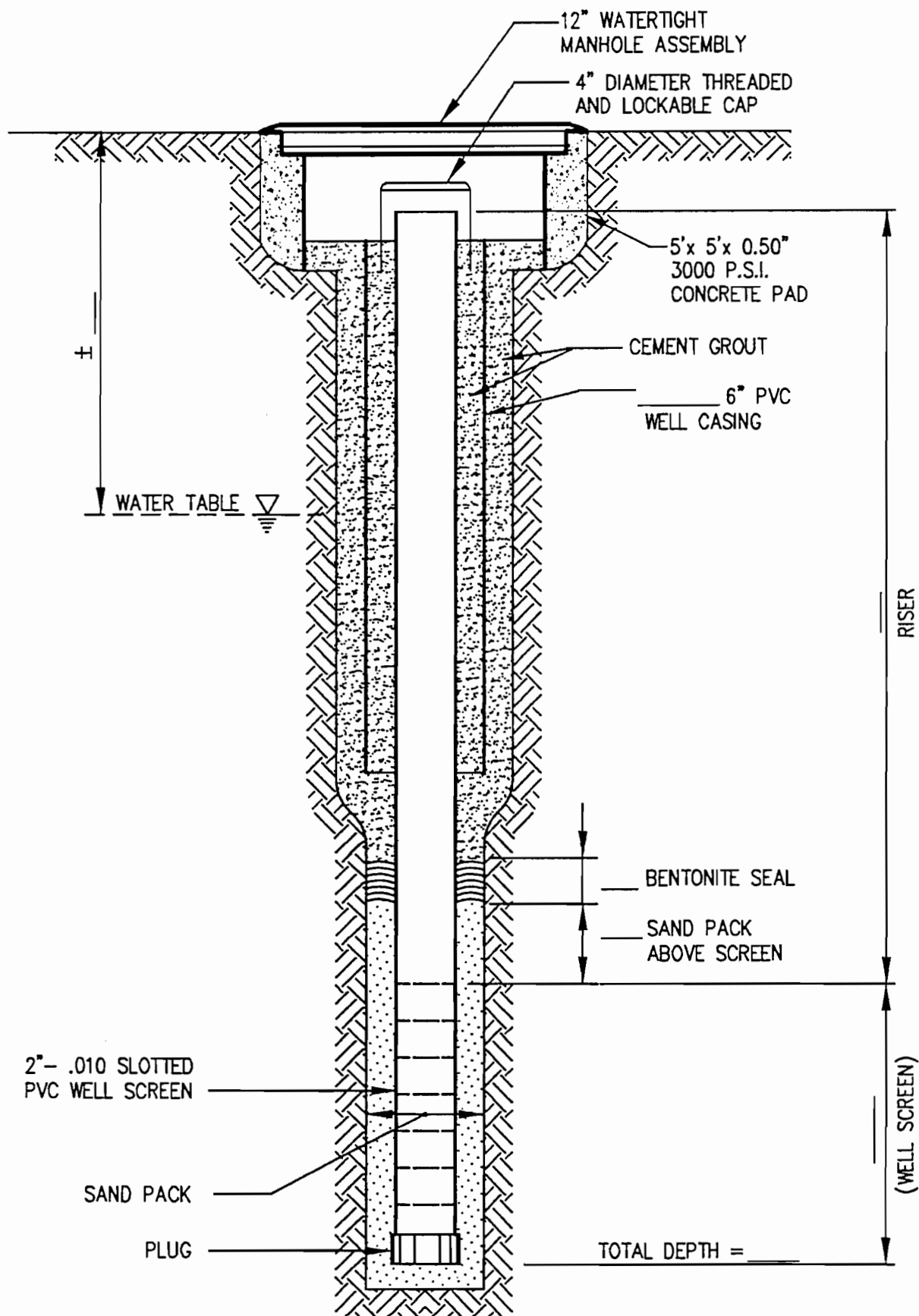
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FIGURE



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LANTDIV NAVFACENGCOM

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DRAWN BY:

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BC&A

FIGURE

FOR OFFICE USE ONLY

Quad. No. _____ Serial No. _____
Lat. _____ Long. _____ Pc _____
Minor Basin _____
Basin Code _____
Header Ent. _____ GW-1 Ent. _____

WELL CONSTRUCTION RECORD

DRILLING CONTRACTOR _____

DRILLER REGISTRATION NUMBER _____

STATE WELL CONSTRUCTION

PERMIT NUMBER: _____

1. WELL LOCATION: (Show sketch of the location below)

Nearest Town: _____

(Road, Community, or Subdivision and Lot No.)

2. OWNER _____

ADDRESS _____
(Street or Route No.)

City or Town _____ State _____ Zip Code _____

3. DATE DRILLED _____ USE OF WELL _____

4. TOTAL DEPTH _____ CUTTINGS COLLECTED ☐ Yes ☐ No

5. DOES WELL REPLACE EXISTING WELL? ☐ Yes ☐ No

6. STATIC WATER LEVEL: _____ FT. ☐ above TOP OF CASING,
☐ below
TOP OF CASING IS _____ FT. ABOVE LAND SURFACE.

7. YIELD (gpm): _____ METHOD OF TEST _____

8. WATER ZONES (depth): _____

9. CORROSION: Type _____ Amount _____

10. CASING:

Depth	Diameter	Wall Thickness or Weight/Ft.	Material
From _____ To _____ Ft.	_____	_____	_____
From _____ To _____ Ft.	_____	_____	_____
From _____ To _____ Ft.	_____	_____	_____

11. GROUT:

Depth	Material	Method
From _____ To _____ Ft.	_____	_____
From _____ To _____ Ft.	_____	_____

12. SCREEN:

Depth	Diameter	Slot Size	Material
From _____ To _____ Ft.	_____ in.	_____ in.	_____
From _____ To _____ Ft.	_____ in.	_____ in.	_____
From _____ To _____ Ft.	_____ in.	_____ in.	_____

13. GRAVEL PACK:

Depth	Size	Material
From _____ To _____ Ft.	_____	_____
From _____ To _____ Ft.	_____	_____

14. MARKS: _____

County: _____

Depth

From _____ To _____

DRILLING LOG

Formation Description

If additional space is needed use back of form.

LOCATION SKETCH

(Show direction and distance from at least two State Roads,
or other map reference points)

I DO HEREBY CERTIFY THAT THIS WELL WAS CONSTRUCTED IN ACCORDANCE WITH 15 NCAC 2C, WELL CONSTRUCTION
STANDARDS, AND THAT A COPY OF THIS RECORD HAS BEEN PROVIDED TO THE WELL OWNER.

SIGNATURE OF CONTRACTOR OR AGENT

DATE

Submit original to Division of Environmental Management and copy to well owner.

WELL SAMPLING WORKSHEET

PROJECT _____
PROJECT NO. _____

DATE _____
SAMPLED BY _____

WELL NO.	_____
TIME	_____
WELL DIAMETER	_____
WELL DEPTH - A	_____
DEPTH TO WATER - B	_____
(A-B) FT H ₂ O IN WELL - C	_____
GALLONS/FT - D	_____
(C x D) ONE VOLUME - E	_____
(E x 3) THREE VOLUMES - F	_____
VOLUME OF BAILER - G	_____
(F-G) NO. BAILS REQUIRED - H	_____
NO. BAILS TAKEN - I	_____
pH	_____
CONDUCTIVITY	_____
OTHERS	_____

FIELD TESTS:

VOLUMES:

3' x 1.5" BAILER = 0.24 GAL/BAIL
4' x 1.5" BAILER = 0.37 GAL/BAIL

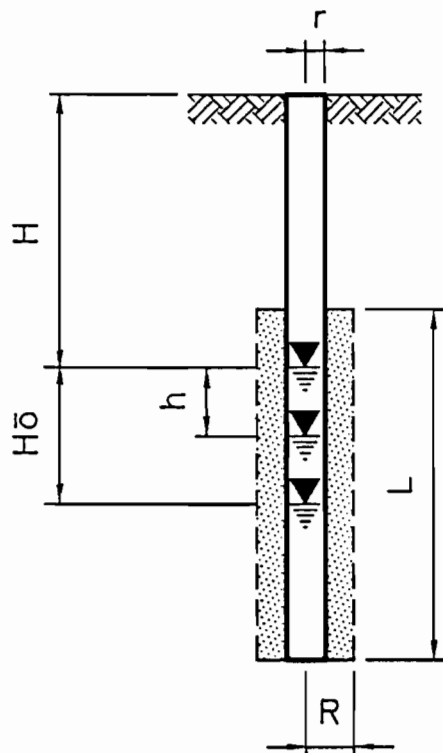
1-1/4" WELL = 0.064 GAL/FT
2" WELL = 0.163 GAL/FT
4" WELL = 0.653 GAL/FT

GeoChem, Incorporated

Environmental Laboratories
2500 Gate Way Centre Blvd., Suite 300
Morrisville, NC 27560

[illegible]

IN-SITU PERMEABILITY (SLUG) TEST (Hvorslev, 1951)



STATIC LEVEL (H): _____ INITIAL RISE (H0): _____

PIPE RADIUS (r): _____ SAND PACK LENGTH (L): _____

BORE HOLE RADIUS (R): _____ LEVEL DURING RECOVERY (h): _____

TIME REQUIRED FOR h/H_0 TO EQUAL 0.37 (T_0): _____

• HYDRAULIC CONDUCTIVITY: $K = \frac{r^2 \ln(L/R)}{2LT_0}$

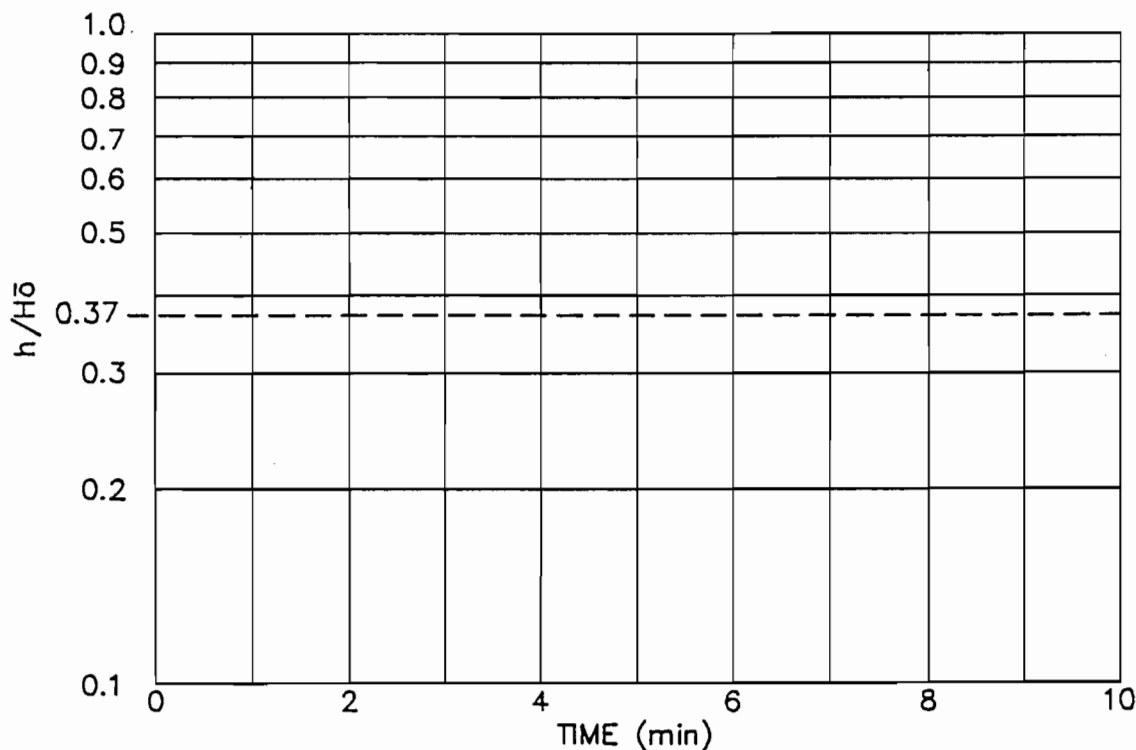
K = _____

HYDRAULIC GRADIENT (dh/dL): _____

EFFECTIVE POROSITY (N_e): _____

• GROUND WATER VELOCITY: $V_x = \frac{K(dh/dL)}{(N_e)}$

V_x = _____



_____ SCREEN INTERSECTS WATER TABLE
_____ REMOVING A SLUG

LOCATION _____
WELL NO. _____

CALCULATED BY: _____

PROJECT NAME: _____

CHECKED BY: _____

PROJECT NO. _____ DATE: _____

APPENDIX III
PROJECT SCHEDULE

APPENDIX B
SOIL TEST BORING RECORDS

BORING LOG

BORING NUMBER AS410N-4
TOTAL DEPTH 12'

SITE LOCATION Building AS-410
MCAS New River
Jacksonville, North Carolina

DRILLED BY C. Farrow
LOGGED BY B. Newland

DRILLING DATE 10/21/93

[illegible]REMARKS Grab = Grab Sample, HP = Hydraulic Push

PAGE 1 OF 1

BORING LOG

BORING NUMBER AS410N-5
TOTAL DEPTH 15'

SITE LOCATION Building AS-410
MCAS New River
Jacksonville, North Carolina

DRILLED BY C. Farrow
LOGGED BY B. Newland
DRILLING DATE 10/21/93

[illegible]

PAGE 1 OF 1

BORING LOG

BORING NUMBER AS410N-6
TOTAL DEPTH 15'

SITE LOCATION Building AS-410
MCAS New River
Jacksonville, North Carolina

DRILLED BY C. Farrow
LOGGED BY B. Newland
DRILLING DATE 10/21/93

[illegible]REMARKS NE = Not enough to sample

PAGE 1 OF 1

BORING LOG

BORING NUMBER AS410N-7
TOTAL DEPTH 15'

SITE LOCATION Building AS-410
MCAS New River
Jacksonville, North Carolina

DRILLED BY C. Farrow
LOGGED BY B. Newland

DRILLING DATE 10/22/93

[illegible]

REMARKS Grab = Grab Sample, HP = Hydraulic Push, NE = Not enough to sample

PAGE 1 OF 1

BORING LOG

BORING NUMBER AS410N-8
TOTAL DEPTH 15'

SITE LOCATION Building AS-410
MCAS New River
Jacksonville, North Carolina

DRILLED BY C. Farrow
LOGGED BY B. Newland

DRILLING DATE 10/22/93[illegible]

REMARKS Grab = Grab Sample, HP = Hydraulic Push

PAGE 1 OF 1

BORING LOG

BORING NUMBER AS410N-9
TOTAL DEPTH 15'

SITE LOCATION Building AS-410
MCAS New River
Jacksonville, North Carolina

DRILLED BY C. Farrow
LOGGED BY B. Newland

DRILLING DATE 10/25/93

[illegible]

REMARKS Grab = Grab Sample, HP = Hydraulic Push; strong HC odor when installing well

PAGE 1 OF 1

BORING LOG

BORING NUMBER AS410N-10
TOTAL DEPTH 15'

SITE LOCATION Building As-410
MCAS New River
Jacksonville, North Carolina

DRILLED BY C. Farrow
LOGGED BY B. Newland
DRILLING DATE 10/25/93

[illegible]

REMARKS HP = Hydraulic Push

PAGE 1 OF 1

BORING LOG

BORING NUMBER AS410N-11
TOTAL DEPTH 15'

SITE LOCATION Building AS-410
MCAS New River
Jacksonville, North Carolina

DRILLED BY C. Farrow
LOGGED BY B. Newland

DRILLING DATE 10/25/93

[illegible]

REMARKS Grab = Grab Sample, HP = Hydraulic Push,

PAGE 1 OF 1

BORING LOG

BORING NUMBER AS410N-12
TOTAL DEPTH 15'

SITE LOCATION Building AS-410
MCAS New River
Jacksonville, North Carolina

DRILLED BY C. Farrow
LOGGED BY B. Newland

DRILLING DATE 10/27/93[illegible]

REMARKS Grab = Grab Sample, HP = Hydraulic Push

PAGE 1 OF 1

BORING LOG

BORING NUMBER AS410N-13
TOTAL DEPTH 15'

SITE LOCATION Building AS-410
MCAS New River
Jacksonville, North Carolina

DRILLED BY C. Farrow
LOGGED BY B. Newland

DRILLING DATE 10/26/93[illegible]

REMARKS Grab = Grab Sample, HP = Hydraulic Push, RPO = Rain Prevents OVA Reading

PAGE 1 OF 1

BORING LOG

BORING NUMBER AS410N-14
TOTAL DEPTH 15'

SITE LOCATION Building AS-410
MCAS New River
Jacksonville, North Carolina

DRILLED BY C. Farrow
LOGGED BY B. Newland
DRILLING DATE 10/27/93

[illegible]

REMARKS Grab = Grab Sample, HP = Hydraulic Push

PAGE 1 OF 1

BORING LOG

BORING NUMBER AS410N-15
TOTAL DEPTH 15'

SITE LOCATION Building AS-410
MCAS New River
Jacksonville, North Carolina

DRILLED BY C. Farrow
LOGGED BY B. Newland

DRILLING DATE 10/27/93

[illegible]

REMARKS Grab = Grab Sample, HP = Hydraulic Push

PAGE 1 OF 1

BORING LOG

BORING NUMBER AS410N-16
 TOTAL DEPTH 51'

SITE LOCATION Building AS-410
MCAS New River
Jacksonville, North Carolina

DRILLED BY C. Farrow
 LOGGED BY B. Newland
 DRILLING DATE 10/28/93

SAMPLE DEPTH (FT.)	SAMPLE DESCRIPTION	USCS	WATER CONTENT	HC ODOR	PID/ FID PPM	BLOW COUNT
2.5 5.0	Brown, fine sand with some clay.	SC	Moist	Slight	10.0	4-5-3-4-2
5.0 7.5	Gray/white, fine sand.	SP	Wet	Slight	3.0	6-7-8-5-6
7.5 10.0	Gray/white, fine sand.	SP	Wet	Slight	5.0	7-8-10-12-7
10.0 12.5	Orange, fine sand.	SP	Wet	No	6.0	10-10-10-10-12
12.5 15.0	Brown, fine sand.	SP	Wet	No	15.0	16-10-9-10-15
15.0 17.5	Brown, fine sand.	SP	Wet	No	600.0	Wt. of rod
17.5 20.0	Gray, fine sand.	SP	Wet	Strong	600.0	25-11-10-9-10
20.5 22.5	Gray, fine sand with some silt.	SM	Wet		70.0	HP
22.5 25.0	Gray, fine sand with some silt and trace of clay.	SM	Wet	Yes	700.0	HP
25.0 27.5	Gray, fine sand with some silt and trace of clay.	SM	Wet	Yes	50.0	HP
27.5 30.0	Tan, silty fine sand, over 10" of limestone.	SM/LM	Wet	No	600.0	HP
30.0 32.5	Gray, weathered limestone.	LM	Wet		70.0	HP
32.5 35.0	Gray, weathered limestone, coarse sand limestone.	LM	Wet		30.0	19-33-26-9-25

REMARKS LM = Limestone, HP = Hydraulic Push

PAGE 1 OF 2

BORING LOG

BORING NUMBER AS410N-16 cont'd
TOTAL DEPTH 51'

SITE LOCATION Building AS-410
MCAS New River
Jacksonville, North

DRILLED BY C. Farrow
LOGGED BY B. Newland
Carolina
DRILLING DATE 10/28/93

[illegible]REMARKS LM = Limestone, HP = Hydraulic PushPAGE 2 OF 2

BORING LOG

BORING NUMBER AS410N-17
 TOTAL DEPTH 50'

SITE LOCATION Building AS-410
MCAS New River
Jacksonville, North Carolina

DRILLED BY C. Farrow
 LOGGED BY B. Newland

DRILLING DATE 10/29/93

SAMPLE DEPTH (FT.)		SAMPLE DESCRIPTION	USCS	WATER CONTENT	HC ODOR	PID/FID PPM	BLOW COUNT
2.5	5.0	Orange/Gray, fine sand with some clay.	SC	Moist	No	5.0	HP
5.0	7.5	Tan, fine sand.	SP	Moist/wet	No	17.0	HP
7.5	10.0	Tan, fine sand.	SP	Wet	Yes	30.0	HP
10.0	12.5	Orange, fine sand.	SP	Wet	Yes	20.0	HP
12.5	15.0	Orange, fine sand.	SP	Wet	Yes	20.0	HP
15.0	17.5	Orange, fine sand.	SP	Wet	Yes	4.0	HP
17.5	20.0	Orange, fine sand.	SP	Wet	No	2.0	HP
20.5	22.5	Orange, fine sand.	SP	Wet	No	8.0	HP
22.5	25.0	Gray, fine sand with some clay.	SC	Wet	No	6.0	HP
25.0	27.5	Gray, fine sand with some clay.	SC	Wet	No	15.0	HP
27.5	30.0	8" gray, fine sand with some clay, 4" gray clay with some fine sand, over 6" of weathered limestone.	SC/LM	Wet	No	15.0	HP
		(coarse gravel w/some fine sand and silt)					

REMARKS LM = Limestone, HP = Hydraulic Push

PAGE 1 OF 2

BORING LOG

BORING NUMBER AS410N-17 cont'd
TOTAL DEPTH 50'

SITE LOCATION Building AS-410
MCAS New River
Jacksonville, North

DRILLED BY C. Farrow
LOGGED BY B. Newland
DRILLING DATE 10/29/93

[illegible]

REMARKS LM = Limestone, HP = Hydraulic Push

PAGE 2 OF 2

BORING LOG

BORING NUMBER AS410N-18
 TOTAL DEPTH 50'

SITE LOCATION Building AS-410
MCAS New River
Jacksonville, North Carolina

DRILLED BY C. Farrow
 LOGGED BY B. Newland

DRILLING DATE 10/28/93

SAMPLE DEPTH (FT.)	SAMPLE DESCRIPTION	USCS	WATER CONTENT	HC ODOR	PID/ FID PPM	BLOW COUNT
2.5 5.0	Brown, fine sand with some clay.	SC	Moist	Some	800.0	3-5-8-7-6
5.0 7.5	Gray, fine sand.	SP	Wet	Some	850.0	5-6-8-7-7
7.5 10.0	Gray, fine sand.	SP	Wet	Some	400.0	1-8-9-5-4
10.0 12.5	Gray, fine sand.	SP	Wet	Some	400.0	9-5-7-5-7
12.5 15.0	Gray, fine sand, brown stain bottom 4".	SP	Wet	Some	300.0	8-6-10-11-10
15.0 17.5	Gray, fine sand.	SP	Wet	Some	140.0	7-10-10-15-24
17.5 20.0	Gray, fine sand.	SP	Wet	Some	240.0	20-25-17-12-15-4
20.5 22.5	Tan, fine sand with some silt and trace of clay.	SM/SC	Wet	Yes	110.0	Wt. of rods
22.5 25.0	Tan, fine sand with some silt and trace of clay.	SM/SC	Wet	Yes	40.0	HP
25.0 27.5	Tan, fine sand with some silt and slightly more clay.	SM/SC	Wet	Yes	120.0	HP
27.5 30.0	Tan, fine sand, grading to 3" 50/50 sand/clay, gray 4" limestone.	SM/SC/ CL/GP	Wet	Yes	40.0	HP

REMARKS HP = Hydraulic Push

PAGE 1 OF 2

BORING LOG

BORING NUMBER AS410N-18 cont'd SITE LOCATION Building AS-410
 TOTAL DEPTH 50' MCAS New River
Jacksonville, North Carolina

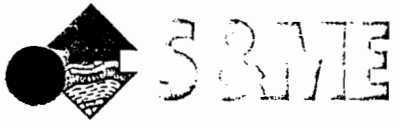
DRILLED BY C. Farrow
LOGGED BY B. Newland
DRILLING DATE 10/28/93

[illegible]REMARKS LM = LimestonePAGE 2 OF 2

APPENDIX C

GRAIN SIZE DISTRIBUTION AND RISING HEAD TEST DATA-HYDRAULIC CONDUCTIVITY CALCULATIONS

FILE COPY



November 9, 1993

Richard Catlin & Associates
Post Office Box 10279
Wilmington, North Carolina 28405-3755

Attention: Mr. Jim Cornett

Reference: Gradation Testing
Camp Lejeune, North Carolina
Job No. 1063-93-448

Dear Mr. Cornett:

As requested, S&ME personnel have performed laboratory gradation testing of the six soil samples which you recently delivered to our Wilmington office. The distribution of the soil particle sizes retained on a No. 200 sieve were determined 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."

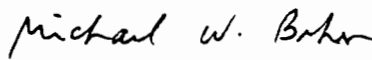
The results of our laboratory testing are presented in Tables 1 through 3.

If you have any questions after reviewing this letter, please do not hesitate to contact us at your convenience.

Very truly yours,

S&ME, INC.


Steven D. Kelly, P.E.
Branch Manager


Michael W. Behen, P.E.
Senior Geotechnical Engineer

SDK:MWB/jns
Attachments

TABLE 1
 Gradation Test Results
 Job No. 1063-93-448
 AS410

Sample Number	12	15
Depth (Ft.)	10-12	10-12
Percent Moisture	18.6	12.0
Sieve Number	Percent Passing, By Weight	
4	100.0	100.0
10	99.1	99.7
40	66.1	84.6
80	23.9	34.1
200	4.4	5.6
Soil Description	Tan Fine to Medium SAND (SP)	Tan & Orange Fine to Medium SAND - Trace of Clay (SP-SC)

JOB: AS-410N COMPUTED BY: JC DATE: 1/5/94
DESCRIPTION: Grain Size K CHECKED BY: JMP DATE: 1/12/94

GRAIN SIZE HYDRAULIC CONDUCTIVITY CALCULATIONS

1.0 Grain Size Sample: AS410N-12

Depth: 10-12 Feet

Soil Description: Fine to Med. SAND (SP)

Hydraulic Conductivity (K_1)*: 23.78 Ft/day

2.0 Grain Size Sample: AS410N-15

Depth: 10-12 Feet

Soil Description: Fine to Med. SAND
with Trace * CLAY (SP/SC)

Hydraulic Conductivity (K_2): 23.78 Ft/day

$$K_{AV} = \frac{K_1 + K_2}{2}$$

Where:

K_{AV} = Average Hydraulic Conductivity

$$K_{AV} = 23.78 \text{ Ft/day}$$

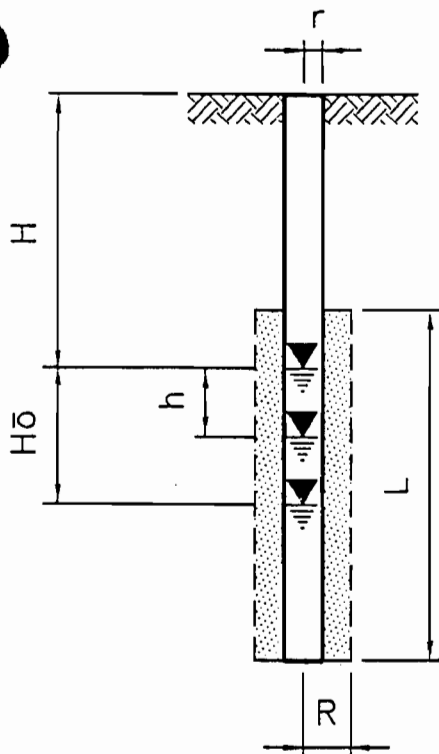
* From Todd, 1980

Richard Catlin & Associates, Inc.

CONSULTING ENGINEERS
AND HYDROGEOLOGISTS

RC&A

IN-SITU PERMEABILITY (SLUG) TEST (HVORSLEV, 1951)



STATIC LEVEL (H): 5.83' INITIAL DROP (H_0): 6.941'
 PIPE RADIUS (r): .083' SAND PACK LENGTH (L): 15'
 BORE HOLE RADIUS (R): .333' LEVEL DURING RECOVERY (h): See table
 TIME REQUIRED FOR h/H_0 TO EQUAL 0.37 (T_0): 3 sec.

• HYDRAULIC CONDUCTIVITY: $K = \frac{r^2 \ln(L/R)}{2LT_0}$

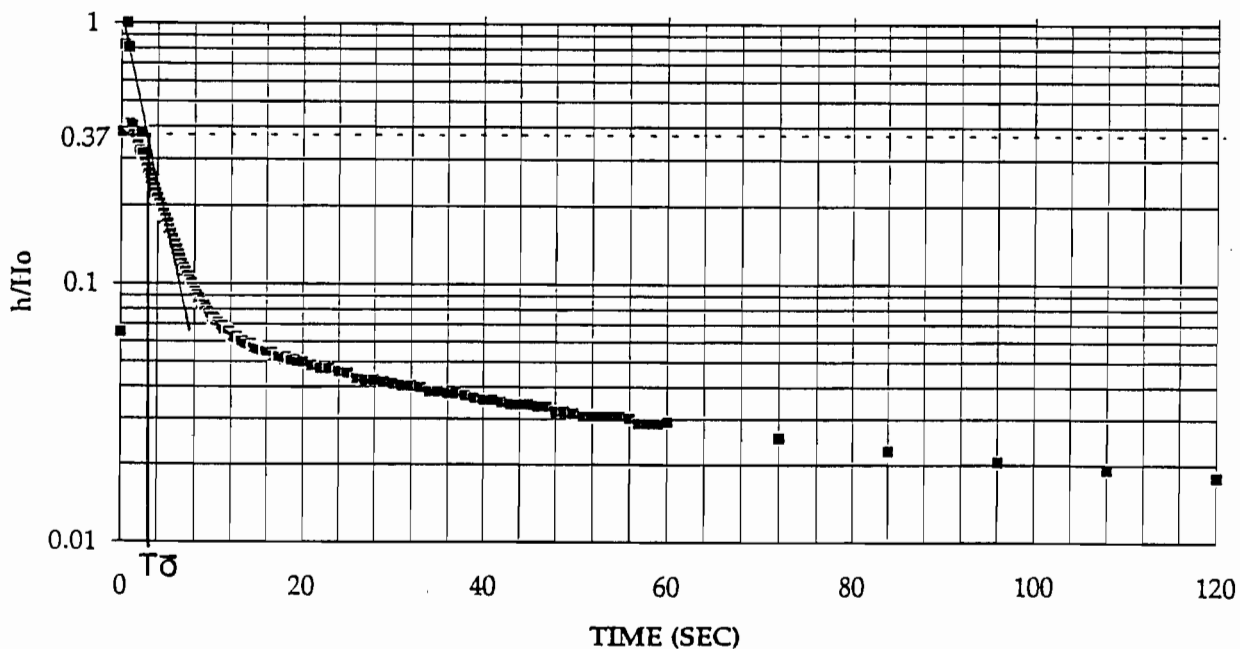
$K =$ 25 feet/day

HYDRAULIC GRADIENT (dh/dL): 1.08×10^{-3} (between wells AS410N-11 & AS410N-4)

EFFECTIVE POROSITY (N_e): .25 (assumed)

• GROUND WATER VELOCITY: $V_x = \frac{K(dh/dL)}{(N_e)}$

$V_x =$ 0.1 feet/day



LOCATION AS410N
 WELL NO. AS410-4

CALCULATED BY: MJD

PROJECT NAME: Building AS-410

CHECKED BY: SC

PROJECT NO. 93125 DATE: 1-3-94

SLUG TEST DATA TABLE**WELL # AS410N-4**

Recorded 12/21/93 10:35 AM

Project #93125-F
Project Name: AS-410

TIME (SEC)	h(FEET)	h/Ho
0	0.45	0.06
0.2	2.64	0.38
0.4	5.69	0.82
0.6	6.94	1
0.8	5.59	0.81
1	2.83	0.41
1.2	2.77	0.4
1.4	2.57	0.37
1.6	2.46	0.35
1.8	2.33	0.34
2	2.24	0.32
2.2	2.62	0.38
2.4	2.19	0.31
2.6	2.02	0.29
2.8	1.92	0.28
3	1.83	0.26
3.2	1.74	0.25
3.4	1.67	0.24
3.6	1.6	0.23
3.8	1.54	0.22
4	1.47	0.21
4.2	1.4	0.2
4.4	1.35	0.19
4.6	1.29	0.19
4.8	1.23	0.18
5	1.18	0.17
5.2	1.12	0.16
5.4	1.08	0.16
5.6	1.02	0.15
5.8	0.98	0.14
6	0.93	0.13
6.2	0.9	0.13
6.4	0.86	0.12
6.6	0.83	0.12

SLUG TEST DATA TABLE**WELL # AS410N-4**

Recorded 12/21/93 10:35 AM

Project #93125-F
Project Name: AS-410

TIME (SEC)	h(FEET)	h/Ho
6.8	0.8	0.11
7	0.77	0.11
7.2	0.74	0.11
7.4	0.71	0.1
7.6	0.69	0.1
7.8	0.67	0.1
8	0.65	0.09
8.2	0.63	0.09
8.4	0.61	0.09
8.6	0.59	0.08
8.8	0.58	0.08
9	0.57	0.08
9.2	0.55	0.08
9.4	0.54	0.08
9.6	0.53	0.08
9.8	0.52	0.07
10	0.51	0.07
10.2	0.5	0.07
10.4	0.49	0.07
10.6	0.49	0.07
10.8	0.48	0.07
11	0.47	0.07
11.2	0.46	0.07
11.4	0.46	0.07
11.6	0.46	0.07
11.8	0.45	0.06
12	0.44	0.06
12.2	0.44	0.06
12.4	0.43	0.06
12.6	0.43	0.06
12.8	0.42	0.06
13	0.42	0.06
13.2	0.42	0.06
13.4	0.41	0.06

SLUG TEST DATA TABLE**WELL # AS410N-4**

Recorded 12/21/93 10:35 AM

Project #93125-F
Project Name: AS-410

TIME (SEC)	h(FEET)	h/Ho
13.6	0.41	0.06
13.8	0.4	0.06
14	0.4	0.06
14.2	0.4	0.06
14.4	0.4	0.06
14.6	0.39	0.06
14.8	0.39	0.06
15	0.39	0.06
15.2	0.39	0.06
15.4	0.38	0.06
15.6	0.38	0.06
15.8	0.38	0.05
16	0.38	0.05
16.2	0.38	0.05
16.4	0.37	0.05
16.6	0.37	0.05
16.8	0.37	0.05
17	0.37	0.05
17.2	0.37	0.05
17.4	0.37	0.05
17.6	0.37	0.05
17.8	0.36	0.05
18	0.36	0.05
18.2	0.36	0.05
18.4	0.36	0.05
18.6	0.36	0.05
18.8	0.35	0.05
19	0.35	0.05
19.2	0.35	0.05
19.4	0.35	0.05
19.6	0.35	0.05
19.8	0.35	0.05
20	0.35	0.05
21	0.34	0.05

SLUG TEST DATA TABLE

Project #93125-F

WELL # AS410N-4

Project Name: AS-410

Recorded 12/21/93 10:35 AM

TIME (SEC)	h(FEET)	h/Ho
22	0.33	0.05
23	0.33	0.05
24	0.32	0.05
25	0.31	0.05
26	0.3	0.04
27	0.29	0.04
28	0.29	0.04
29	0.29	0.04
30	0.28	0.04
31	0.28	0.04
32	0.28	0.04
33	0.28	0.04
34	0.27	0.04
35	0.27	0.04
36	0.26	0.04
37	0.26	0.04
38	0.26	0.04
39	0.25	0.04
40	0.25	0.04
41	0.25	0.04
42	0.24	0.03
43	0.24	0.03
44	0.24	0.03
45	0.24	0.03
46	0.23	0.03
47	0.23	0.03
48	0.22	0.03
49	0.22	0.03
50	0.22	0.03
51	0.21	0.03
52	0.21	0.03
53	0.21	0.03
54	0.21	0.03
55	0.21	0.03

SLUG TEST DATA TABLE**WELL # AS410N-4**

Recorded 12/21/93 10:35 AM

Project #93125-F
Project Name: AS-410

TIME (SEC)	h(FEET)	h/Ho
56	0.21	0.03
57	0.2	0.03
58	0.2	0.03
59	0.2	0.03
60	0.2	0.03
72	0.18	0.03
84	0.16	0.02
96	0.14	0.02
108	0.13	0.02
120	0.12	0.02
132	0.11	0.02
144	0.1	0.01
156	0.1	0.01
168	0.09	0.01
180	0.09	0.01
192	0.08	0.01
204	0.08	0.01
216	0.08	0.01
228	0.08	0.01
240	0.07	0.01
252	0.07	0.01
264	0.07	0.01
276	0.07	0.01
288	0.06	0.01
300	0.06	0.01
312	0.06	0.01
324	0.06	0.01
336	0.06	0.01
348	0.06	0.01
360	0.06	0.01
372	0.05	0.01
384	0.05	0.01
396	0.05	0.01
408	0.05	0.01

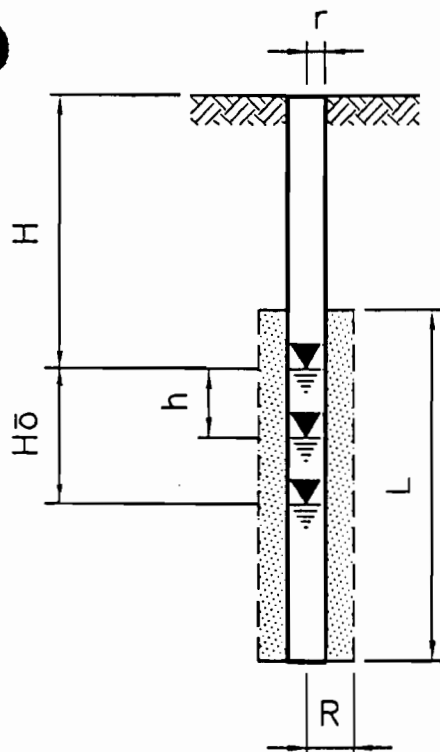
SLUG TEST DATA TABLE**WELL # AS410N-4**

Recorded 12/21/93 10:35 AM

Project #93125-F
Project Name: AS-410

TIME (SEC)	h(FEET)	h/Ho
420	0.05	0.01
432	0.05	0.01
444	0.05	0.01
456	0.04	0.01
468	0.04	0.01
480	0.05	0.01
492	0.04	0.01
504	0.05	0.01
516	0.05	0.01
528	0.04	0.01
540	0.04	0.01
552	0.04	0.01
564	0.05	0.01
576	0.04	0.01
588	0.04	0.01
600	0.04	0.01

IN-SITU PERMEABILITY (SLUG) TEST (HVORSLEV, 1951)



STATIC LEVEL (H): 5.23' INITIAL DROP (H_0): 8.093'
 PIPE RADIUS (r): .083' SAND PACK LENGTH (L): 15'
 BORE HOLE RADIUS (R): .333' LEVEL DURING RECOVERY (h): See table
 TIME REQUIRED FOR h/H_0 TO EQUAL 0.37 (T_0): 2 sec.

• HYDRAULIC CONDUCTIVITY: $K = \frac{r^2 \ln(L/R)}{2LT_0}$

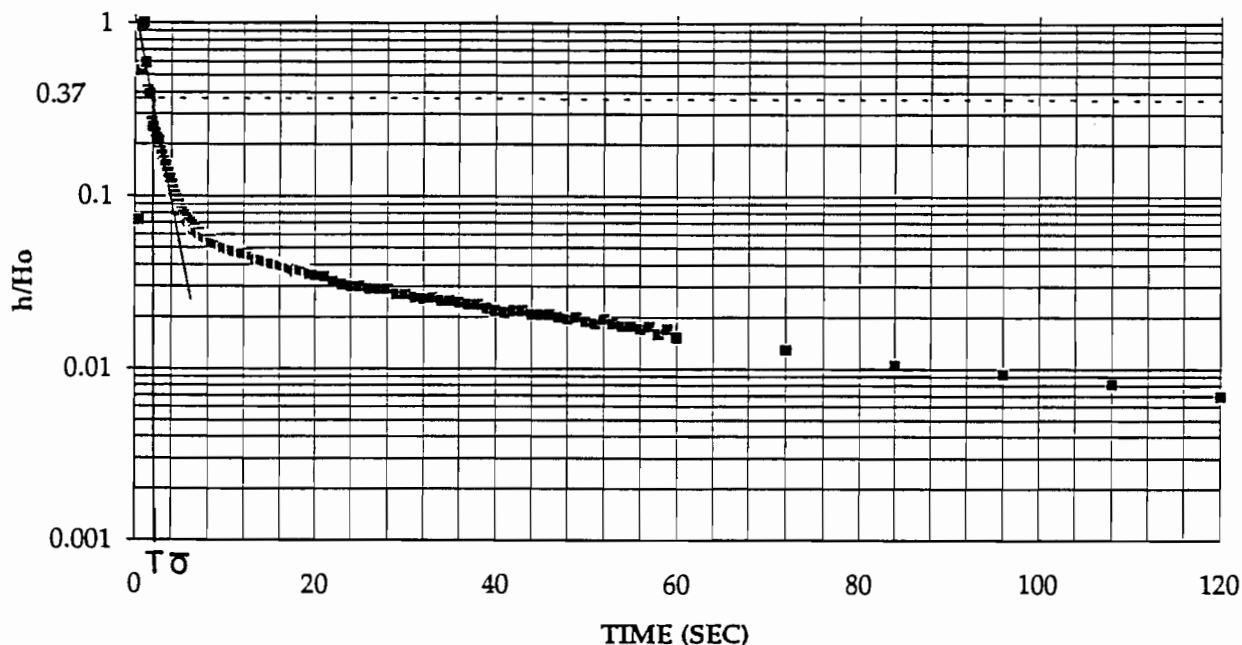
$K =$ 38 feet/day

HYDRAULIC GRADIENT (dh/dL): 1.83×10^{-2} (between wells AS410N-14 & AS410N-8)

EFFECTIVE POROSITY (N_e): .25 (assumed)

• GROUND WATER VELOCITY: $V_x = \frac{K(dh/dL)}{(N_e)}$

$V_x =$ 2.8 feet/day



LOCATION AS410N
 WELL NO. AS410N-8

CALCULATED BY: MJD

PROJECT NAME: Building AS410

CHECKED BY: JC

PROJECT NO. 93125 DATE: 1-3-94

SLUG TEST DATA TABLE**WELL # AS410N-8**

Recorded 12/21/93 11:16 AM

Project No. 93125
Project Name: AS-410

TIME(SEC)	h(FEET)	h/Ho
0	0	0
0.198	-0.004	-0.000494254
0.396	0.588	0.072655381
0.6	4.305	0.531941184
0.798	7.715	0.953292969
0.996	8.093	1
1.2	4.778	0.590386754
1.398	3.31	0.408995428
1.596	3.168	0.391449401
1.8	2.172	0.268380082
1.998	2.035	0.251451872
2.196	1.869	0.230940319
2.4	1.741	0.215124181
2.598	1.689	0.208698876
2.796	1.47	0.181638453
3	1.385	0.171135549
3.198	1.281	0.158284938
3.396	1.219	0.150623996
3.6	1.1	0.135919931
3.798	1.015	0.125417027
3.996	0.939	0.116026195
4.2	0.873	0.107871
4.398	0.816	0.100827876
4.596	0.768	0.094896824
4.8	0.721	0.089089336
4.998	0.678	0.083776103
5.196	0.65	0.080316323
5.4	0.621	0.076732979
5.598	0.597	0.073767453
5.796	0.574	0.070925491
6	0.56	0.069195601
6.198	0.541	0.066847893
6.396	0.526	0.06499444
6.6	0.512	0.06326455
6.798	0.498	0.06153466

SLUG TEST DATA TABLE
WELL # AS410N-8
Recorded 12/21/93 11:16 AM

Project No. 93125
Project Name: AS-410

TIME(SEC)	h(FEET)	h/Ho
6.996	0.488	0.060299024
7.2	0.474	0.058569134
7.398	0.474	0.058569134
7.596	0.465	0.057457062
7.8	0.455	0.056221426
7.998	0.45	0.055603608
8.196	0.446	0.055109354
8.4	0.431	0.0532559
8.598	0.431	0.0532559
8.796	0.427	0.052761646
9	0.422	0.052143828
9.198	0.417	0.05152601
9.396	0.412	0.050908192
9.6	0.408	0.050413938
9.798	0.398	0.049178302
9.996	0.403	0.04979612
10.2	0.398	0.049178302
10.398	0.393	0.048560484
10.596	0.393	0.048560484
10.8	0.389	0.04806623
10.998	0.384	0.047448412
11.196	0.384	0.047448412
11.4	0.379	0.046830594
11.598	0.374	0.046212776
11.796	0.37	0.045718522
12	0.37	0.045718522
12.198	0.37	0.045718522
12.396	0.37	0.045718522
12.6	0.36	0.044482886
12.798	0.36	0.044482886
12.996	0.355	0.043865069
13.2	0.351	0.043370814
13.398	0.341	0.042135179
13.596	0.346	0.042752996
13.8	0.346	0.042752996

SLUG TEST DATA TABLE
WELL # AS410N-8
Recorded 12/21/93 11:16 AM

Project No. 93125
Project Name: AS-410

TIME(SEC)	h(FEET)	h/Ho
13.998	0.346	0.042752996
14.196	0.341	0.042135179
14.4	0.332	0.041023106
14.598	0.337	0.041640924
14.796	0.332	0.041023106
15	0.332	0.041023106
15.198	0.327	0.040405289
15.396	0.327	0.040405289
15.6	0.327	0.040405289
15.798	0.322	0.039787471
15.996	0.318	0.039293216
16.2	0.318	0.039293216
16.398	0.318	0.039293216
16.596	0.313	0.038675398
16.8	0.308	0.038057581
16.998	0.308	0.038057581
17.196	0.308	0.038057581
17.4	0.303	0.037439763
17.598	0.299	0.036945508
17.796	0.294	0.036327691
18	0.303	0.037439763
18.198	0.294	0.036327691
18.396	0.299	0.036945508
18.6	0.299	0.036945508
18.798	0.294	0.036327691
18.996	0.294	0.036327691
19.2	0.289	0.035709873
19.398	0.28	0.034597801
19.596	0.284	0.035092055
19.8	0.284	0.035092055
19.998	0.28	0.034597801
21	0.275	0.033979983
21.996	0.256	0.031632275
22.998	0.246	0.030396639
24	0.242	0.029902385

SLUG TEST DATA TABLE**WELL # AS410N-8**

Recorded 12/21/93 11:16 AM

Project No. 93125
Project Name: AS-410

TIME(SEC)	h(FEET)	h/Ho
24.996	0.242	0.029902385
25.998	0.232	0.028666749
27	0.232	0.028666749
27.996	0.232	0.028666749
28.998	0.218	0.026936859
30	0.218	0.026936859
30.996	0.208	0.025701223
31.998	0.204	0.025206969
33	0.208	0.025701223
33.996	0.199	0.024589151
34.998	0.199	0.024589151
36	0.194	0.023971333
36.996	0.189	0.023353515
37.998	0.189	0.023353515
39	0.18	0.022241443
39.996	0.175	0.021623625
40.998	0.17	0.021005807
42	0.175	0.021623625
42.996	0.175	0.021623625
43.998	0.166	0.020511553
45	0.166	0.020511553
45.996	0.166	0.020511553
46.998	0.161	0.019893735
48	0.156	0.019275917
48.996	0.161	0.019893735
49.998	0.151	0.0186581
51	0.147	0.018163845
51.996	0.156	0.019275917
52.998	0.147	0.018163845
54	0.142	0.017546027
54.996	0.142	0.017546027
55.998	0.137	0.01692821
57	0.142	0.017546027
57.996	0.128	0.015816137
58.998	0.137	0.01692821

SLUG TEST DATA TABLE**WELL # AS410N-8**

Recorded 12/21/93 11:16 AM

Project No. 93125
Project Name: AS-410

TIME(SEC)	h(FEET)	h/Ho
60	0.123	0.01519832
72	0.104	0.012850612
84	0.085	0.010502904
96	0.075	0.009267268
108	0.066	0.008155196
120	0.056	0.00691956
132	0.052	0.006425306
144	0.047	0.005807488
156	0.037	0.004571852
168	0.042	0.00518967
180	0.033	0.004077598
192	0.033	0.004077598
204	0.028	0.00345978
216	0.028	0.00345978
228	0.028	0.00345978
240	0.023	0.002841962
252	0.018	0.002224144
264	0.014	0.00172989
276	0.023	0.002841962
288	0.014	0.00172989
300	0.014	0.00172989
312	0.009	0.001112072
324	0.009	0.001112072
336	0.014	0.00172989
348	0.004	0.000494254
360	0.009	0.001112072
372	0.014	0.00172989
384	0.004	0.000494254
396	0.004	0.000494254
408	0.014	0.00172989
420	0.004	0.000494254
432	0.004	0.000494254
444	0.014	0.00172989
456	0.004	0.000494254
468	0.014	0.00172989

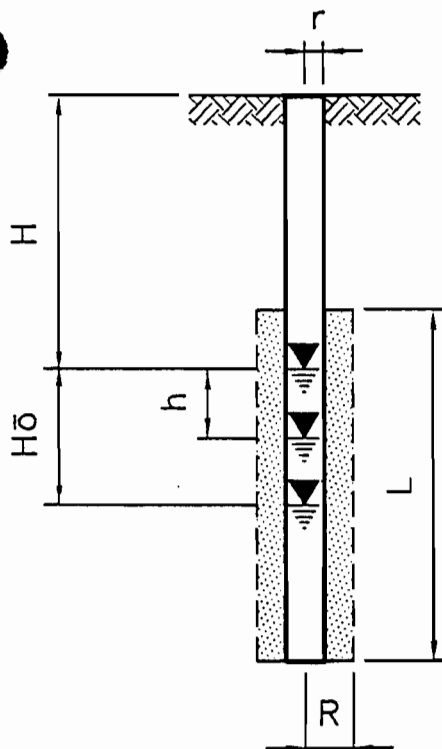
SLUG TEST DATA TABLE**WELL # AS410N-8**

Recorded 12/21/93 11:16 AM

Project No. 93125
Project Name: AS-410

TIME(SEC)	h(FEET)	h/Ho
480	0.009	0.001112072
492	0.009	0.001112072
504	0.004	0.000494254
516	0	0
528	0.004	0.000494254
540	0	0
552	0.004	0.000494254
564	0	0
576	0.004	0.000494254
588	0.004	0.000494254
600	0	0

IN-SITU PERMEABILITY (SLUG) TEST (HVORSLEV, 1951)



STATIC LEVEL (H): 5.82' INITIAL DROP (H_0): 6.101'
 PIPE RADIUS (r): .083' SAND PACK LENGTH (L): 15'
 BORE HOLE RADIUS (R): .333' LEVEL DURING RECOVERY (h): See table
 TIME REQUIRED FOR h/H_0 TO EQUAL 0.37 (T_0): 2 sec.

• HYDRAULIC CONDUCTIVITY: $K = \frac{r^2 \ln(L/R)}{2LT_0}$

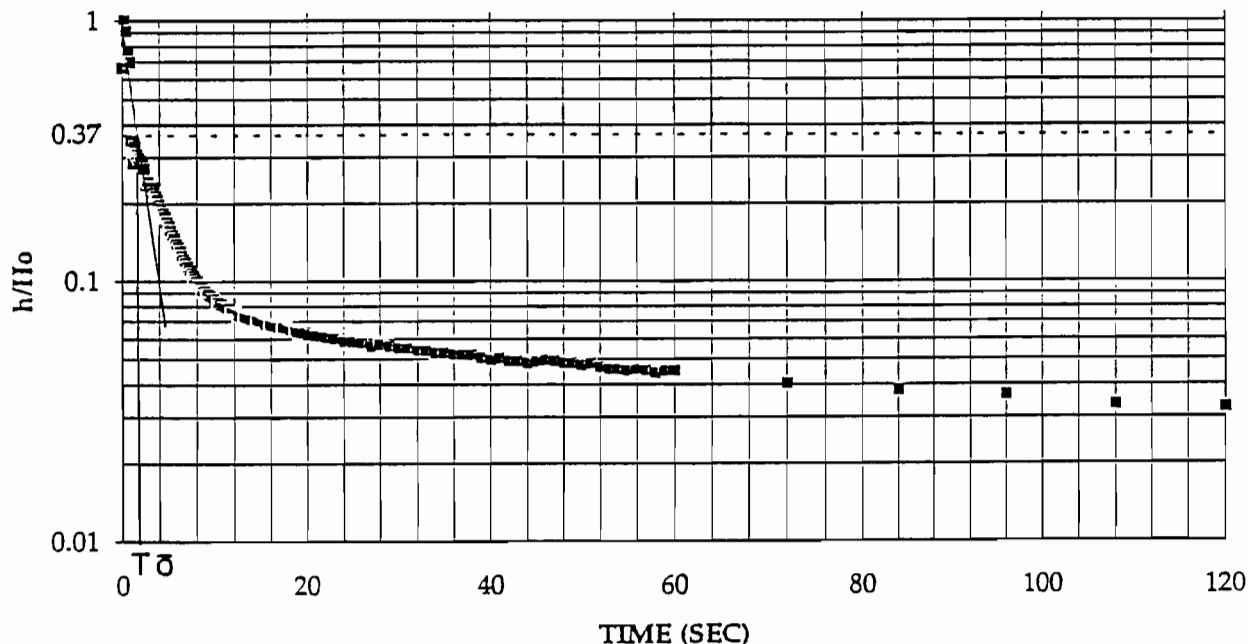
$K =$ 38 feet/day

HYDRAULIC GRADIENT (dh/dL): 2.72×10^{-3} (between wells AS410N-13 & AS410N-6)

EFFECTIVE POROSITY (N_e): .25 (assumed)

• GROUND WATER VELOCITY: $V_x = \frac{K(dh/dL)}{(N_e)}$

$V_x =$.4 feet/day



LOCATION AS410N
 WELL NO. AS410N-13

CALCULATED BY: MJD

PROJECT NAME: Building AS410

CHECKED BY: SC

PROJECT NO. 93125 DATE: 1-3-94

SLUG TEST DATA TABLE**WELL # AS410N-13**

Recorded 12/21/93 12:01 PM

Project #93125-F
Project Name: AS-410

TIME(SEC)	h(FEET)	h/Ho
0	4.042	0.662514342
0.198	6.101	1
0.396	5.557	0.910834289
0.6	4.558	0.747090641
0.798	4.237	0.694476315
0.996	2.115	0.346664481
1.2	1.731	0.28372398
1.398	2.025	0.331912801
1.596	1.873	0.306998853
1.8	1.811	0.296836584
1.998	1.769	0.289952467
2.196	1.712	0.280609736
2.4	1.65	0.270447468
2.598	1.432	0.23471562
2.796	1.47	0.240944108
3	1.413	0.231601377
3.198	1.404	0.230126209
3.396	1.337	0.219144403
3.6	1.294	0.212096378
3.798	1.257	0.206031798
3.996	1.204	0.197344698
4.2	1.162	0.19046058
4.398	1.119	0.183412555
4.596	1.076	0.17636453
4.8	1.029	0.168660875
4.998	0.996	0.163251926
5.196	0.958	0.157023439
5.4	0.92	0.150794952
5.598	0.891	0.146041633
5.796	0.849	0.139157515
6	0.825	0.135223734
6.198	0.797	0.130634322
6.396	0.763	0.125061465
6.6	0.74	0.121291592

SLUG TEST DATA TABLE**WELL # AS410N-13**

Recorded 12/21/93 12:01 PM

Project #93125-F
Project Name: AS-410

TIME(SEC)	h(FEET)	h/Ho
6.798	0.716	0.11735781
6.996	0.692	0.113424029
7.2	0.668	0.109490248
7.398	0.649	0.106376004
7.596	0.635	0.104081298
7.8	0.621	0.101786592
7.998	0.607	0.099491887
8.196	0.588	0.096377643
8.4	0.583	0.095558105
8.598	0.559	0.091624324
8.796	0.555	0.090968694
9	0.545	0.089329618
9.198	0.54	0.08851008
9.396	0.531	0.087034912
9.6	0.521	0.085395837
9.798	0.517	0.084740207
9.996	0.507	0.083101131
10.2	0.502	0.082281593
10.398	0.493	0.080806425
10.596	0.493	0.080806425
10.8	0.483	0.07916735
10.998	0.483	0.07916735
11.196	0.479	0.078511719
11.4	0.474	0.077692182
11.598	0.465	0.076217014
11.796	0.46	0.075397476
12	0.46	0.075397476
12.198	0.455	0.074577938
12.396	0.45	0.0737584
12.6	0.45	0.0737584
12.798	0.445	0.072938862
12.996	0.441	0.072283232
13.2	0.441	0.072283232
13.398	0.436	0.071463694

SLUG TEST DATA TABLE**WELL # AS410N-13**

Recorded 12/21/93 12:01 PM

Project #93125-F
Project Name: AS-410

TIME(SEC)	h(FEET)	h/Ho
13.596	0.436	0.071463694
13.8	0.431	0.070644157
13.998	0.431	0.070644157
14.196	0.431	0.070644157
14.4	0.427	0.069988526
14.598	0.427	0.069988526
14.796	0.427	0.069988526
15	0.422	0.069168989
15.198	0.417	0.068349451
15.396	0.412	0.067529913
15.6	0.412	0.067529913
15.798	0.412	0.067529913
15.996	0.412	0.067529913
16.2	0.408	0.066874283
16.398	0.408	0.066874283
16.596	0.403	0.066054745
16.8	0.403	0.066054745
16.998	0.403	0.066054745
17.196	0.398	0.065235207
17.4	0.403	0.066054745
17.598	0.403	0.066054745
17.796	0.398	0.065235207
18	0.393	0.06441567
18.198	0.389	0.063760039
18.396	0.389	0.063760039
18.6	0.389	0.063760039
18.798	0.389	0.063760039
18.996	0.384	0.062940502
19.2	0.389	0.063760039
19.398	0.384	0.062940502
19.596	0.384	0.062940502
19.8	0.384	0.062940502
19.998	0.379	0.062120964
21	0.374	0.061301426

SLUG TEST DATA TABLE**WELL # AS410N-13**

Recorded 12/21/93 12:01 PM

Project #93125-F
Project Name: AS-410

TIME(SEC)	h(FEET)	h/Ho
21.996	0.37	0.060645796
22.998	0.365	0.059826258
24	0.355	0.058187182
24.996	0.355	0.058187182
25.998	0.351	0.057531552
27	0.341	0.055892477
27.996	0.346	0.056712014
28.998	0.341	0.055892477
30	0.336	0.055072939
30.996	0.336	0.055072939
31.998	0.327	0.053597771
33	0.327	0.053597771
33.996	0.322	0.052778233
34.998	0.322	0.052778233
36	0.317	0.051958695
36.996	0.317	0.051958695
37.998	0.317	0.051958695
39	0.308	0.050483527
39.996	0.303	0.04966399
40.998	0.308	0.050483527
42	0.298	0.048844452
42.996	0.298	0.048844452
43.998	0.294	0.048188822
45	0.298	0.048844452
45.996	0.303	0.04966399
46.998	0.298	0.048844452
48	0.294	0.048188822
48.996	0.294	0.048188822
49.998	0.289	0.047369284
51	0.294	0.048188822
51.996	0.284	0.046549746
52.998	0.279	0.045730208
54	0.279	0.045730208
54.996	0.275	0.045074578

SLUG TEST DATA TABLE**WELL # AS410N-13**

Recorded 12/21/93 12:01 PM

Project #93125-F
Project Name: AS-410

TIME(SEC)	h(FEET)	h/Ho
55.998	0.279	0.045730208
57	0.275	0.045074578
57.996	0.27	0.04425504
58.998	0.275	0.045074578
60	0.275	0.045074578
72	0.246	0.040321259
84	0.232	0.038026553
96	0.223	0.036551385
108	0.204	0.033437141
120	0.199	0.032617604
132	0.194	0.031798066
144	0.189	0.030978528
156	0.175	0.028683822
168	0.166	0.027208654
180	0.161	0.026389117
192	0.156	0.025569579
204	0.151	0.024750041
216	0.147	0.024094411
228	0.137	0.022455335
240	0.128	0.020980167
252	0.132	0.021635797
264	0.123	0.020160629
276	0.123	0.020160629
288	0.109	0.017865924
300	0.113	0.018521554
312	0.109	0.017865924
324	0.109	0.017865924
336	0.104	0.017046386
348	0.104	0.017046386
360	0.094	0.01540731
372	0.094	0.01540731
384	0.094	0.01540731
396	0.09	0.01475168
408	0.085	0.013932142

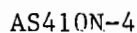
SLUG TEST DATA TABLE
WELL # AS410N-13
Recorded 12/21/93 12:01 PM

Project #93125-F
Project Name: AS-410

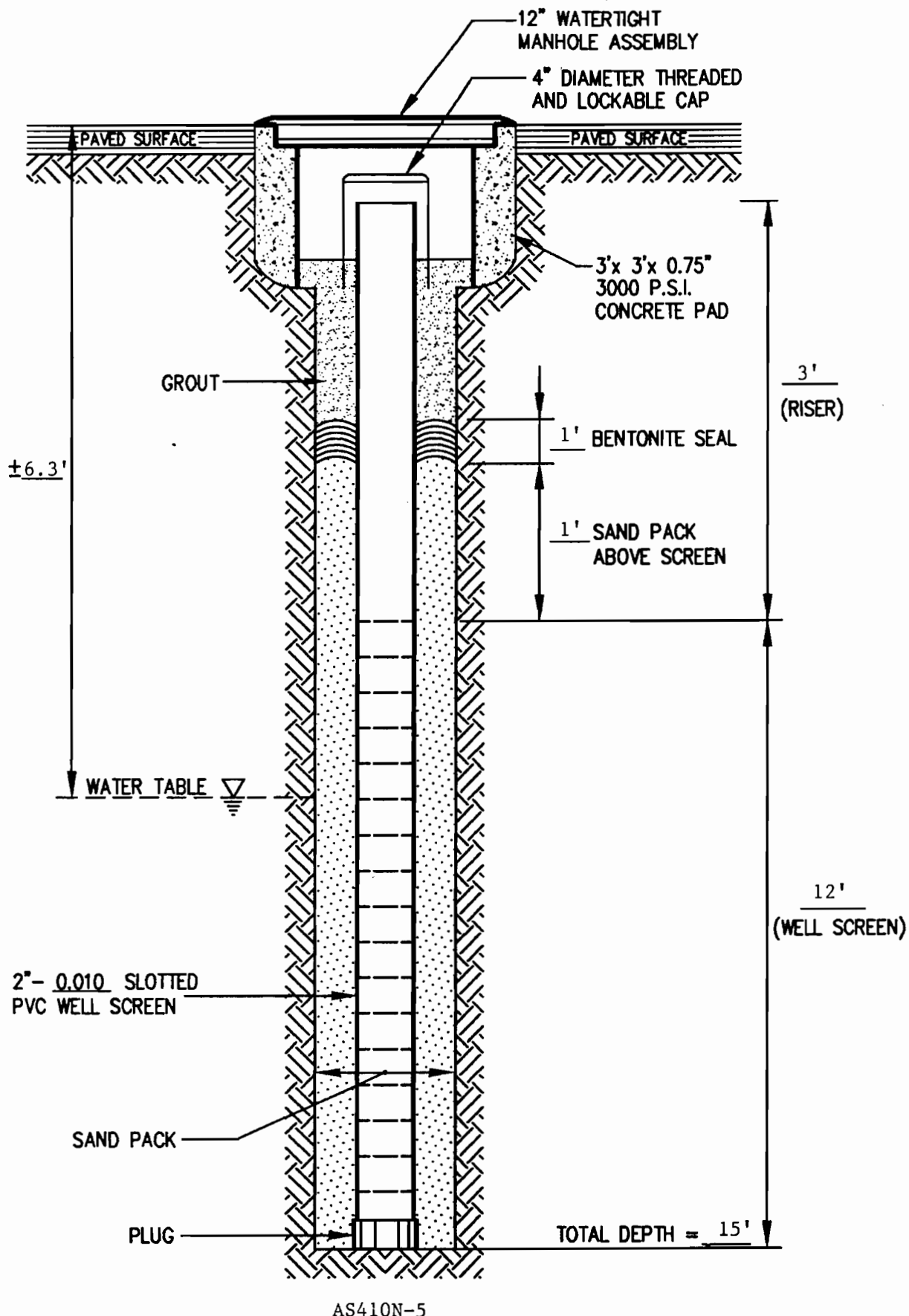
TIME(SEC)	h(FEET)	h/Ho
420	0.08	0.013112604
432	0.085	0.013932142
444	0.08	0.013112604
456	0.08	0.013112604
468	0.075	0.012293067
480	0.075	0.012293067
492	0.075	0.012293067
504	0.075	0.012293067
516	0.071	0.011637436
528	0.066	0.010817899
540	0.071	0.011637436
552	0.066	0.010817899
564	0.066	0.010817899
576	0.061	0.009998361
588	0.066	0.010817899
600	0.061	0.009998361

APPENDIX D

**WELL CONSTRUCTION RECORDS AND GROUND WATER
MONITORING WELL INSTALLATION DETAILS**



Richard Catlin & Associates, Inc. ENVIRONMENTAL ENGINEERS AND HYDROGEOLOGISTS WILMINGTON, NC CHARLESTON, SC ATLANTA, GA WINSTON-SALEM, NC	PROJECT BUILDING AS-410 LANTDIV NAVFACENGCOM CAMP LEJEUNE, NC	TITLE UNPAVED SURFACE TYPE II MONITORING WELL DETAIL			FIGURE
BCAA	JOB NO: 93125	DATE: 12-1993	SCALE: AS SHOWN	DRAWN BY: WHW	CHECKED BY: JC



Richard Catlin & Associates, Inc.
 ENVIRONMENTAL ENGINEERS
 AND HYDROGEOLOGISTS

PROJECT
BUILDING AS-410
LANTDIV NAVFACENGCOM
CAMP LEJEUNE, NC

TITLE
PAVED SURFACE TYPE II
MONITORING WELL DETAIL

FIGURE

WILMINGTON, NC CHARLESTON, SC ATLANTA, GA WINSTON-SALEM, NC

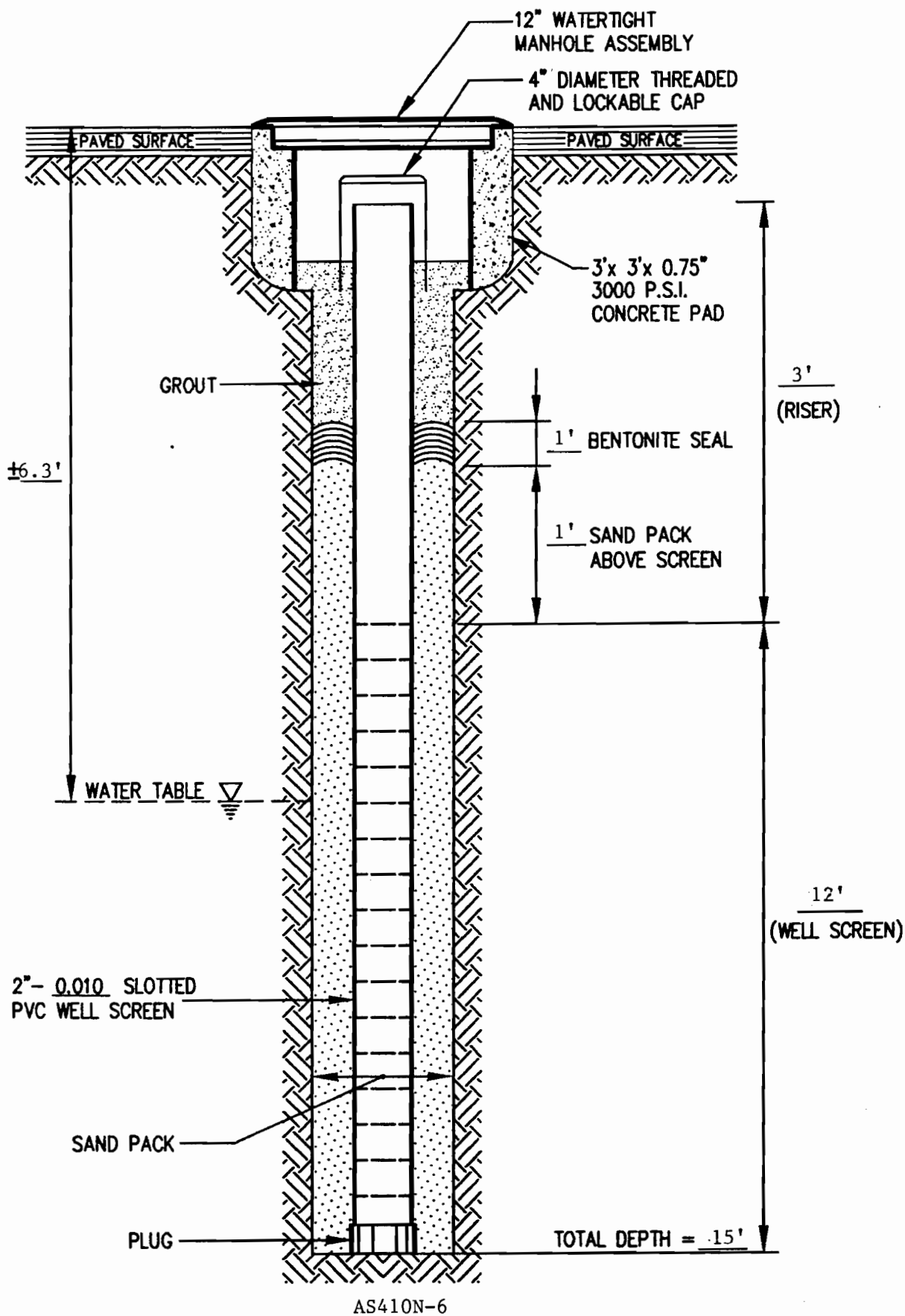
JOB NO: 93125

DATE: 12-1993

SCALE: AS SHOWN

DRAWN BY: WHW

CHECKED BY: JC



Richard Catlin & Associates, Inc.
 ENVIRONMENTAL ENGINEERS
 AND HYDROGEOLOGISTS

PROJECT
 BUILDING AS-410
 LANTDIV NAVFACENGCOM
 CAMP LEJEUNE, NC

TITLE
 PAVED SURFACE TYPE II
 MONITORING WELL DETAIL

FIGURE

WILMINGTON, NC CHARLESTON, SC ATLANTA, GA WINSTON-SALEM, NC

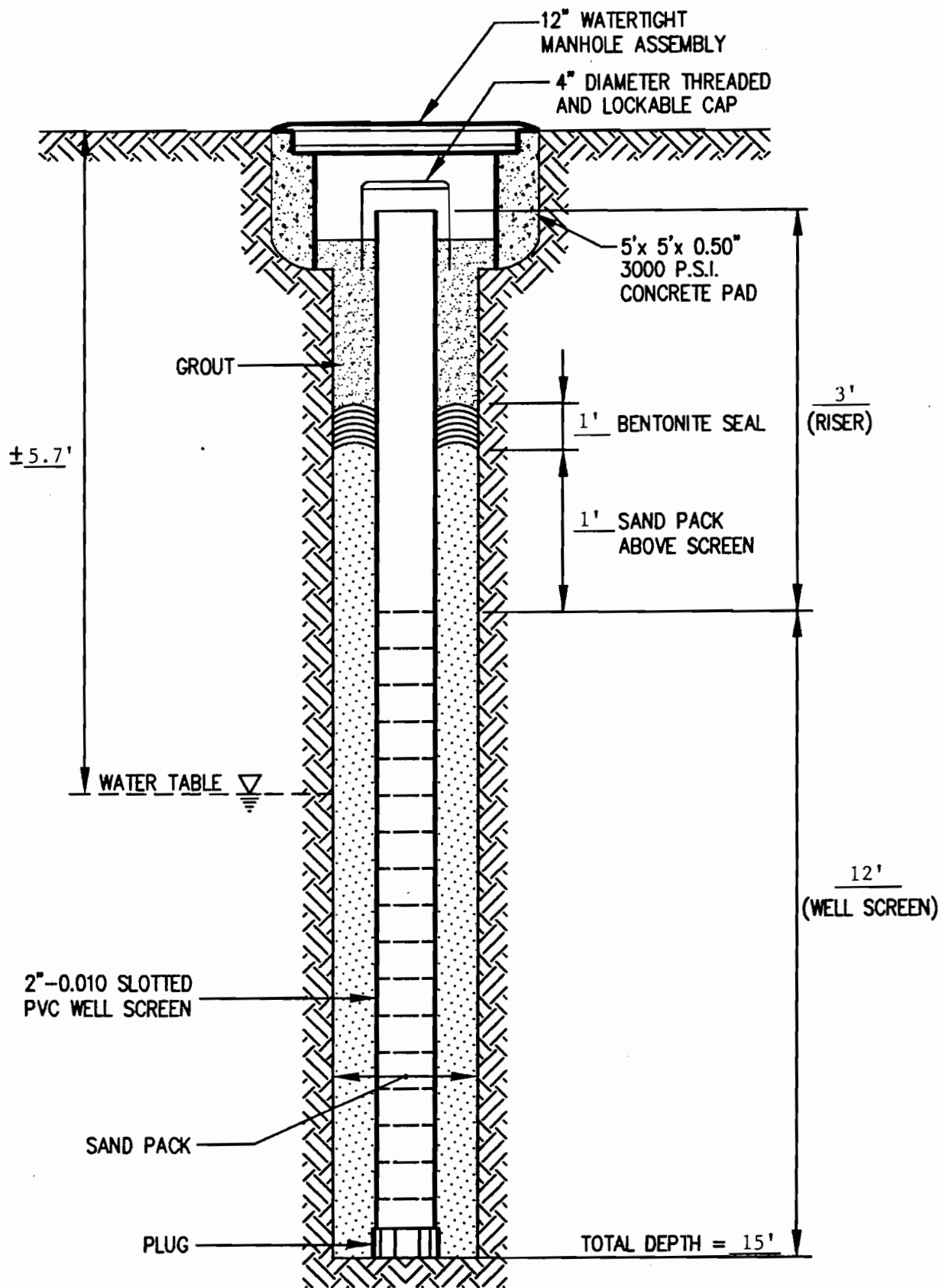
JOB NO: 93125

DATE: 12-1993

SCALE: AS SHOWN

DRAWN BY: WHW

CHECKED BY: JC



AS410N-7

Richard Catlin & Associates, Inc.
 ENVIRONMENTAL ENGINEERS
 AND HYDROGEOLOGISTS

PROJECT
 BUILDING AS-410
 LANTDIV NAVFACENGCOM
 CAMP LEJEUNE, NC

TITLE
 UNPAVED SURFACE TYPE II
 MONITORING WELL DETAIL

FIGURE

WILMINGTON, NC CHARLESTON, SC ATLANTA, GA WINSTON-SALEM, NC

JOB NO: 93125

DATE: 12-1993

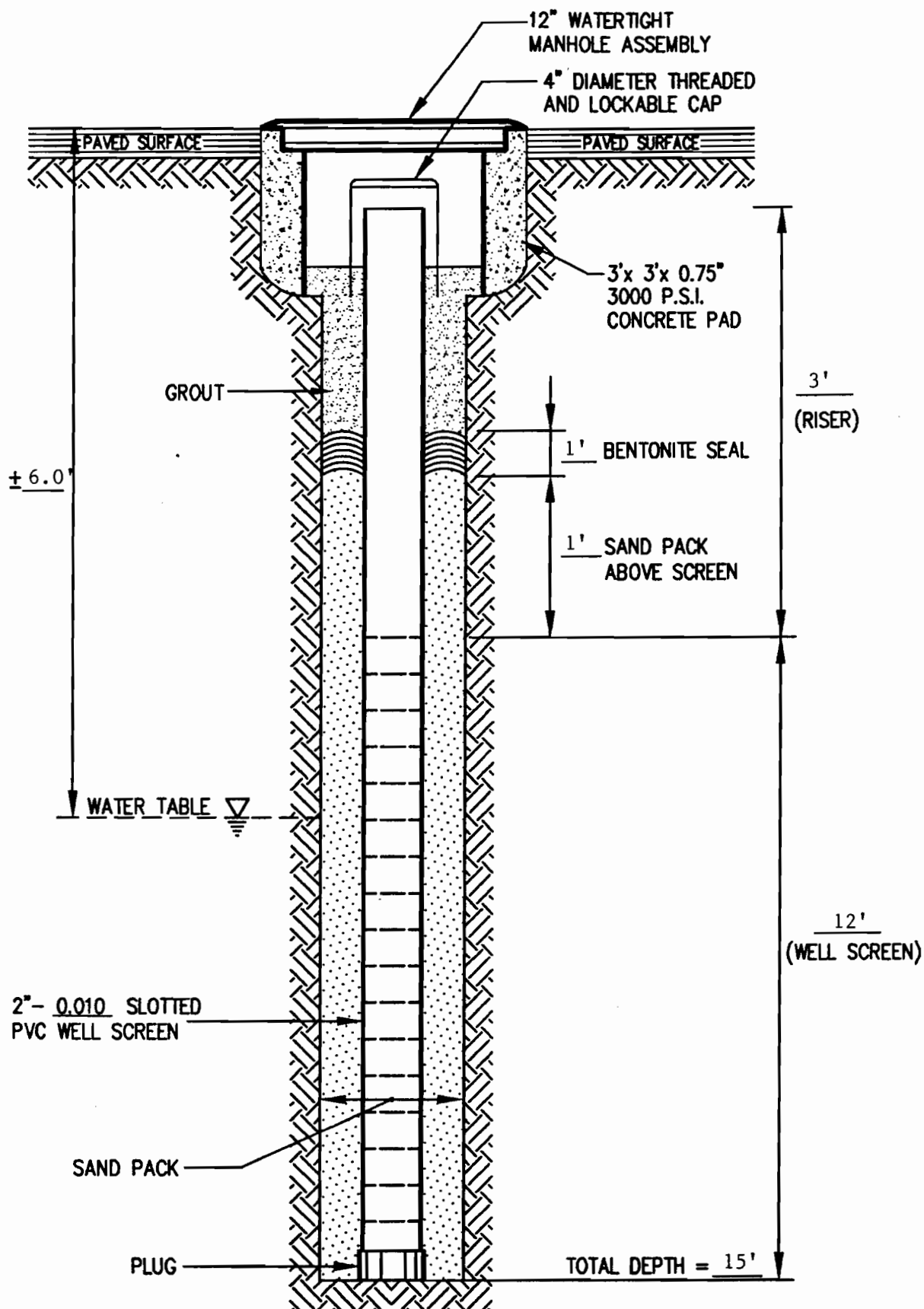
SCALE: AS SHOWN

DRAWN BY:

WHW

CHECKED BY:

JC



AS410N-9

Richard Catlin & Associates, Inc.
 ENVIRONMENTAL ENGINEERS
 AND HYDROGEOLOGISTS

WILMINGTON, NC CHARLESTON, SC ATLANTA, GA WINSTON-SALEM, NC

PROJECT
BUILDING AS-410
LANTDIV NAVFACENGCOM
CAMP LEJEUNE, NC

JOB NO: 93125

DATE: 12-1993

TITLE

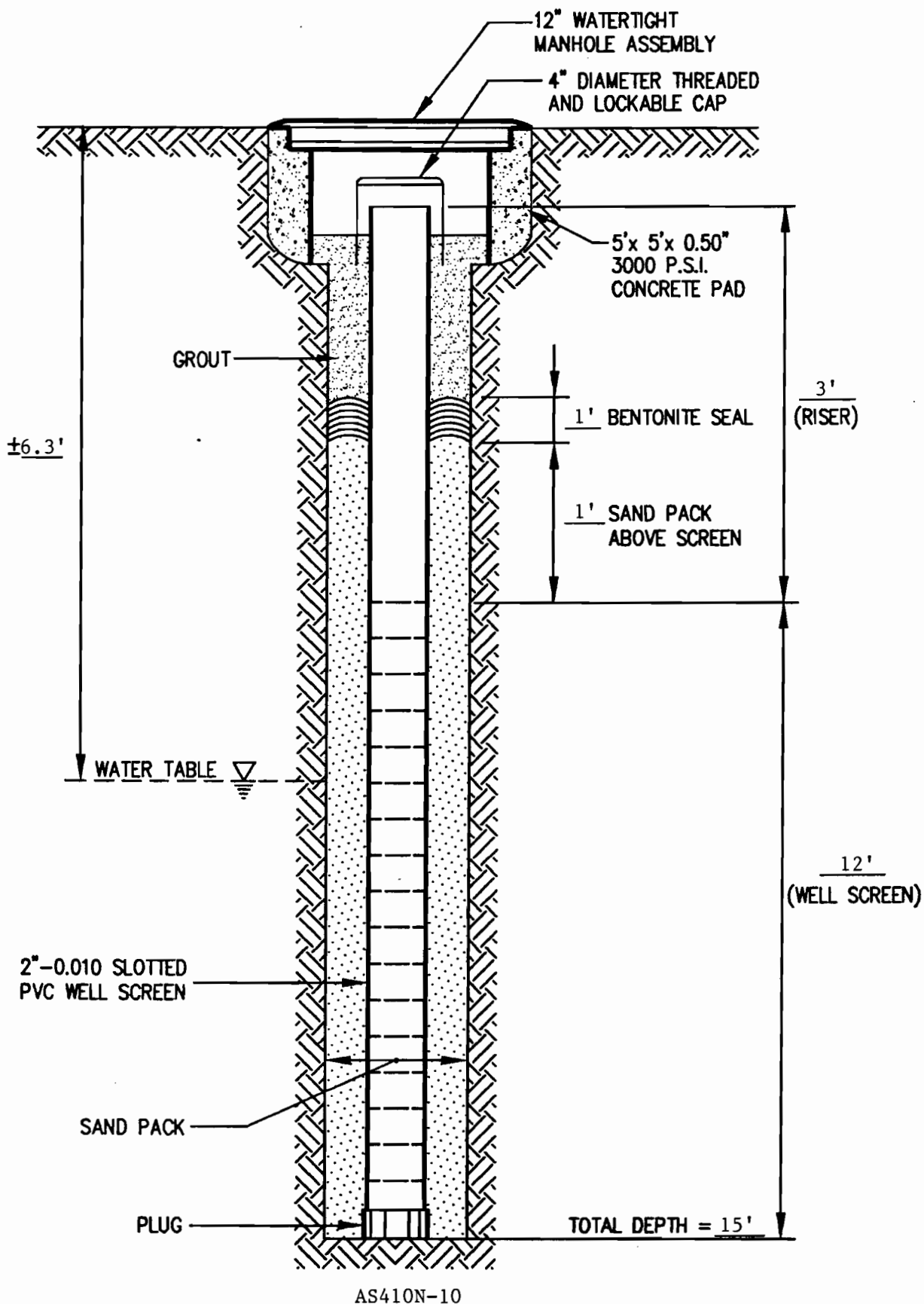
PAVED SURFACE TYPE II
MONITORING WELL DETAIL

FIGURE

SCALE: AS SHOWN

DRAWN BY: WHW

CHECKED BY: JC



Richard Catlin & Associates, Inc.
 ENVIRONMENTAL ENGINEERS
 AND HYDROGEOLOGISTS

BCMA

WILMINGTON, NC CHARLESTON, SC ATLANTA, GA WINSTON-SALEM, NC

PROJECT
 BUILDING AS-410
 LANTDIV NAVFACENGCOM
 CAMP LEJEUNE, NC

JOB NO: 93125

DATE: 12-1993

TITLE

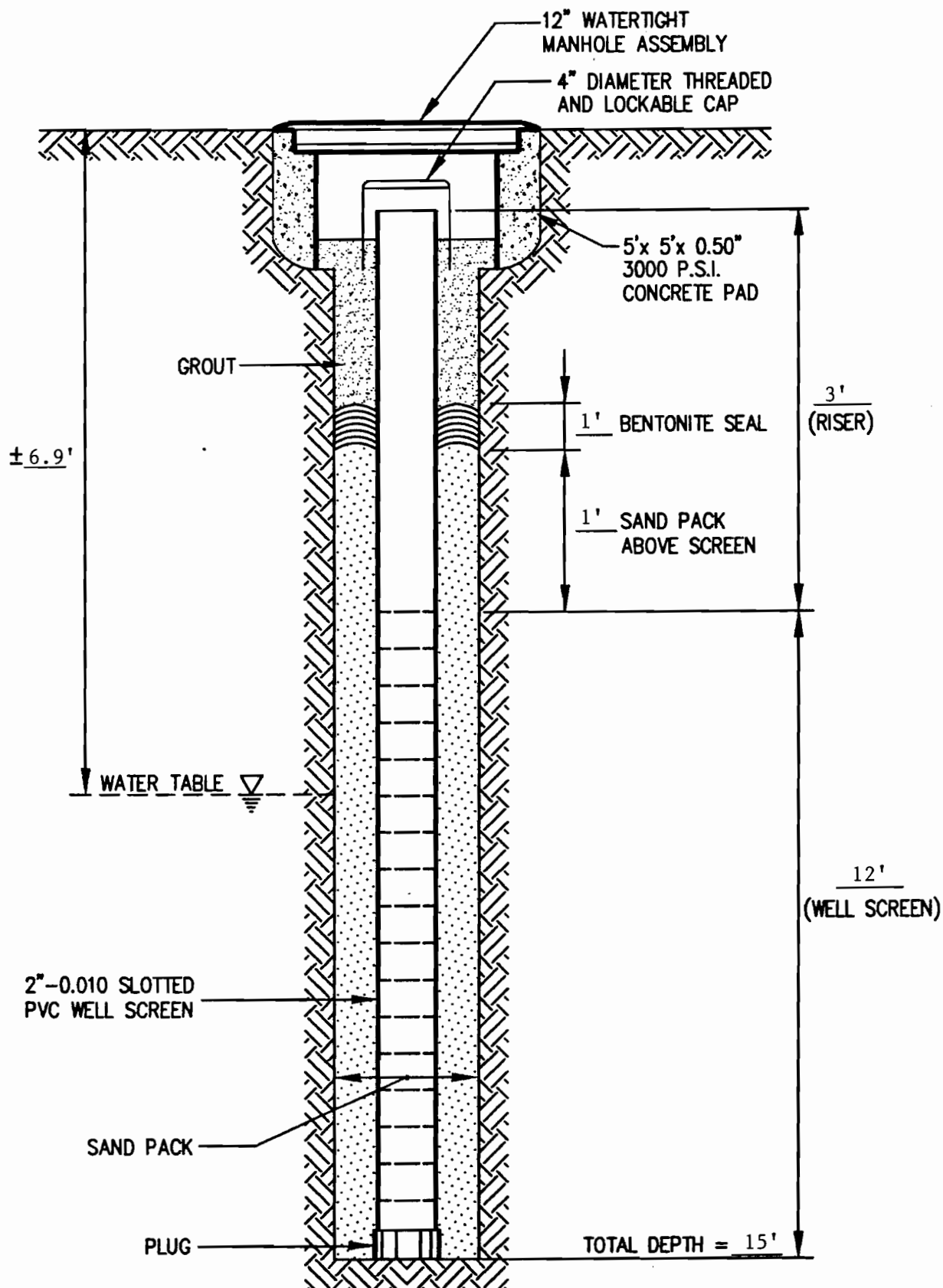
UNPAVED SURFACE TYPE II
 MONITORING WELL DETAIL

SCALE: AS SHOWN

DRAWN BY: WHW

CHECKED BY: JC

FIGURE



Richard Catlin & Associates, Inc.
 ENVIRONMENTAL ENGINEERS
 AND HYDROGEOLOGISTS
 WILMINGTON, NC CHARLESTON, SC ATLANTA, GA WINSTON-SALEM, NC

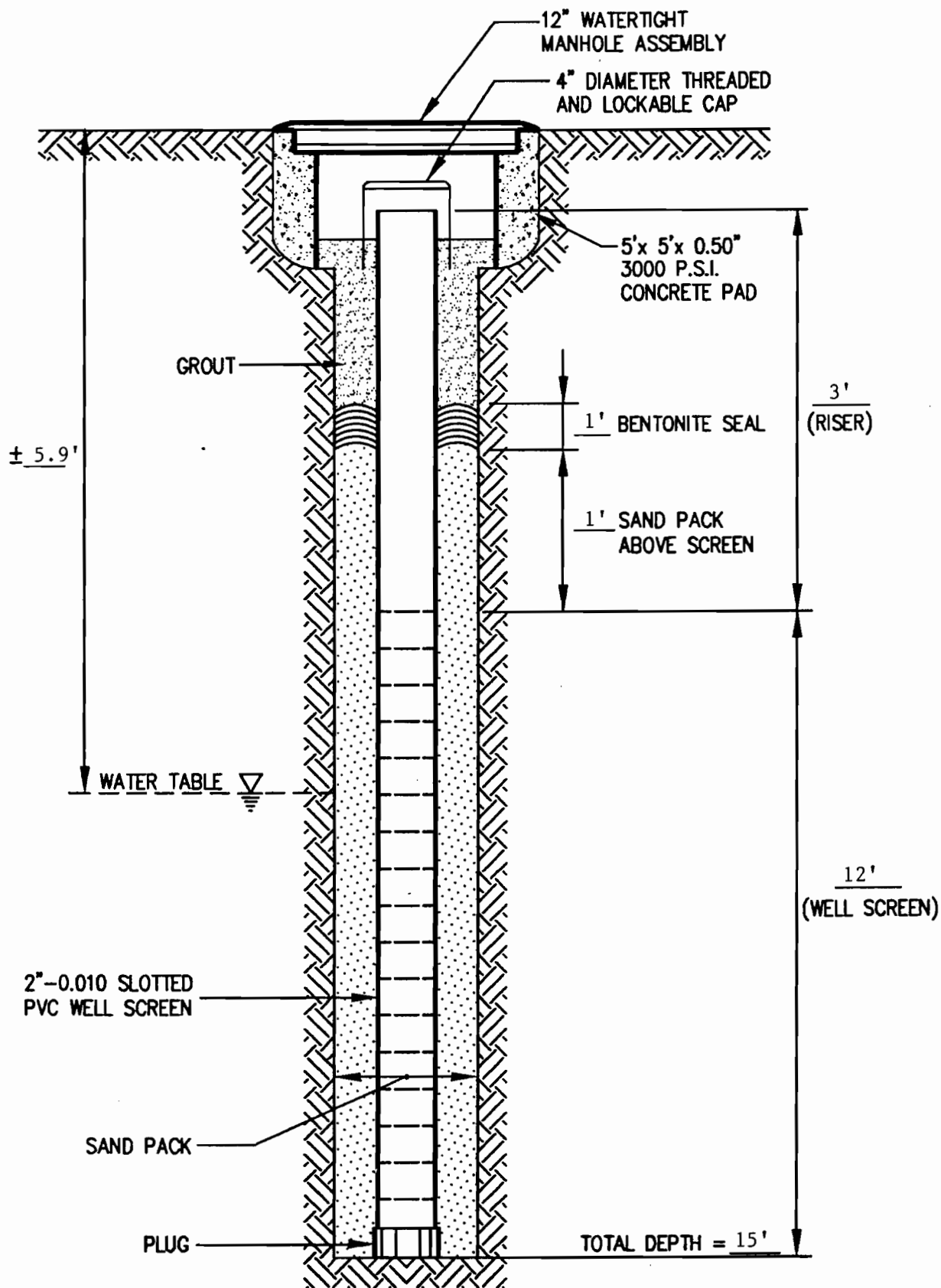
PROJECT
 BUILDING AS-410
 LAND DIV NAVFACENGCOM
 CAMP LEJEUNE, NC

TITLE
 UNPAVED SURFACE TYPE II
 MONITORING WELL DETAIL

FIGURE

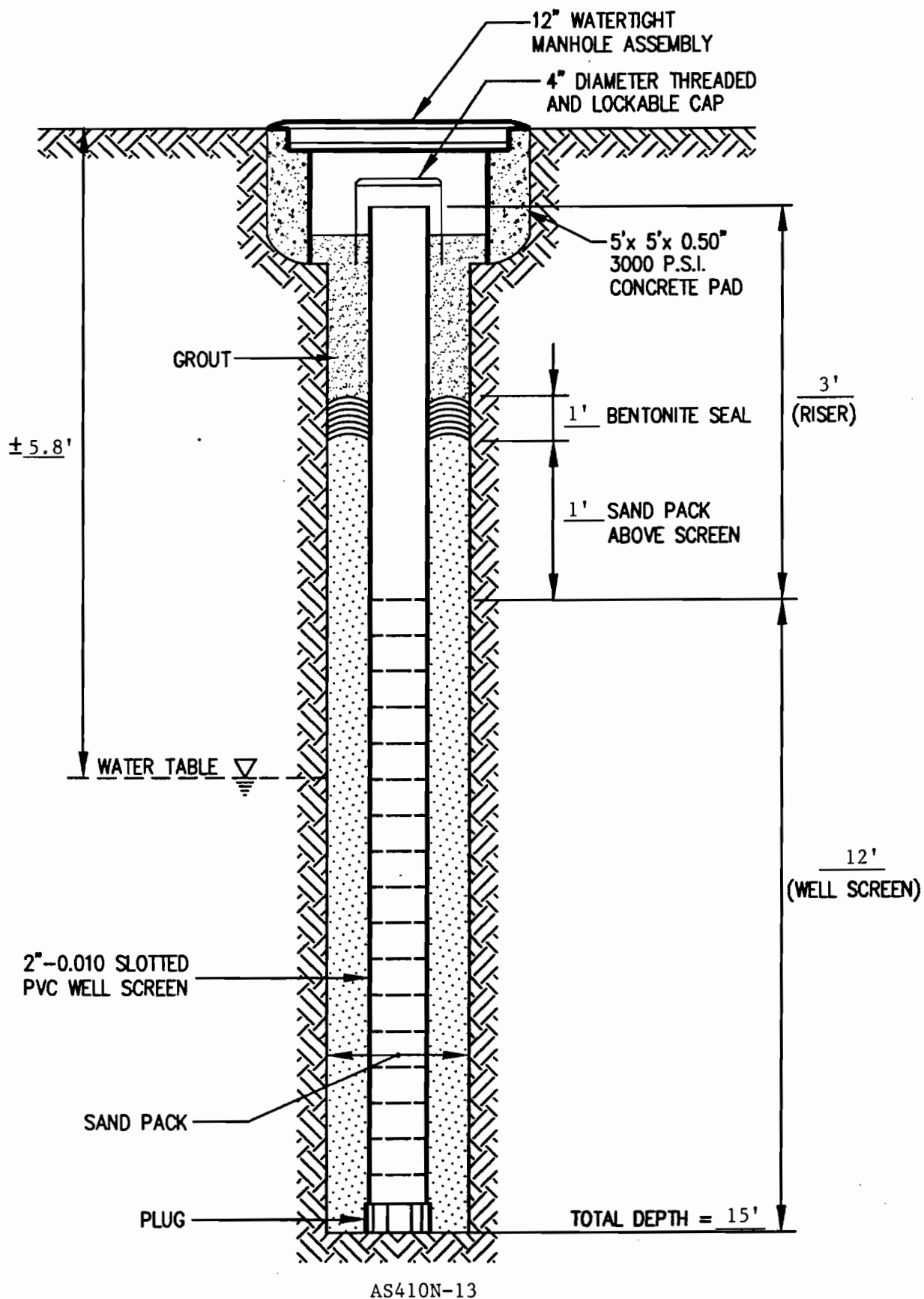
JOB NO: 93125 DATE: 12-1993

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



AS410N-12

Richard Catlin & Associates, Inc. ENVIRONMENTAL ENGINEERS AND HYDROGEOLOGISTS WILMINGTON, NC CHARLESTON, SC ATLANTA, GA WINSTON-SALEM, NC	PROJECT BUILDING AS-410 LANDDIV NAVFACENGCOM CAMP LEJEUNE, NC JOB NO: 93125 DATE: 12-1993	TITLE UNPAVED SURFACE TYPE II MONITORING WELL DETAIL SCALE: AS SHOWN DRAWN BY: WHW CHECKED BY: JC	FIGURE

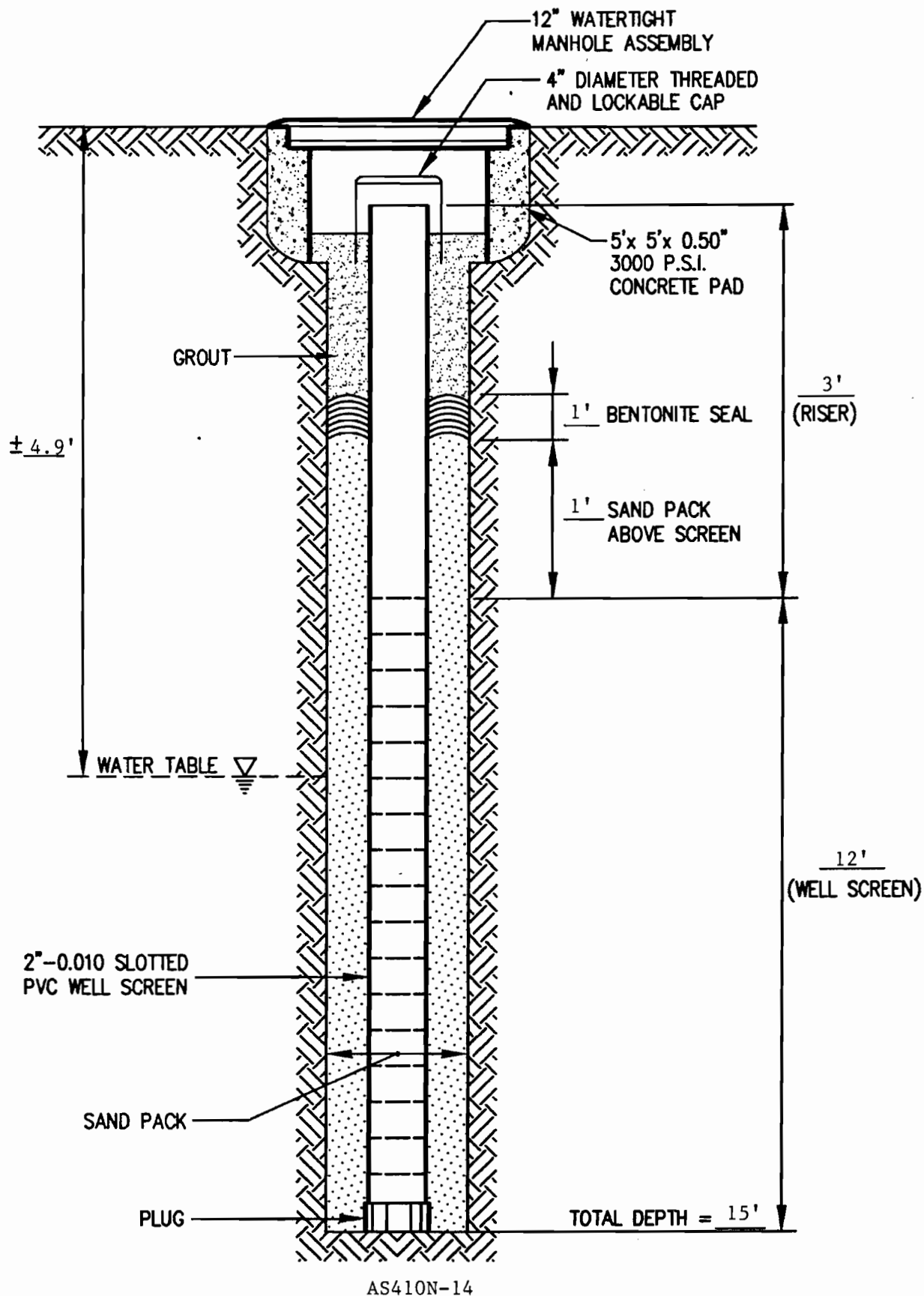


Richard Catlin & Associates, Inc.
 ENVIRONMENTAL ENGINEERS
 AND HYDROGEOLOGISTS
 WILMINGTON, NC CHARLESTON, SC ATLANTA, GA WINSTON-SALEM, NC

PROJECT
BUILDING AS-410
LANTDIV NAVFACENGCOM
CAMP LEJEUNE, NC
 JOB NO: 93125 DATE: 12-1993

TITLE
UNPAVED SURFACE TYPE II
MONITORING WELL DETAIL
 SCALE: AS SHOWN DRAWN BY: WHW CHECKED BY: JC

FIGURE



Richard Catlin & Associates, Inc.
 ENVIRONMENTAL ENGINEERS
 AND HYDROGEOLOGISTS
 WILMINGTON, NC CHARLESTON, SC ATLANTA, GA WINSTON-SALEM, NC

PROJECT
BUILDING AS-410
LANTDIV NAVFACENGCOM
CAMP LEJEUNE, NC

TITLE
UNPAVED SURFACE TYPE II
MONITORING WELL DETAIL

FIGURE

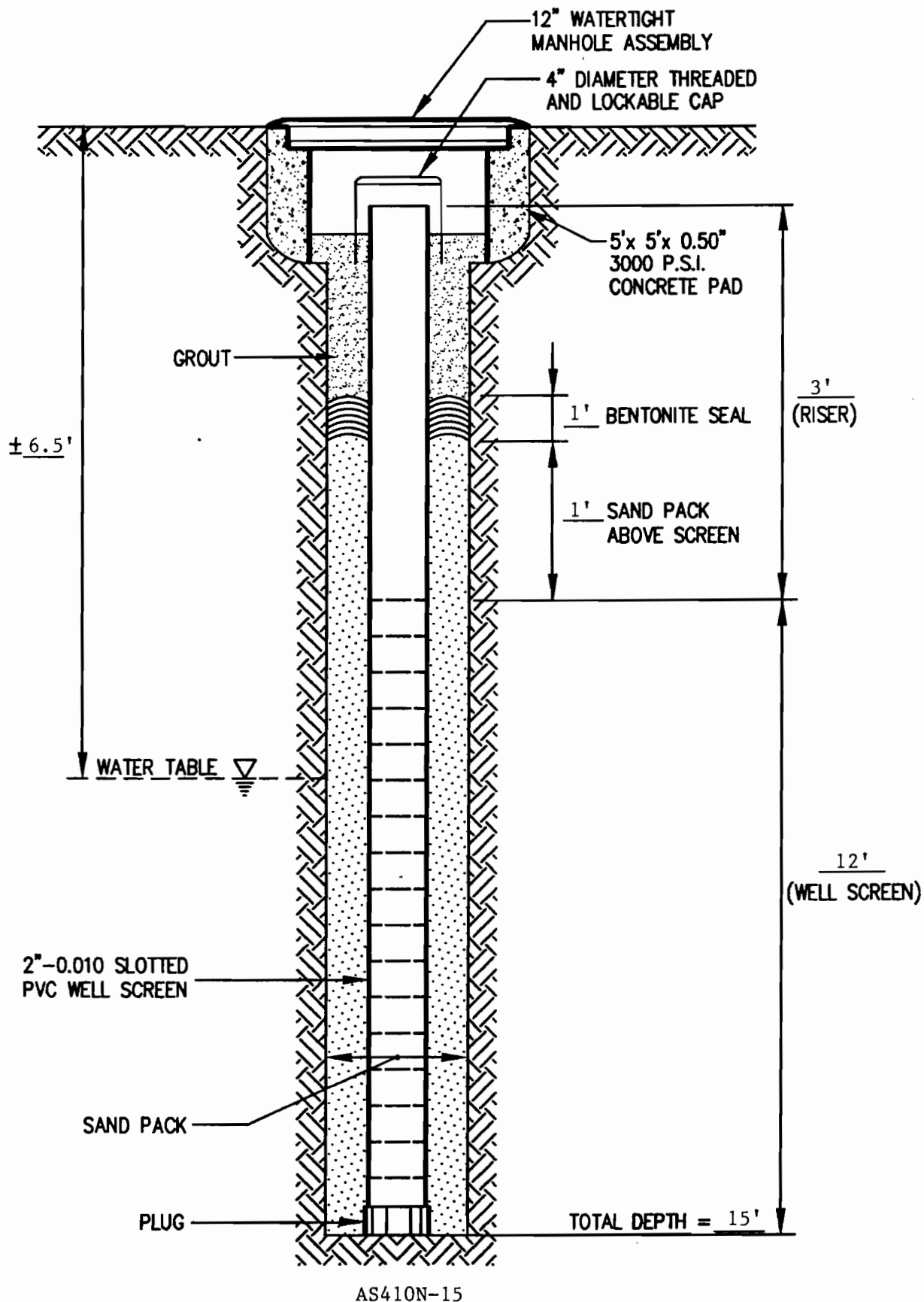
JOB NO: 93125

DATE: 12-1993

SCALE: AS SHOWN

DRAWN BY: WHW

CHECKED BY: JC



Richard Catlin & Associates, Inc.
 ENVIRONMENTAL ENGINEERS
 AND HYDROGEOLOGISTS

PROJECT
 BUILDING AS-410
 LAND DIV NAVFACENGCOM
 CAMP LEJEUNE, NC

TITLE
 UNPAVED SURFACE TYPE II
 MONITORING WELL DETAIL

FIGURE

WILMINGTON, NC CHARLESTON, SC ATLANTA, GA WINSTON-SALEM, NC

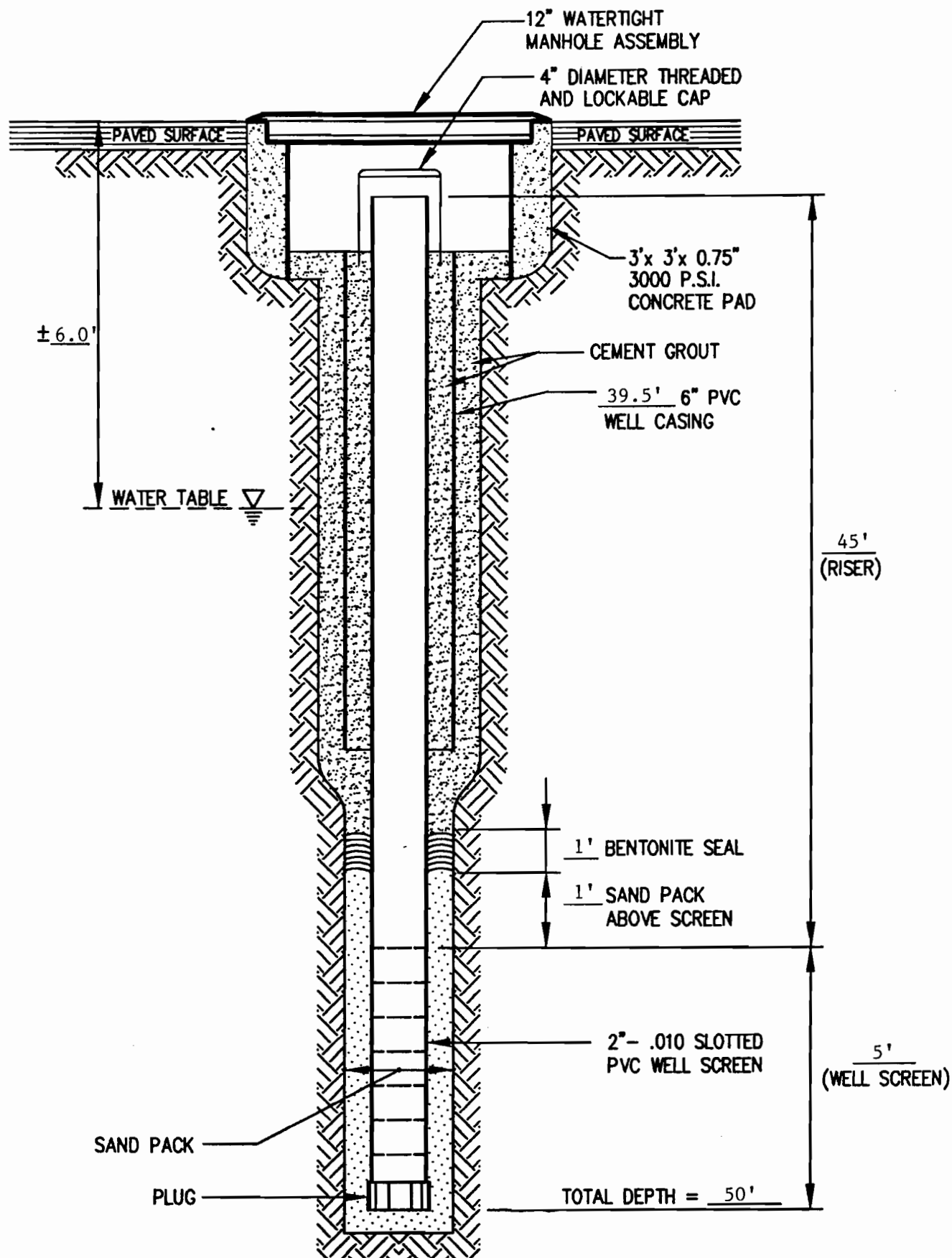
JOB NO: 93125

DATE: 12-1993

SCALE: AS SHOWN

DRAWN BY: WHW

CHECKED BY: JC



AS410N-16

Richard Catlin & Associates, Inc.
ENVIRONMENTAL ENGINEERS
AND HYDROGEOLOGISTS

BCMA

PROJECT
BUILDING AS-410
LAND DIV NAVFACENGCOM
CAMP LEJEUNE, NC

TITLE

PAVED SURFACE TYPE III
MONITORING WELL DETAIL

FIGURE

WILMINGTON, NC CHARLESTON, SC ATLANTA, GA WINSTON-SALEM, NC

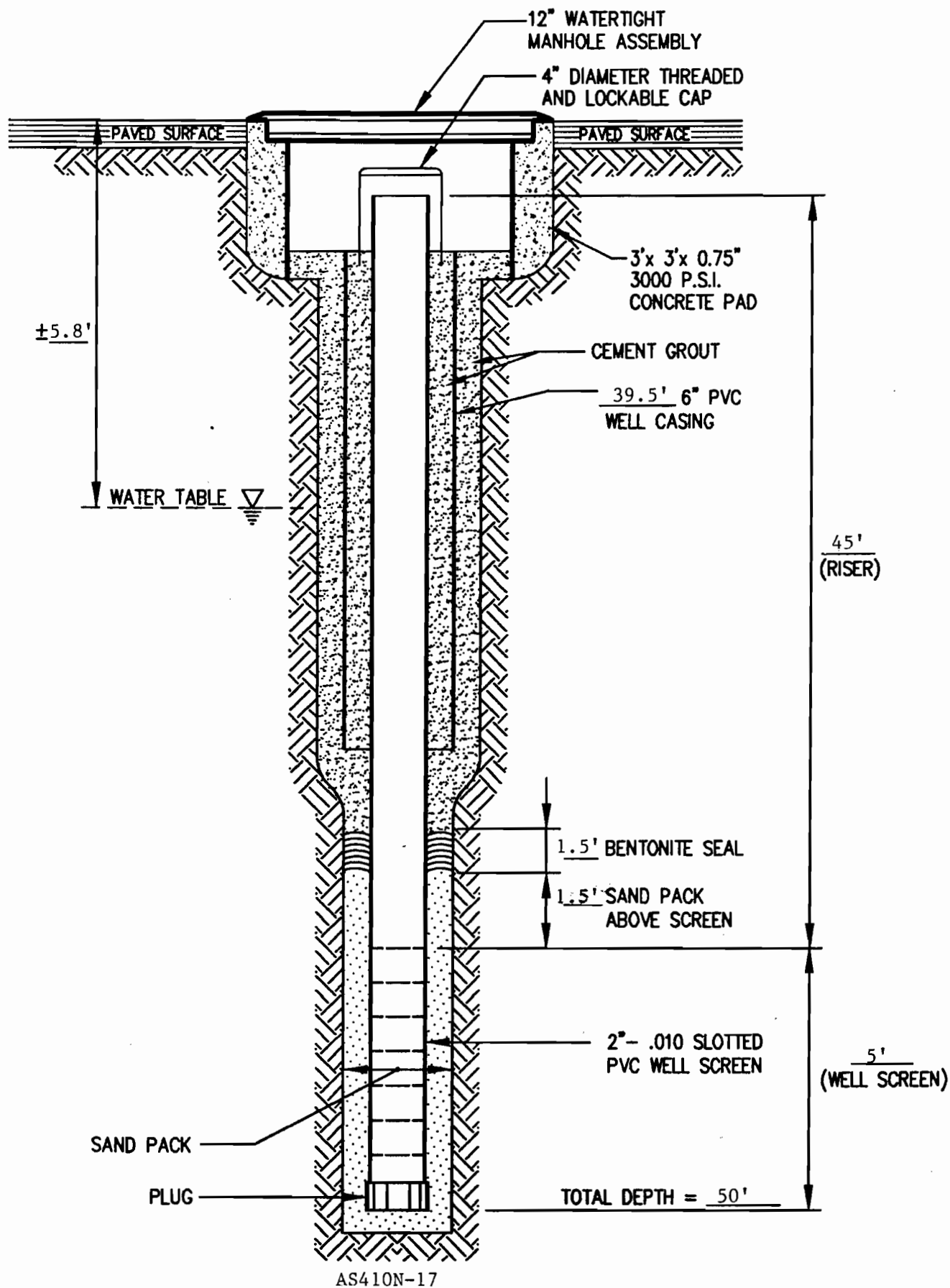
JOB NO: 93125

DATE: 12-1993

SCALE: AS SHOWN

DRAWN BY: WHW

CHECKED BY: JC



Richard Catlin & Associates, Inc.
 ENVIRONMENTAL ENGINEERS
 AND HYDROGEOLOGISTS

PROJECT
 BUILDING AS-410
 LANTDIV NAVFACENGCOM
 CAMP LEJEUNE, NC

TITLE
 PAVED SURFACE TYPE III
 MONITORING WELL DETAIL

FIGURE

WILMINGTON, NC CHARLESTON, SC ATLANTA, GA WINSTON-SALEM, NC

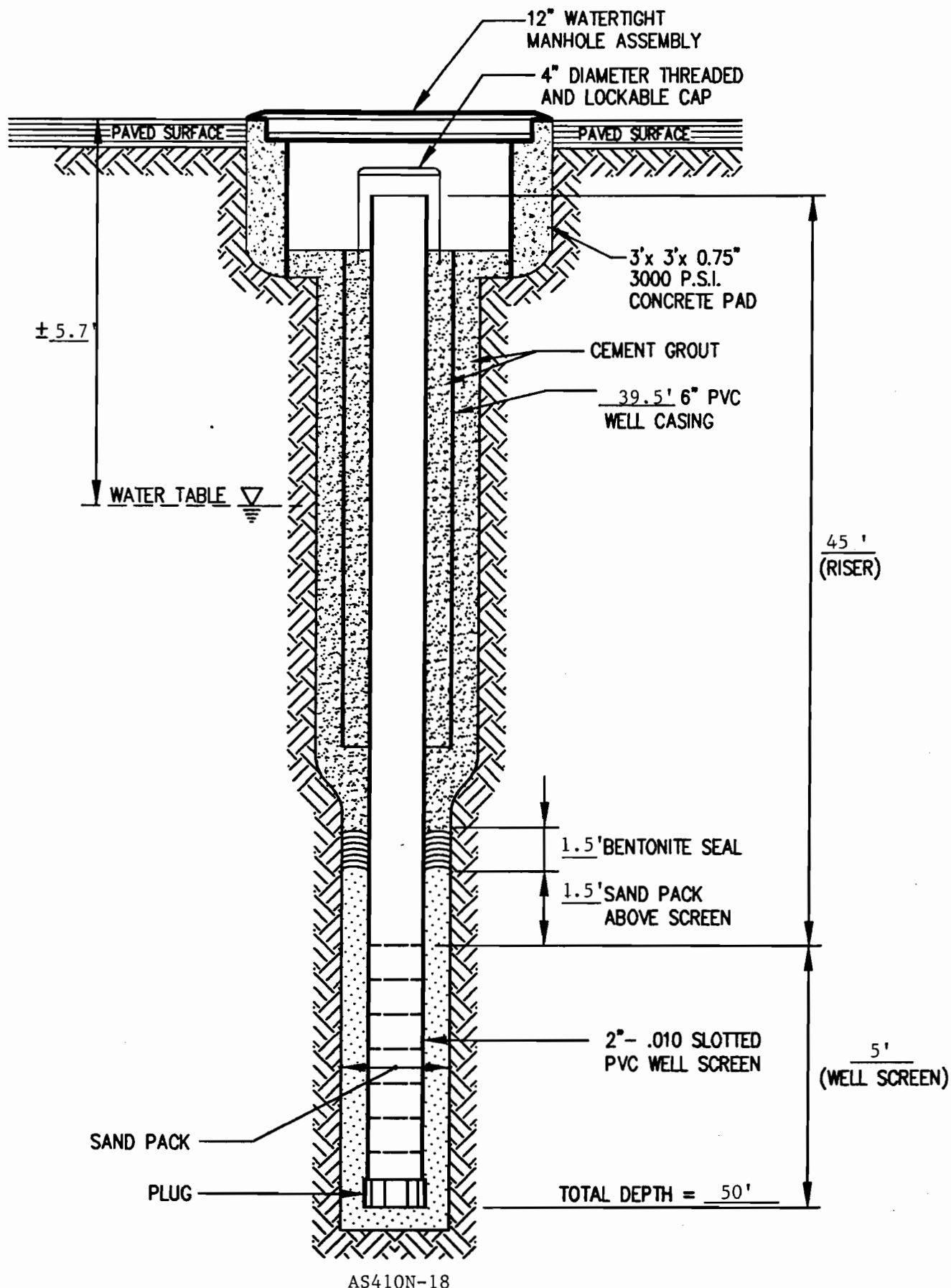
JOB NO: 93125

DATE: 12-1993

SCALE: AS SHOWN

DRAWN BY: WHW

CHECKED BY: JC



AS410N-18

Richard Catlin & Associates, Inc.
 ENVIRONMENTAL ENGINEERS
 AND HYDROGEOLOGISTS

PROJECT
 BUILDING AS-410
 LAND DIV NAVFACENGCOM
 CAMP LEJEUNE, NC

TITLE
 PAVED SURFACE TYPE III
 MONITORING WELL DETAIL

FIGURE

WILMINGTON, NC CHARLESTON, SC ATLANTA, GA WINSTON-SALEM, NC

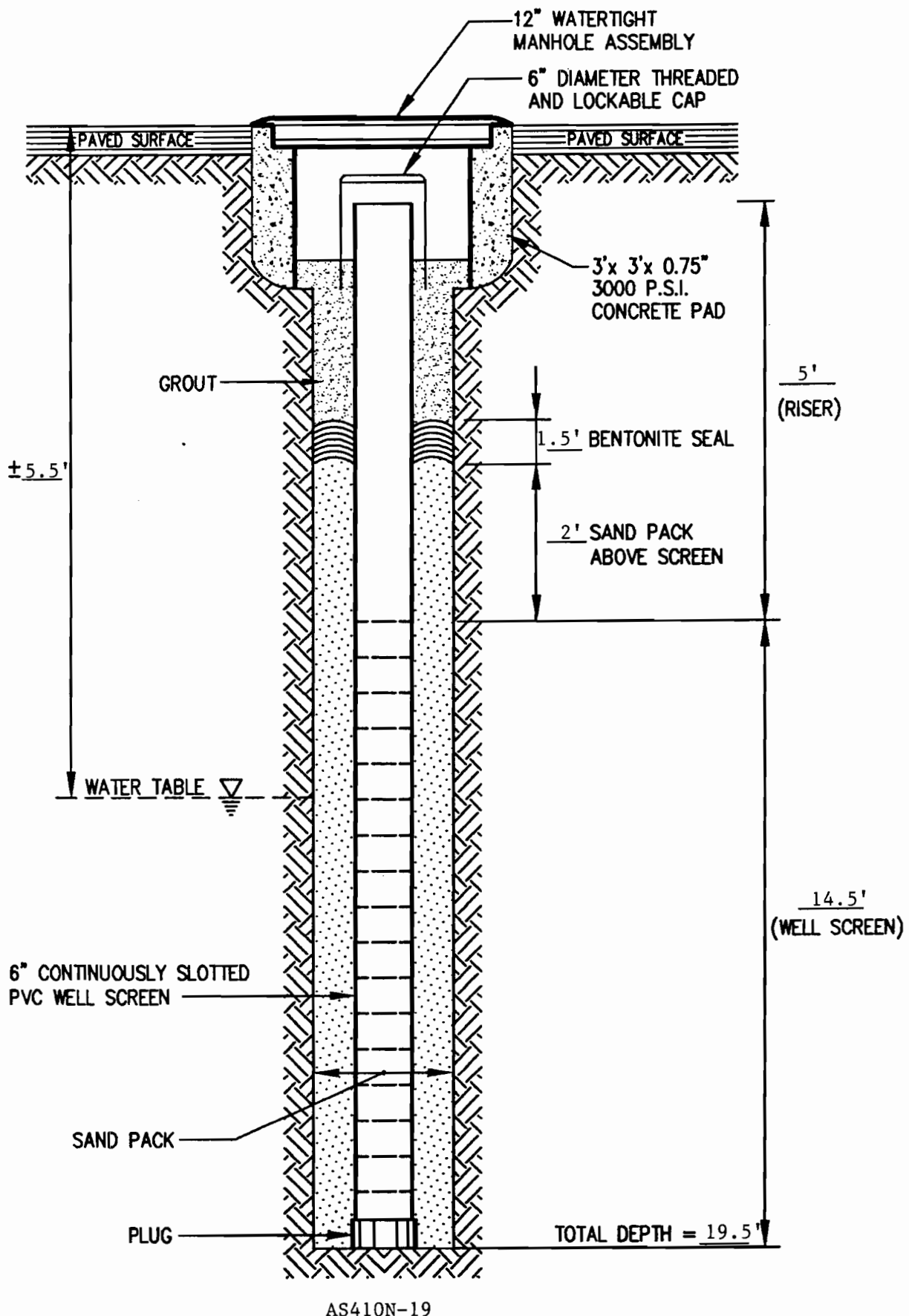
JOB NO: 93125

DATE: 12-1993

SCALE: AS SHOWN

DRAWN BY: WHW

CHECKED BY: JC



Richard Collin & Associates, Inc.
 ENVIRONMENTAL ENGINEERS
 AND HYDROGEOLOGISTS

WILMINGTON, NC CHARLESTON, SC ATLANTA, GA WINSTON-SALEM, NC

PROJECT
 BUILDING AS-410
 LAND DIV NAVFACENGCOM
 CAMP LEJEUNE, NC

JOB NO: 93125

DATE: 12-1993

TITLE

PAVED SURFACE
 PUMPING WELL DETAIL

SCALE: AS SHOWN

DRAWN BY: WHW

CHECKED BY: JC

FIGURE

FOR OFFICE USE ONLY

Quad. No. _____ Serial No. _____
Lat. _____ Long. _____ Pc _____
Minor Basin _____
Basin Code _____
Header Ent. _____ GW-1 Ent. _____

WELL CONSTRUCTION RECORD

AS410N-4

DRILLING CONTRACTOR Richard Catlin & Associates, Inc.

DRILLER REGISTRATION NUMBER 1142

STATE WELL CONSTRUCTION

PERMIT NUMBER: NA

WELL LOCATION: (Show sketch of the location below)

Nearest Town: Camp Lejeune
Building AS-410

County: Onslow

(Road, Community, or Subdivision and Lot No.)

OWNER LANTDIV NAVFACENGCOM Commanding General

ADDRESS AC/S EMD/Marine Corps Base/PSC Box 20004
Camp Lejeune NC 28542-0004

City or Town _____ State _____ Zip Code _____

DATE DRILLED 10-21-93 USE OF WELL Monitoring

TOTAL DEPTH 15' CUTTINGS COLLECTED ☒ Yes ☐ No

DOES WELL REPLACE EXISTING WELL? ☐ Yes ☒ No

STATIC WATER LEVEL: 5.7 FT. ☐ above TOP OF CASING,
☒ below
TOP OF CASING IS _____ FT. ABOVE LAND SURFACE.

YIELD (gpm): _____ METHOD OF TEST _____

WATER ZONES (depth): Surficial Aquifer

CONTAMINATION: Type _____ Amount _____

CASING:

From	Depth	To	Diameter	Wall Thickness or Weight/Ft.	Material
0'	3'	Ft.	2"	SCH40	PVC
From	To	Ft.			
From	To	Ft.			

GROUT:

From	Depth	To	Material	Method
0'	1'	Ft.	Cement	Poured
1'	2'	Ft.	Bentonite	Chips/Pellets

SCREEN:

From	Depth	To	Diameter	Slot Size	Material
3'	15'	Ft.	2"	.010 in.	PVC
From	To	Ft.	in.	in.	
From	To	Ft.	in.	in.	

GRAVEL PACK:

From	Depth	To	Size	Material
2'	15'	Ft.	Torpedo	Sand
From	To	Ft.		

REMARKS:

I DO HEREBY CERTIFY THAT THIS WELL WAS CONSTRUCTED IN ACCORDANCE WITH 15 NCAC 2C. WELL CONSTRUCTION STANDARDS, AND THAT A COPY OF THIS RECORD HAS BEEN PROVIDED TO THE WELL OWNER.

SIGNATURE OF CONTRACTOR OR AGENT

DATE

Submit original to Division of Environmental Management and copy to well owner.

FOR OFFICE USE ONLY

Quad. No. _____ Serial No. _____
Lat. _____ Long. _____ Pc _____
Minor Basin _____
Basin Code _____
Header Ent. _____ GW-1 Ent. _____

WELL CONSTRUCTION RECORD AS410N-5

DRILLING CONTRACTOR Richard Catlin & Associates, Inc.

DRILLER REGISTRATION NUMBER 1142

STATE WELL CONSTRUCTION
PERMIT NUMBER: NA

1. WELL LOCATION: (Show sketch of the location below)

Nearest Town: Camp Lejeune
Building AS-410

(Road, Community, or Subdivision and Lot No.)

2. OWNER LANTDIV NAVFACENGCOM Commanding General

ADDRESS AC/S EMD/Marine Corps Base/PSC Box 20004
Camp Lejeune (Street or Route No.) NC 28542-0004
City or Town State Zip Code

3. DATE DRILLED 10-21-93 USE OF WELL Monitoring

4. TOTAL DEPTH 15' CUTTINGS COLLECTED ☒ Yes ☐ No

5. DOES WELL REPLACE EXISTING WELL? ☐ Yes ☒ No

6. STATIC WATER LEVEL: 6.3 FT. ☐ above TOP OF CASING,
☒ below
TOP OF CASING IS _____ FT. ABOVE LAND SURFACE.

7. YIELD (gpm): _____ METHOD OF TEST _____

8. WATER ZONES (depth): Surficial Aquifer

9. CORINATION: Type _____ Amount _____

10. CASING:

Depth	Diameter	Wall Thickness or Weight/Ft.	Material
From <u>0'</u> To <u>3'</u> Ft.	<u>2"</u>	<u>SCH40</u>	<u>PVC</u>
From _____ To _____ Ft.	_____	_____	_____
From _____ To _____ Ft.	_____	_____	_____

11. GROUT:

Depth	Material	Method
From <u>0'</u> To <u>1'</u> Ft.	<u>Cement</u>	<u>Poured</u>
From <u>1'</u> To <u>2'</u> Ft.	<u>Bentonite</u>	<u>Chips/Pellets</u>

12. SCREEN:

Depth	Diameter	Slot Size	Material
From <u>3'</u> To <u>15'</u> Ft.	<u>2"</u>	<u>.010</u> in.	<u>PVC</u>
From _____ To _____ Ft.	_____	_____	_____
From _____ To _____ Ft.	_____	_____	_____

13. GRAVEL PACK:

Depth	Size	Material
From <u>2'</u> To <u>15'</u> Ft.	<u>Torpedo</u>	<u>Sand</u>
From _____ To _____ Ft.	_____	_____

14. REMARKS:

I DO HEREBY CERTIFY THAT THIS WELL WAS CONSTRUCTED IN ACCORDANCE WITH 15 NCAC 2C, WELL CONSTRUCTION STANDARDS, AND THAT A COPY OF THIS RECORD HAS BEEN PROVIDED TO THE WELL OWNER.

SIGNATURE OF CONTRACTOR OR AGENT

DATE

Submit original to Division of Environmental Management and copy to well owner.

FOR OFFICE USE ONLY

Quad. No. _____ Serial No. _____
Lat. _____ Long. _____ Pc _____
Minor Basin _____
Basin Code _____
Header Ent. _____ GW-1 Ent. _____

WELL CONSTRUCTION RECORD

AS410N-6

DRILLING CONTRACTOR Richard Catlin & Associates, Inc.

DRILLER REGISTRATION NUMBER 1142

STATE WELL CONSTRUCTION

PERMIT NUMBER: NA

1. WELL LOCATION: (Show sketch of the location below)

Nearest Town: Camp Lejeune
Building AS-410
(Road, Community, or Subdivision and Lot No.)

County: Onslow

2. OWNER LANTDIV NAVFACENGCOM Commanding General

ADDRESS AC/S EMD/Marine Corps Base/PSC Box 20004
Camp Lejeune (Street or Route No.) NC 28542-0004
City or Town State Zip Code

Depth DRILLING LOG
From To Formation Description

3. DATE DRILLED 10-21-93 USE OF WELL Monitoring

4. TOTAL DEPTH 15' CUTTINGS COLLECTED ☒ Yes ☐ No

5. DOES WELL REPLACE EXISTING WELL? ☐ Yes ☒ No

6. STATIC WATER LEVEL: 6.3 FT. ☐ above TOP OF CASING,
☒ below
TOP OF CASING IS _____ FT. ABOVE LAND SURFACE.

7. YIELD (gpm): _____ METHOD OF TEST _____

8. WATER ZONES (depth): Surficial Aquifer

9. DRINATION: Type _____ Amount _____

10. CASING:

From	Depth	To	Diameter	Wall Thickness or Weight/Ft.	Material
0'	3'	Ft.	2"	SCH40	PVC
From	To	Ft.			
From	To	Ft.			

If additional space is needed use back of form.

LOCATION SKETCH

(Show direction and distance from at least two State Roads, or other map reference points)

11. GROUT:

From	Depth	To	Material	Method
0'	1'	Ft.	Cement	Poured
1'	2'	Ft.	Bentonite	Chips/Pellets

12. SCREEN:

From	Depth	To	Diameter	Slot Size	Material
3'	15'	Ft.	2"	.010 in.	PVC
From	To	Ft.			
From	To	Ft.			

13. GRAVEL PACK:

From	Depth	To	Size	Material
2'	15'	Ft.	Torpedo	Sand
From	To	Ft.		

14. REMARKS:

I DO HEREBY CERTIFY THAT THIS WELL WAS CONSTRUCTED IN ACCORDANCE WITH 15 NCAC 2C, WELL CONSTRUCTION STANDARDS, AND THAT A COPY OF THIS RECORD HAS BEEN PROVIDED TO THE WELL OWNER.

Jim M. Pover
SIGNATURE OF CONTRACTOR OR AGENT

January 1994
DATE

Submit original to Division of Environmental Management and copy to well owner.

FOR OFFICE USE ONLY

Quad. No. _____ Serial No. _____
Lat. _____ Long. _____ Pc _____
Minor Basin _____
Basin Code _____
Header Ent. _____ GW-1 Ent. _____

WELL CONSTRUCTION RECORD

AS410N-7

DRILLING CONTRACTOR Richard Catlin & Associates, Inc.

DRILLER REGISTRATION NUMBER 1142

STATE WELL CONSTRUCTION

PERMIT NUMBER: NA

1. WELL LOCATION: (Show sketch of the location below)

Nearest Town: Camp Lejeune
Building AS-410

(Road, Community, or Subdivision and Lot No.)

2. OWNER LANTDIV NAVFACENGCOM Commanding General

ADDRESS AC/S EMD/Marine Corps Base/PSC Box 20004
Camp Lejeune NC 28542-0004

City or Town State Zip Code

3. DATE DRILLED 10-22-93 USE OF WELL Monitoring

4. TOTAL DEPTH 15' CUTTINGS COLLECTED ☒ Yes ☐ No

5. DOES WELL REPLACE EXISTING WELL? ☐ Yes ☒ No

6. STATIC WATER LEVEL: 5.7 FT. ☐ above TOP OF CASING,
☒ below TOP OF CASING IS _____ FT. ABOVE LAND SURFACE.

7. YIELD (gpm): _____ METHOD OF TEST _____

8. WATER ZONES (depth): Surficial Aquifer

9. CONTAMINATION: Type _____ Amount _____

10. CASING:

From	Depth	To	Diameter	Wall Thickness or Weight/Ft.	Material
0'	3'	Ft.	2"	SCH40	PVC
From	To	Ft.			
From	To	Ft.			

1. GROUT:

From	Depth	To	Material	Method
0'	1'	Ft.	Cement	Poured
1'	2'	Ft.	Bentonite	Chips/Pellets

2. SCREEN:

From	Depth	To	Diameter	Slot Size	Material
3'	15'	Ft.	2"	.010 in.	PVC
From	To	Ft.			
From	To	Ft.			

3. GRAVEL PACK:

From	Depth	To	Size	Material
2'	15'	Ft.	Torpedo	Sand
From	To	Ft.		

4. REMARKS:

I DO HEREBY CERTIFY THAT THIS WELL WAS CONSTRUCTED IN ACCORDANCE WITH 15 NCAC 2C. WELL CONSTRUCTION STANDARDS, AND THAT A COPY OF THIS RECORD HAS BEEN PROVIDED TO THE WELL OWNER.

SIGNATURE OF CONTRACTOR OR AGENT

DATE

Submit original to Division of Environmental Management and copy to well owner.

FOR OFFICE USE ONLY

Quad. No. _____ Serial No. _____
Lat. _____ Long. _____ Pc _____
Minor Basin _____
Basin Code _____
Header Ent. _____ GW-1 Ent. _____

WELL CONSTRUCTION RECORD

AS410N-8

DRILLING CONTRACTOR Richard Catlin & Associates, Inc.

DRILLER REGISTRATION NUMBER 1142

STATE WELL CONSTRUCTION

PERMIT NUMBER: NA

1. WELL LOCATION: (Show sketch of the location below)

Nearest Town: Camp Lejeune
Building AS-410
(Road, Community, or Subdivision and Lot No.)

County: Onslow

2. OWNER LANTDIV NAVFACENGCOM Commanding General

ADDRESS AC/S EMD/Marine Corps Base/PSC Box 20004
Camp Lejeune (Street or Route No.) NC 28542-0004
City or Town State Zip Code

3. DATE DRILLED 10-22-93 USE OF WELL Monitoring

4. TOTAL DEPTH 15' CUTTINGS COLLECTED ☒ Yes ☐ No

5. DOES WELL REPLACE EXISTING WELL? ☐ Yes ☒ No

6. STATIC WATER LEVEL: 5.0 FT. ☐ above TOP OF CASING,
☒ below
TOP OF CASING IS _____ FT. ABOVE LAND SURFACE.

7. YIELD (gpm): _____ METHOD OF TEST _____

8. WATER ZONES (depth): Surficial Aquifer

9. CONTAMINATION: Type _____ Amount _____

10. CASING:

From	Depth	To	Diameter	Wall Thickness	Material
0'	3'	2"	SCH80	PVC	

11. GROUT:

From	Depth	To	Material	Method
0'	1'	Cement	Poured	
1'	2'	Bentonite	Chips/Pellets	

12. SCREEN:

From	Depth	To	Diameter	Slot Size	Material
3'	15'	2"	.010	PVC	

13. GRAVEL PACK:

From	Depth	To	Size	Material
2'	15'	Torpedo	Sand	

14. REMARKS:

I DO HEREBY CERTIFY THAT THIS WELL WAS CONSTRUCTED IN ACCORDANCE WITH 15 NCAC 2C. WELL CONSTRUCTION STANDARDS, AND THAT A COPY OF THIS RECORD HAS BEEN PROVIDED TO THE WELL OWNER.

SIGNATURE OF CONTRACTOR OR AGENT

DATE

Submit original to Division of Environmental Management and copy to well owner.

FOR OFFICE USE ONLY

Quad. No. _____ Serial No. _____
Lat. _____ Long. _____ Pc _____
Minor Basin _____
Basin Code _____
Header Ent. _____ GW-1 Ent. _____

WELL CONSTRUCTION RECORD

AS410N-9

DRILLING CONTRACTOR Richard Catlin & Associates, Inc.

DRILLER REGISTRATION NUMBER 1142

STATE WELL CONSTRUCTION
PERMIT NUMBER: NA

1. WELL LOCATION: (Show sketch of the location below)

Nearest Town: Camp Lejeune
Building AS-410

(Road, Community, or Subdivision and Lot No.)

2. OWNER LANTDIV NAVFACENGCOM Commanding General

ADDRESS AC/S EMD/Marine Corps Base/PSC Box 20004

Camp Lejeune (Street or Route No.) NC 28542-0004

City or Town State Zip Code

3. DATE DRILLED 10-25-93 USE OF WELL Monitoring

4. TOTAL DEPTH 15' CUTTINGS COLLECTED ☒ Yes ☐ No

5. DOES WELL REPLACE EXISTING WELL? ☐ Yes ☒ No

6. STATIC WATER LEVEL: 6.0 FT. ☐ above TOP OF CASING.
☒ below
TOP OF CASING IS _____ FT. ABOVE LAND SURFACE.

7. YIELD (gpm): _____ METHOD OF TEST _____

8. WATER ZONES (depth): Surficial Aquifer

9. CORINATION: Type _____ Amount _____

10. CASING:

From	Depth	Diameter	Wall Thickness or Weight/Ft.	Material
0'	3'	2"	SCH80	PVC
From	To	Ft.		
From	To	Ft.		
From	To	Ft.		

1. GROUT:

From	Depth	Material	Method
0'	1'	Cement	Poured
1'	2'	Bentonite	Chips/Pellets
From	To	Ft.	
From	To	Ft.	

2. SCREEN:

From	Depth	Diameter	Slot Size	Material
3'	15'	2"	.010 in.	PVC
From	To	Ft.	in.	in.
From	To	Ft.	in.	in.

3. GRAVEL PACK:

From	Depth	Size	Material
2'	15'	Torpedo	Sand
From	To	Ft.	
From	To	Ft.	

4. MARKS:

I DO HEREBY CERTIFY THAT THIS WELL WAS CONSTRUCTED IN ACCORDANCE WITH 15 NCAC 2C. WELL CONSTRUCTION STANDARDS, AND THAT A COPY OF THIS RECORD HAS BEEN PROVIDED TO THE WELL OWNER.

SIGNATURE OF CONTRACTOR OR AGENT

DATE

Submit original to Division of Environmental Management and copy to well owner.

FOR OFFICE USE ONLY

Quad. No. _____ Serial No. _____
Lat. _____ Long. _____ Pc _____
Minor Basin _____
Basin Code _____
Header Ent. _____ GW-1 Ent. _____

WELL CONSTRUCTION RECORD

AS410N-10

DRILLING CONTRACTOR Richard Catlin & Associates, Inc.

DRILLER REGISTRATION NUMBER 1142

STATE WELL CONSTRUCTION

PERMIT NUMBER: NA

1. WELL LOCATION: (Show sketch of the location below)

Nearest Town: Camp Lejeune
Building AS-410

(Road, Community, or Subdivision and Lot No.)

2. OWNER LANTDIV NAVFACENGCOM Commanding General

ADDRESS AC/S EMD/Marine Corps Base/PSC Box 20004

Camp Lejeune (Street or Route No.) NC 28542-0004

City or Town State Zip Code

3. DATE DRILLED 10-25-93 USE OF WELL Monitoring

4. TOTAL DEPTH 15' CUTTINGS COLLECTED ☒ Yes ☐ No

5. DOES WELL REPLACE EXISTING WELL? ☐ Yes ☒ No

6. STATIC WATER LEVEL: 6.3 FT. ☐ above TOP OF CASING,
☒ below
TOP OF CASING IS _____ FT. ABOVE LAND SURFACE.

7. YIELD (gpm): _____ METHOD OF TEST _____

8. WATER ZONES (depth): Surficial Aquifer

9. CONTAMINATION: Type _____ Amount _____

10. CASING:

From	To	Depth	Diameter	Wall Thickness or Weight/Ft.	Material
0'	3'	3'	2"	SCH80	PVC
From	To	Depth	Diameter	Wall Thickness or Weight/Ft.	Material
From	To	Depth	Diameter	Wall Thickness or Weight/Ft.	Material

1. GROUT:

From	To	Depth	Material	Method
0'	1'	1'	Cement	Poured
1'	2'	2'	Bentonite	Chips/Pellets

2. SCREEN:

From	To	Depth	Diameter	Slot Size	Material
3'	15'	15'	2"	.010 in.	PVC
From	To	Depth	Diameter	Slot Size	Material
From	To	Depth	Diameter	Slot Size	Material

3. GRAVEL PACK:

From	To	Depth	Size	Material
2'	15'	15'	Torpedo	Sand
From	To	Depth	Size	Material
From	To	Depth	Size	Material

4. REMARKS:

I DO HEREBY CERTIFY THAT THIS WELL WAS CONSTRUCTED IN ACCORDANCE WITH 15 NCAC 2C. WELL CONSTRUCTION STANDARDS, AND THAT A COPY OF THIS RECORD HAS BEEN PROVIDED TO THE WELL OWNER.

SIGNATURE OF CONTRACTOR OR AGENT

DATE

Submit original to Division of Environmental Management and copy to well owner.

FOR OFFICE USE ONLY

Quad. No. _____ Serial No. _____
Lat. _____ Long. _____ Pc _____
Minor Basin _____
Basin Code _____
Header Ent. _____ GW-1 Ent. _____

WELL CONSTRUCTION RECORD

AS410N-11

DRILLING CONTRACTOR Richard Catlin & Associates, Inc.

DRILLER REGISTRATION NUMBER 1142

STATE WELL CONSTRUCTION
PERMIT NUMBER: NA

1. WELL LOCATION: (Show sketch of the location below)

Nearest Town: Camp Lejeune
Building AS-410

(Road, Community, or Subdivision and Lot No.)

County: Onslow

Depth

From _____ To _____

DRILLING LOG

Formation Description

2. OWNER LANTDIV NAVFACENGCOM Commanding General

ADDRESS AC/S EMD/Marine Corps Base/PSC Box 20004

Camp Lejeune (Street or Route No.) NC 28542-0004

City or Town State Zip Code

3. DATE DRILLED 10-25-93 USE OF WELL Monitoring

4. TOTAL DEPTH 15' CUTTINGS COLLECTED ☒ Yes ☐ No

5. DOES WELL REPLACE EXISTING WELL? ☐ Yes ☒ No

6. STATIC WATER LEVEL: 6.9 FT. ☐ above TOP OF CASING,
☒ below
TOP OF CASING IS _____ FT. ABOVE LAND SURFACE.

7. YIELD (gpm): _____ METHOD OF TEST _____

8. WATER ZONES (depth): Surficial Aquifer

9. DRINATION: Type _____ Amount _____

10. CASING:

From	Depth	To	Diameter	Wall Thickness or Weight/Ft.	Material
0'		3'	2"	SCH40	PVC
From		To	Ft.		
From		To	Ft.		

If additional space is needed use back of form.

LOCATION SKETCH

(Show direction and distance from at least two State Roads, or other map reference points)

1. GROUT:

From	Depth	To	Material	Method
0'		1'	Cement	Poured
1'		2'	Bentonite	Chips/Pellets
From		To	Ft.	

2. SCREEN:

From	Depth	To	Diameter	Slot Size	Material
3'		15'	2"	.010 in.	PVC
From		To	Ft.	in.	in.
From		To	Ft.	in.	in.

3. GRAVEL PACK:

From	Depth	To	Size	Material
2'		15'	Torpedo	Sand
From		To	Ft.	

4. REMARKS:

I DO HEREBY CERTIFY THAT THIS WELL WAS CONSTRUCTED IN ACCORDANCE WITH 15 NCAC 2C. WELL CONSTRUCTION STANDARDS, AND THAT A COPY OF THIS RECORD HAS BEEN PROVIDED TO THE WELL OWNER.

SIGNATURE OF CONTRACTOR OR AGENT

DATE

Submit original to Division of Environmental Management and copy to well owner.

FOR OFFICE USE ONLY

Quad. No. _____ Serial No. _____
Lat. _____ Long. _____ Pc _____
Minor Basin _____
Basin Code _____
Header Ent. _____ GW-1 Ent. _____

WELL CONSTRUCTION RECORD

AS410N-12

DRILLING CONTRACTOR Richard Catlin & Associates, Inc.

DRILLER REGISTRATION NUMBER 1142

STATE WELL CONSTRUCTION
PERMIT NUMBER: NA

1. WELL LOCATION: (Show sketch of the location below)

Nearest Town: Camp Lejeune
Building AS-410

(Road, Community, or Subdivision and Lot No.)

2. OWNER LANTDIV NAVFACENGCOM Commanding General

ADDRESS AC/S EMD/Marine Corps Base/PSC Box 20004

Camp Lejeune (Street or Route No.) NC 28542-0004

City or Town State Zip Code

3. DATE DRILLED 10-27-93 USE OF WELL Monitoring

4. TOTAL DEPTH 15' CUTTINGS COLLECTED ☒ Yes ☐ No

5. DOES WELL REPLACE EXISTING WELL? ☐ Yes ☒ No

6. STATIC WATER LEVEL: 5.9 FT. ☐ above TOP OF CASING,
☒ below
TOP OF CASING IS _____ FT. ABOVE LAND SURFACE

7. YIELD (gpm): _____ METHOD OF TEST _____

8. WATER ZONES (depth): Surficial Aquifer

9. DRINATION: Type _____ Amount _____

10. CASING:

Depth	Diameter	Wall Thickness or Weight/Ft.	Material
From <u>0'</u> To <u>3'</u> Ft.	<u>2"</u>	<u>SCH40</u>	<u>PVC</u>
From _____ To _____ Ft.	_____	_____	_____
From _____ To _____ Ft.	_____	_____	_____

11. GROUT:

Depth	Material	Method
From <u>0'</u> To <u>1'</u> Ft.	<u>Cement</u>	<u>Poured</u>
From <u>1'</u> To <u>2'</u> Ft.	<u>Bentonite</u>	<u>Chips/Pellets</u>

12. SCREEN:

Depth	Diameter	Slot Size	Material
From <u>3'</u> To <u>15'</u> Ft.	<u>2"</u>	<u>in. .010</u>	<u>PVC</u>
From _____ To _____ Ft.	_____	_____	_____
From _____ To _____ Ft.	_____	_____	_____

13. GRAVEL PACK:

Depth	Size	Material
From <u>2'</u> To <u>15'</u> Ft.	<u>Torpedo</u>	<u>Sand</u>
From _____ To _____ Ft.	_____	_____

14. REMARKS:

I DO HEREBY CERTIFY THAT THIS WELL WAS CONSTRUCTED IN ACCORDANCE WITH 15 NCAC 2C. WELL CONSTRUCTION STANDARDS, AND THAT A COPY OF THIS RECORD HAS BEEN PROVIDED TO THE WELL OWNER.

SIGNATURE OF CONTRACTOR OR AGENT

DATE

Submit original to Division of Environmental Management and copy to well owner.

FOR OFFICE USE ONLY

Quad. No. _____ Serial No. _____
Lat. _____ Long. _____ Pc _____
Minor Basin _____
Basin Code _____
Header Ent. _____ GW-1 Ent. _____

WELL CONSTRUCTION RECORD

AS410N-13

DRILLING CONTRACTOR Richard Catlin & Associates, Inc.

DRILLER REGISTRATION NUMBER 1142

STATE WELL CONSTRUCTION

PERMIT NUMBER: NA

1. WELL LOCATION: (Show sketch of the location below)

Nearest Town: Camp Lejeune

Building AS-410

(Road, Community, or Subdivision and Lot No.)

County: Onslow

Depth

DRILLING LOG

From _____ To _____

Formation Description

2. OWNER LANTDIV NAVFACENGCOM Commanding General

ADDRESS AC/S EMD/Marine Corps Base/PSC Box 20004

Camp Lejeune (Street or Route No.)

NC

28542-0004

City or Town

State

Zip Code

3. DATE DRILLED 10-26-93 USE OF WELL Monitoring

4. TOTAL DEPTH 15' CUTTINGS COLLECTED ☒ Yes ☐ No

5. DOES WELL REPLACE EXISTING WELL? ☐ Yes ☒ No

6. STATIC WATER LEVEL: 5.8 FT. ☐ above TOP OF CASING.

☒ below

TOP OF CASING IS _____ FT. ABOVE LAND SURFACE.

7. YIELD (gpm): _____ METHOD OF TEST _____

8. WATER ZONES (depth): Surficial Aquifer

9. CONTAMINATION: Type _____ Amount _____

10. CASING:

If additional space is needed use back of form.

From	Depth	To	Diameter	Wall Thickness or Weight/Ft.	Material
0'	3'	Ft.	2"	SCH40	PVC
From	To	Ft.			
From	To	Ft.			

LOCATION SKETCH

(Show direction and distance from at least two State Roads, or other map reference points)

11. GROUT:

From	Depth	To	Material	Method
0'	1'	Ft.	Cement	Poured
1'	2'	Ft.	Bentonite	Chips/Pellets

12. SCREEN:

From	Depth	To	Diameter	Slot Size	Material
3'	15'	Ft.	2"	in. .010 in.	PVC
From	To	Ft.			
From	To	Ft.			

13. GRAVEL PACK:

From	Depth	To	Size	Material
2'	15'	Ft.	Torpedo	Sand
From	To	Ft.		

14. REMARKS:

I DO HEREBY CERTIFY THAT THIS WELL WAS CONSTRUCTED IN ACCORDANCE WITH 15 NCAC 2C. WELL CONSTRUCTION STANDARDS, AND THAT A COPY OF THIS RECORD HAS BEEN PROVIDED TO THE WELL OWNER.

SIGNATURE OF CONTRACTOR OR AGENT

DATE

Submit original to Division of Environmental Management and copy to well owner.

FOR OFFICE USE ONLY

Quad. No. _____ Serial No. _____
Lat. _____ Long. _____ Pc _____
Minor Basin _____
Basin Code _____
Header Ent. _____ GW-1 Ent. _____

WELL CONSTRUCTION RECORD

AS-410N-14

DRILLING CONTRACTOR Richard Catlin & Associates, Inc.

DRILLER REGISTRATION NUMBER 1142

STATE WELL CONSTRUCTION
PERMIT NUMBER: NA

1. WELL LOCATION: (Show sketch of the location below)

Nearest Town: Camp Lejeune
Building AS-410

(Road, Community, or Subdivision and Lot No.)

2. OWNER LANTDIV NAVFACENGCOM Commanding General

ADDRESS AC/S EMD/Marine Corps Base/PSC Box 20004

Camp Lejeune (Street or Route No.) NC 28542-0004

City or Town State Zip Code

3. DATE DRILLED 10-27-93 USE OF WELL Monitoring

4. TOTAL DEPTH 15' CUTTINGS COLLECTED ☒ Yes ☐ No

5. DOES WELL REPLACE EXISTING WELL? ☐ Yes ☒ No

6. STATIC WATER LEVEL: 4.9 FT. ☐ above TOP OF CASING,
☒ below
TOP OF CASING IS _____ FT. ABOVE LAND SURFACE.

7. YIELD (gpm): _____ METHOD OF TEST _____

8. WATER ZONES (depth): Surficial Aquifer

9. CONTAMINATION: Type _____ Amount _____

10. CASING:

From	Depth	To	Diameter	Wall Thickness or Weight/Ft.	Material
0'	3'	Ft.	2"	SCH40	PVC
From	To	Ft.			
From	To	Ft.			

11. GROUT:

From	Depth	To	Material	Method
0'	1'	Ft.	Cement	Poured
1'	2'	Ft.	Bentonite	Chips/Pellets

12. SCREEN:

From	Depth	To	Diameter	Slot Size	Material
3'	15'	Ft.	2"	.010 in.	PVC
From	To	Ft.			
From	To	Ft.			

13. GRAVEL PACK:

From	Depth	To	Size	Material
2'	15'	Ft.	Torpedo	Sand
From	To	Ft.		

14. MARKS:

I DO HEREBY CERTIFY THAT THIS WELL WAS CONSTRUCTED IN ACCORDANCE WITH 15 NCAC 2C. WELL CONSTRUCTION STANDARDS, AND THAT A COPY OF THIS RECORD HAS BEEN PROVIDED TO THE WELL OWNER.

John M. Shaw
SIGNATURE OF CONTRACTOR OR AGENT

4 January 1994
DATE

FOR OFFICE USE ONLY

Quad. No. _____ Serial No. _____
Lat. _____ Long. _____ Pc _____
Minor Basin _____
Basin Code _____
Header Ent. _____ GW-1 Ent. _____

WELL CONSTRUCTION RECORD AS410N-15

DRILLING CONTRACTOR Richard Catlin & Associates, Inc.

DRILLER REGISTRATION NUMBER 1142

STATE WELL CONSTRUCTION
PERMIT NUMBER: NA

1. WELL LOCATION: (Show sketch of the location below)

Nearest Town: Camp Lejeune
Building AS-410

(Road, Community, or Subdivision and Lot No.)

2. OWNER LANTDIV NAVFACENGCOM Commanding General

ADDRESS AC/S EMD/Marine Corps Base/PSC Box 20004

Camp Lejeune (Street or Route No.) NC 28542-0004

City or Town State Zip Code

3. DATE DRILLED 10-27-93 USE OF WELL Monitoring

4. TOTAL DEPTH 15' CUTTINGS COLLECTED ☒ Yes ☐ No

5. DOES WELL REPLACE EXISTING WELL? ☐ Yes ☒ No

6. STATIC WATER LEVEL: 6.5 FT. ☐ above TOP OF CASING,
☒ below
TOP OF CASING IS _____ FT. ABOVE LAND SURFACE.

7. YIELD (gpm): _____ METHOD OF TEST _____

8. WATER ZONES (depth): Surficial Aquifer

9. CONTAMINATION: Type _____ Amount _____

10. CASING:

From	Depth	To	Diameter	Wall Thickness or Weight/Ft.	Material
0'	3'	Fl.	2"	SCH40	PVC
From	To	Fl.			
From	To	Fl.			

11. GROUT:

From	Depth	To	Material	Method
0'	1'	Fl.	Cement	Poured
1'	2'	Fl.	Bentonite	Chips/Pellets

12. SCREEN:

From	Depth	To	Diameter	Slot Size	Material
3'	15'	Fl.	2"	.010 in.	PVC
From	To	Fl.			
From	To	Fl.			

13. GRAVEL PACK:

From	Depth	To	Size	Material
2'	15'	Fl.	Torpedo	Sand
From	To	Fl.		

14. REMARKS:

I DO HEREBY CERTIFY THAT THIS WELL WAS CONSTRUCTED IN ACCORDANCE WITH 15 NCAC 2C. WELL CONSTRUCTION STANDARDS, AND THAT A COPY OF THIS RECORD HAS BEEN PROVIDED TO THE WELL OWNER.

SIGNATURE OF CONTRACTOR OR AGENT

DATE

Submit original to Division of Environmental Management and copy to well owner.

FOR OFFICE USE ONLY

Quad. No. _____ Serial No. _____
Lat. _____ Long. _____ Pc _____
Minor Basin _____
Basin Code _____
Header Ent. _____ GW-1 Ent. _____

WELL CONSTRUCTION RECORD

AS410N-16

DRILLING CONTRACTOR Richard Catlin & Associates, Inc.

DRILLER REGISTRATION NUMBER 1142

STATE WELL CONSTRUCTION
PERMIT NUMBER: NA

1. WELL LOCATION: (Show sketch of the location below)

Nearest Town: Camp Lejeune
Building AS-410

(Road, Community, or Subdivision and Lot No.)

2. OWNER LANTDIV NAVFACENGCOM Commanding General

ADDRESS AC/S EMD/Marine Corps Base/PSC Box 20004
Camp Lejeune NC 28542-0004

City or Town State Zip Code

3. DATE DRILLED 11-05-93 USE OF WELL Monitoring

4. TOTAL DEPTH 50' CUTTINGS COLLECTED ☒ Yes ☐ No

5. DOES WELL REPLACE EXISTING WELL? ☐ Yes ☒ No

6. STATIC WATER LEVEL: 6.0 FT. ☐ above TOP OF CASING.
☒ below
TOP OF CASING IS _____ FT. ABOVE LAND SURFACE.

7. YIELD (gpm): _____ METHOD OF TEST _____

8. WATER ZONES (depth): Surficial Aquifer

9. DRINATION: Type _____ Amount _____

10. CASING:

From	To	Depth	Diameter	Wall Thickness or Weight/Ft.	Material
From <u>0'</u>	To <u>39.5'</u>	Ft. <u>6.0"</u>	<u>SCH80</u>	<u>PVC</u>	
From <u>0'</u>	To <u>45'</u>	Ft. <u>2.0"</u>	<u>SCH80</u>	<u>PVC</u>	
From _____	To _____	Ft. _____	_____	_____	

11. GROUT:

From	To	Depth	Material	Method
From <u>0'</u>	To <u>43'</u>	Ft. <u>Cement</u>	<u>Poured</u>	
From <u>43'</u>	To <u>44'</u>	Ft. <u>Bentonite</u>	<u>Chips/Pellets</u>	

12. SCREEN:

From	To	Depth	Diameter	Slot Size	Material
From <u>45'</u>	To <u>50'</u>	Ft. <u>2"</u>	<u>.010</u>	<u>PVC</u>	
From _____	To _____	Ft. _____	_____	_____	
From _____	To _____	Ft. _____	_____	_____	

13. GRAVEL PACK:

From	To	Depth	Size	Material
From <u>44'</u>	To <u>50'</u>	Ft. <u>Torpedo</u>	<u>Sand</u>	
From _____	To _____	Ft. _____	_____	

14. REMARKS:

I DO HEREBY CERTIFY THAT THIS WELL WAS CONSTRUCTED IN ACCORDANCE WITH 15 NCAC 2C. WELL CONSTRUCTION STANDARDS, AND THAT A COPY OF THIS RECORD HAS BEEN PROVIDED TO THE WELL OWNER.

SIGNATURE OF CONTRACTOR OR AGENT

DATE

Submit original to Division of Environmental Management and copy to well owner.

FOR OFFICE USE ONLY

Quad. No. _____ Serial No. _____
Lat. _____ Long. _____ Pc _____
Minor Basin _____
Basin Code _____
Header Ent. _____ GW-1 Ent. _____

WELL CONSTRUCTION RECORD

AS410N-17

DRILLING CONTRACTOR Richard Catlin & Associates, Inc.

DRILLER REGISTRATION NUMBER 1142

STATE WELL CONSTRUCTION
PERMIT NUMBER: NA

1. WELL LOCATION: (Show sketch of the location below)

Nearest Town: Camp Lejeune
Building AS-410

(Road, Community, or Subdivision and Lot No.)

2. OWNER LANTDIV NAVFACENGCOM Commanding General

ADDRESS AC/S EMD/Marine Corps Base/PSC Box 20004

Camp Lejeune (Street or Route No.) NC 28542-0004

City or Town State Zip Code

3. DATE DRILLED 11-9-93 USE OF WELL Monitoring

4. TOTAL DEPTH 50' CUTTINGS COLLECTED ☒ Yes ☐ No

5. DOES WELL REPLACE EXISTING WELL? ☐ Yes ☒ No

6. STATIC WATER LEVEL: 5.8 FT. ☐ above TOP OF CASING,
☒ below
TOP OF CASING IS _____ FT. ABOVE LAND SURFACE.

7. YIELD (gpm): _____ METHOD OF TEST _____

8. WATER ZONES (depth): Surficial Aquifer

9. CORINATION: Type _____ Amount _____

10. CASING:

From	To	Depth	Diameter	Wall Thickness or Weight/Ft.	Material
0'	39.5'	Ft.	6.0"	SCH80	PVC
0'	45'	Ft.	2.0"	SCH80	PVC
From	To	Ft.			

11. GROUT:

From	To	Depth	Material	Method
0'	41'	Ft.	Cement	Poured
41'	43.5'	Ft.	Bentonite	Chips/Pellets
From	To	Ft.		

12. SCREEN:

From	To	Depth	Diameter	Slot Size	Material
45'	50'	Ft.	2"	.010 in.	PVC
From	To	Ft.			

13. GRAVEL PACK:

From	To	Depth	Size	Material
43.5'	50'	Ft.	Torpedo	Sand
From	To	Ft.		

14. REMARKS:

I DO HEREBY CERTIFY THAT THIS WELL WAS CONSTRUCTED IN ACCORDANCE WITH 15 NCAC 2C, WELL CONSTRUCTION STANDARDS, AND THAT A COPY OF THIS RECORD HAS BEEN PROVIDED TO THE WELL OWNER.

SIGNATURE OF CONTRACTOR OR AGENT

DATE

Submit original to Division of Environmental Management and copy to well owner.

FOR OFFICE USE ONLY

Quad. No. _____ Serial No. _____
Lat. _____ Long. _____ Pc _____
Minor Basin _____
Basin Code _____
Header Ent. _____ GW-1 Ent. _____

WELL CONSTRUCTION RECORD

AS410N-18

DRILLING CONTRACTOR Richard Catlin & Associates, Inc.

DRILLER REGISTRATION NUMBER 1142

STATE WELL CONSTRUCTION
PERMIT NUMBER: NA

1. WELL LOCATION: (Show sketch of the location below)

Nearest Town: Camp Lejeune
Building AS-410

(Road, Community, or Subdivision and Lot No.)

2. OWNER LANTDIV NAVFACENGCOM Commanding General

ADDRESS AC/S EMD/Marine Corps Base/PSC Box 20004

Camp Lejeune (Street or Route No.) NC 28542-0004

City or Town State Zip Code

3. DATE DRILLED 11-05-93 USE OF WELL Monitoring

4. TOTAL DEPTH 50' CUTTINGS COLLECTED ☒ Yes ☐ No

5. DOES WELL REPLACE EXISTING WELL? ☐ Yes ☒ No

6. STATIC WATER LEVEL: 5.7 FT. ☐ above TOP OF CASING.

☒ below
TOP OF CASING IS _____ FT. ABOVE LAND SURFACE.

7. YIELD (gpm): _____ METHOD OF TEST _____

8. WATER ZONES (depth): Surficial Aquifer

9. CONTAMINATION: Type _____ Amount _____

10. CASING:

From	Depth	To	Diameter	Wall Thickness or Weight/Ft.	Material
0'	39.5'	Ft.	6.0"	SCH80	PVC
0'	45'	Ft.	2.0"	SCH80	PVC
From	To	Ft.			

1. GROUT:

From	Depth	To	Material	Method
0'	41'	Ft.	Cement	Poured
41'	43.5'	Ft.	Bentonite	Chips/Pellets

2. SCREEN:

From	Depth	To	Diameter	Slot Size	Material
45'	50'	Ft.	2"	.010 in.	PVC
From	To	Ft.	in.	in.	
From	To	Ft.	in.	in.	

3. GRAVEL PACK:

From	Depth	To	Size	Material
43.5'	50'	Ft.	Torpedo	Sand
From	To	Ft.		

4. REMARKS:

I DO HEREBY CERTIFY THAT THIS WELL WAS CONSTRUCTED IN ACCORDANCE WITH 15 NCAC 2C. WELL CONSTRUCTION STANDARDS, AND THAT A COPY OF THIS RECORD HAS BEEN PROVIDED TO THE WELL OWNER.

SIGNATURE OF CONTRACTOR OR AGENT

DATE

Submit original to Division of Environmental Management and copy to well owner.

FOR OFFICE USE ONLY

Quad. No. _____ Serial No. _____
Lat. _____ Long. _____ Pc _____
Minor Basin _____
Basin Code _____
Header Ent. _____ GW-1 Ent. _____

WELL CONSTRUCTION RECORD

AS410N-19

DRILLING CONTRACTOR Richard Catlin & Associates, Inc.

DRILLER REGISTRATION NUMBER 1142

STATE WELL CONSTRUCTION

PERMIT NUMBER: 66-0296-WR-0326

1. WELL LOCATION: (Show sketch of the location below)

Nearest Town: Camp Lejeune
Building AS-410

(Road, Community, or Subdivision and Lot No.)

2. OWNER LANTDIV NAVFACENGCOM Commanding General

ADDRESS AC/S EMD/Marine Corps Base/PSC Box 20004
Camp Lejeune NC 28542-0004
(Street or Route No.)
City or Town State Zip Code

3. DATE DRILLED 10-29-93 USE OF WELL Monitoring

4. TOTAL DEPTH 19.5' CUTTINGS COLLECTED ☒ Yes ☐ No

5. DOES WELL REPLACE EXISTING WELL? ☐ Yes ☒ No

6. STATIC WATER LEVEL: 5.5 FT. ☐ above TOP OF CASING.
☒ below
TOP OF CASING IS _____ FT. ABOVE LAND SURFACE.

7. YIELD (gpm): _____ METHOD OF TEST _____

8. WATER ZONES (depth): Surficial Aquifer

9. CONTAMINATION: Type _____ Amount _____

10. CASING:

From	Depth	To	Diameter	Wall Thickness or Weight/Ft.	Material
From <u>0'</u>	Depth <u>5'</u>	To <u>5'</u>	Diameter <u>6"</u>	Wall Thickness <u>SCH40</u>	Material <u>PVC</u>
From _____	Depth _____	To _____	Diameter _____	Wall Thickness _____	Material _____
From _____	Depth _____	To _____	Diameter _____	Wall Thickness _____	Material _____

11. GROUT:

From	Depth	To	Material	Method
From <u>0'</u>	Depth <u>1.5'</u>	To <u>1.5'</u>	Material <u>Cement</u>	Method <u>Poured</u>
From <u>1.5'</u>	Depth <u>3'</u>	To <u>3'</u>	Material <u>Bentonite</u>	Method <u>Chips/Pellets</u>

12. SCREEN:

From	Depth	To	Diameter	Slot Size	Material
From <u>5'</u>	Depth <u>19.5'</u>	To <u>19.5'</u>	Diameter <u>6"</u>	Slot Size <u>.010 in.</u>	Material <u>PVC</u>
From _____	Depth _____	To _____	Diameter _____	Slot Size _____	Material _____
From _____	Depth _____	To _____	Diameter _____	Slot Size _____	Material _____

13. GRAVEL PACK:

From	Depth	To	Size	Material
From <u>3'</u>	Depth <u>19.5'</u>	To <u>19.5'</u>	Size <u>Torpedo</u>	Material <u>Sand</u>
From _____	Depth _____	To _____	Size _____	Material _____

14. MARKS:

I DO HEREBY CERTIFY THAT THIS WELL WAS CONSTRUCTED IN ACCORDANCE WITH 15 NCAC 2C. WELL CONSTRUCTION STANDARDS, AND THAT A COPY OF THIS RECORD HAS BEEN PROVIDED TO THE WELL OWNER.

SIGNATURE OF CONTRACTOR OR AGENT

DATE

Submit original to Division of Environmental Management and copy to well owner.

APPENDIX E

MONITORING WELL CASING AND WATER ELEVATION WORKSHEETS

APPENDIX E

MONITORING WELL CASING AND WATER ELEVATIONS WORKSHEET

DATA POINT	TOP OF CASING ELEVATION (in feet)	DEPTH TO WATER (in feet)	FREE PRODUCT THICKNESS	SPECIFIC GRAVITY ADJUSTMENT	WATER TABLE ELEVATION (in feet)
AS410N-1	19.18	5.15	NMT	--	14.03
AS410N-2	18.62	5.31	NMT	--	13.31
AS410N-3	18.73	5.41	NMT	--	13.32
AS410N-4	18.35	5.15	NMT	--	13.20
AS410N-5	18.98	5.78	NMT	--	13.20
AS410N-6	19.04	5.73	NMT	--	13.31
AS410N-7	18.40	5.03	NMT	--	13.37
AS410N-8	17.77	4.12	NMT	--	13.65
AS410N-9	18.68	5.34	NMT	--	13.34
AS410N-10	18.90	5.69	NMT	--	13.21
AS410N-11	19.44	6.07	NMT	--	13.37
AS410N-12	18.60	5.25	NMT	--	13.35
AS410N-13	18.59	5.06	NMT	--	13.53
AS410N-14	17.63	4.97	NMT	--	12.66
AS410N-15	19.05	5.84	NMT	--	13.21
AS410N-16	18.19	5.15	NMT	--	13.04
AS410N-17	18.01	4.96	NMT	--	13.05
AS410N-18	18.70	5.76	NMT	--	12.94
AS410N-19	18.21	4.84	NMT	--	13.37

NMT = No Measurable Thickness

APPENDIX F

**GROUND WATER FLOW DIRECTION AND
VELOCITY OF SURFICIAL AQUIFER**

JOB: AS-410 COMPUTED BY: JC DATE: 1/11/94
DESCRIPTION: GROUND WATER VELOCITY CHECKED BY: JMP DATE: _____

GROUND WATER FLOW VELOCITY
CALCULATIONS

$$V = \frac{K (dh/dl)}{N_e}$$

WHERE:

V = Ground Water Flow Velocity (Ft/day)

K = Hydraulic Conductivity (Ft/day)
From Slug Test Performed On
AS410N-1

dh/dl = Hydraulic Gradient (unitless)
Measured Between Wells AS410N-1
And AS410N-4.

N_e = Effective Porosity (unitless)
Assumed From Boring Logs
0.25.

$$V = \frac{38(4.6 \times 10^{-3})}{0.25}$$

$V = 7.0 \times 10^{-1}$ Ft/day
to the southeast

APPENDIX G

MONITORING WELL AND SAMPLING FIELD DATA WORKSHEETS

SAMPLING FIELD DATA WORKSHEET

PROJECT: BUILDING AS-410
PROJECT NO.: 93125

SAMPLED BY: S. Carroll, M. Dunlap

WELL NO.	AS410N-2	AS410N-4	AS410N-5	AS410N-6	AS410N-7	AS410N-8	AS410N-9	AS410N-10
DATE SAMPLED	10-21-93	10-25-93	10-25-93	10-25-93	10-21-93	11-10-93	11-10-93	11-10-93
TIME SAMPLED	1017	1200	1215	1155	1220	1330	1300	1445
WELL DIAMETER	2"	2"	2"	2"	2"	2"	2"	2"
WELL DEPTH - A	20'	15'	15'	15'	15'	15'	15'	15'
DEPTH TO WATER - B	5.90	5.70	6.31	6.31	5.72	5.04	5.95	6.25
(A-B) FT. H ₂ O IN WELL - C	14.10	9.30	8.70	8.70	9.30	10.0	9.0	8.70
GALLONS/FT. - D	.163	.163	.163	.163	.163	.163	.163	.163
(CXD) ONE VOLUME - E	2.30	1.5	1.4	1.4	1.5	1.6	1.5	1.4
(EX3) THREE VOLUMES - F	6.89	4.5	4.2	4.2	4.5	4.8	4.5	4.2
VOLUME OF BAILER - G	.24	.24	.24	.24	.24	.24	.24	.24
(F/G) NO. BAILS REQUIRED - H	29	19	18	18	19	20	19	18
NO. BAILS TAKEN - I	30	20	19	19	20	21	20	19

FIELD TESTS: pH _____

CONDUCTIVITY _____

OTHERS _____

VOLUMES:

1-1/4" WELL = 0.064 GAL/FT
2" WELL = 0.163 GAL/FT

4" WELL = 0.653 GAL/FT
3' x 1.5" BAILER = 0.24 GAL/BAIL
4' x 1.5" BAILER = 0.37 GAL/BAIL

SAMPLING FIELD DATA WORKSHEET

PROJECT: BUILDING AS-410
PROJECT NO.: 93125

SAMPLED BY: S. Carroll, M. Dunlap

WELL NO.	AS410N-11	AS410N-12	AS410N-13	AS410N-14	AS410N-15
DATE SAMPLED	11-10-93	11-10-93	11-10-93	11-10-93	11-10-93
TIME SAMPLED	1415	1315	1515	1400	1430
WELL DIAMETER	2"	2"	2"	2"	2"
WELL DEPTH - A	15'	15'	15'	15'	15'
DEPTH TO WATER - B	6.89	5.89	5.76	4.85	6.52
(A-B) FT. H ₂ O IN WELL - C	8.1	9.1	9.2	10.1	8.5
GALLONS/FT. - D	.163	.163	.163	.163	.163
(CxD) ONE VOLUME - E	1.3	1.5	1.5	1.6	1.4
(EX3) THREE VOLUMES - F	3.9	4.5	4.5	4.8	4.2
VOLUME OF BAILER - G	.24	.24	.24	.24	.24
(F/G) NO. BAILS REQUIRED - H	16	19	19	20	18
NO. BAILS TAKEN - I	17	20	20	21	19

FIELD TESTS: pH _____

CONDUCTIVITY _____

OTHERS _____

VOLUMES:

1-1/4" WELL = 0.064 GAL/FT
2" WELL = 0.163 GAL/FT

4" WELL = 0.653 GAL/FT
3' x 1.5" BAILER = 0.24 GAL/BAIL
4' x 1.5" BAILER = 0.37 GAL/BAIL

SAMPLING FIELD DATA WORKSHEET

PROJECT: BUILDING AS-410
PROJECT NO.: 93125

SAMPLED BY: S. Carroll, M. Dunlap

WELL NO.	AS410N-16	AS410N-17	AS410N-18	AS410N-19
DATE SAMPLED	11-16-93	11-16-93	11-16-93	10-09-93
TIME SAMPLED	1430	1530	1430	1600
WELL DIAMETER	2"	2"	2"	6"
WELL DEPTH - A	50'	50'	50'	19.5'
DEPTH TO WATER - B	5.98	5.75	5.72	5.48
(A-B) FT. H ₂ O IN WELL - C	44.02	44.25	44.28	14.0
GALLONS/FT. - D	.163	.163	.163	1.42
(CxD) ONE VOLUME - E	7.18	7.21	7.23	19.9
(EX3) THREE VOLUMES - F	21.53	21.64	21.65	59.6
VOLUME OF BAILER - G	.24	.24	.24	.24
(F/G) NO. BAILS REQUIRED - H	90	90	90	248
NO. BAILS TAKEN - I	91	91	91	249

FIELD TESTS: pH _____

CONDUCTIVITY _____

OTHERS _____

VOLUMES:

1-1/4" WELL = 0.064 GAL/FT
2" WELL = 0.163 GAL/FT

4" WELL = 0.653 GAL/FT
3' x 1.5" BAILER = 0.24 GAL/BAIL
4' x 1.5" BAILER = 0.37 GAL/BAIL

APPENDIX H

CONTAMINANT VELOCITY CALCULATIONS

JOB: AS-410 COMPUTED BY: JC DATE: 1/11/94

DESCRIPTION: Retardation Calc. CHECKED BY: JMP DATE: 1/12/94

CALCULATE CONTAMINANT VELOCITY Page 1 of 3

$K_{ow} = 100$ for Benzene

Determine Contaminant Velocity For:
Benzene

$$V_c = \frac{V_{MAX}}{R_d}$$

Where: V_{MAX} = Maximum Ground Water Velocity

R_d = Retardation Factor

Calculate Retardation Factor

$$R_d = 1 + \left(K_d \frac{\rho_b}{P} \right)$$

Where: K_d = Distribution Coefficient (ml/g)

ρ_b = Bulk Density (g/ml)

P = Porosity (decimal)

JOB: AS-410COMPUTED BY: JSCDATE: 1/11/94

DESCRIPTION: _____

CHECKED BY: JMPDATE: 1/12/94

Page 2 of 3

$$K_d = K_{oc} [0.2(1-F)x_{oc}^s + Fx_{oc}^f]$$

Where: $F = \frac{\text{Mass of Silt and Clay}}{\text{Mass of Sand, Silt, and Clay}}$

$x_{oc}^s = \text{Organic Fraction of Sand } (0 \leq x_{oc}^s \leq 0.1)$

$x_{oc}^f = \text{Organic Fraction of Silt and Clay } (0 \leq x_{oc}^f \leq 0.1)$

$K_{oc} = 0.63 K_{ow}$ (Organic Carbon Partition Coefficient)

$K_{ow} = \text{Octanol Water Partition Coefficient}$

Benzene $K_{ow} = 100$

$K_{oc} = 0.63(100)$

$K_{oc} = 63$

$F = 0.044$ (Grain Size 10-12 Feet deep, Well AS410N-12)

$\rho_b = 1.55 \text{ g/cm}^3$ (Fine grained SAND (SP) > 314, Table VII-2, EPA WQA Part II)

JOB: AS-410 COMPUTED BY: JC DATE: 1/11/94

DESCRIPTION: _____ CHECKED BY: JMP DATE: 1/12/94

Page 3 of 3

$P = 0.43$ (Well AS410N, 10-12 feet deep
P. 318, Table 11-4, EPA
PWQA Part II)

$$x_{oc}^S = 0.025 \text{ (Mean Value)}$$

$$x_{oc}^F = 0.065 \text{ (Mean Value)}$$

$$K_d = K_{oc} [0.2(1-F)x_{oc}^S + f x_{oc}^F]$$

$$K_d = 63 [0.2(1-0.044)0.025 + 0.044(0.065)]$$

$$K_d = 0.48$$

$$R_d = 1 + K_d \frac{P_b}{P}$$

$$R_d = 1 + 0.48 \frac{1.55}{0.43} = 2.73$$

$$\text{Benzene } V_c = \frac{V_{max}}{R_d}$$

$$V_c = \frac{0.7}{2.73} = 0.26 \text{ ft/day}$$

APPENDIX I

LABORATORY ANALYTICAL TEST REPORTS/CHAIN OF CUSTODY RECORDS

GeoChem, Incorporated

Environmental Laboratories

October 25, 1993

Mr. Jim Cornette
Richard Catlin & Assoc.
P.O. Box 10279
Wilmington, NC 28405-3755

FILE COPY
93125C

Reference: **AS 410 (weekly summary)**
93125
GCI# 9310-012M/9310-014M

Dear Mr. Jim Cornette:

This is the analytical report for the above referenced project. On October 19-20, 1993 we received seven water samples for analysis. The analytical and quality control results are presented in separate tables for your convenience. Brief summaries of analytical methods employed are as follows. GeoChem analytical reports contain information based strictly on the analysis requested on the chain of custody (COC) accompanying this report. Non-target compounds are not identified or quantified.

EPA method 602

Samples are loaded into a specially designed purging chamber at ambient temperature. Helium is bubbled through the sample. This drives the organics onto a sorbent trap. Once purging has been completed the sorbent column is rapidly heated. This efficiently transfers the organics into the gas chromatograph which separates the components of the sample. The purgeable organics are then detected using flame ionization and photo ionization detectors.

If there are any technical questions please feel free to call me at 919-460-8093. Thank you for allowing **GEOCHEM** to serve your analytical needs.

Sincerely,

Kevin Gokel
Dean Gokel
President

GeoChem, Incorporated

Environmental Laboratories

Geochem (NC # 336/SC # 99008)

Project mobile summary

1

Site Name AS 410

LAB ID.	092	093	094
DATE SAMPLED	10/18/93	10/18/93	10/18/93
DATE ANALYZED	10/19/93	10/19/93	10/19/93
FIELD ID.	HP-9	HP-3	HP-1

METHOD

ANALYTE	<u>ug/l</u>	<u>pql</u>	<u>ug/l</u>	<u>pql</u>	<u>ug/l</u>	<u>pql</u>
EPA 602						
Benzene	BDL	0.5	BDL	0.5	BDL	0.5
Toluene	BDL		BDL		9.2	
Chlorobenzene	BDL		BDL		BDL	
Ethylbenzene	BQL		BDL		BDL	
Xylenes	BDL		BDL		BDL	
1,3 Dichlorobenzene	BDL		BDL		BDL	
1,4 Dichlorobenzene	BDL		BDL		BDL	
1,2 Dichlorobenzene	BDL		BDL		BDL	

LAB ID.	095	102	103
DATE SAMPLED	10/18/93	10/20/93	10/20/93
DATE ANALYZED	10/19/93	10/20/93	10/20/93
FIELD ID.	DUP-1	HP-4	HP-6

METHOD

ANALYTE	<u>ug/l</u>	<u>pql</u>	<u>ug/l</u>	<u>pql</u>	<u>ug/l</u>	<u>pql</u>
EPA 602						
Benzene	BDL	0.5	BDL	0.5	BDL	0.5
Toluene	BDL		BDL		1.7	
Chlorobenzene	BDL		BDL		BDL	
Ethylbenzene	BDL		BDL		BDL	
Xylenes	BDL		BDL		BDL	
1,3 Dichlorobenzene	BDL		BDL		BDL	
1,4 Dichlorobenzene	BDL		BDL		BDL	
1,2 Dichlorobenzene	BDL		BDL		BDL	

soil water
parts per million = mg/kg mg/l
parts per billion = ug/kg ug/l
pql = practical quantitation limit due to matrix effects.
bdl = below method detection limit.
bql = below quantitation limit.

GeoChem, Incorporated

Environmental Laboratories

Geochem (NC # 336/SC # 99008)

Project mobile summary 2

Site Name AS 410

LAB ID.	104
DATE SAMPLED	10/20/93
DATE ANALYZED	10/20/93
FIELD ID.	HP-8

METHOD

ANALYTE	<u>ug/l</u>	<u>pql</u>

EPA 602

Benzene	BDL	0.5
Toluene	BDL	
Chlorobenzene	BDL	
Ethylbenzene	BDL	
Xylenes	BDL	
1,3 Dichlorobenzene	BDL	
1,4 Dichlorobenzene	BDL	
1,2 Dichlorobenzene	BDL	

soil water
parts per million = mg/kg mg/l
parts per billion = ug/kg ug/l
pql = practical quantitation limit due to matrix effects.
bdl = below method detection limit.
bql = below quantitation limit.

GeoChem, Incorporated

Environmental Laboratories

QUALITY CONTROL RESULTS

METHOD	RECOVERY	METHOD DETECTION LIMIT
602		
Benzene	90 %	0.5 ppb
Toluene	104 %	
Chlorobenzene	88 %	
Ethylbenzene	80 %	
Xylenes	70 %	
1,3-Dichlorobenzene	80 %	
1,2-Dichlorobenzene	73 %	
1,4-Dichlorobenzene	73 %	

REVIEWED BY

Laura Tagliavini

REVIEWED BY

John Valeri, C. Geo

Kita

Jim Cornette

Environmental Laboratories

Morrisville, NC 27560

1

W11-011

[illegible]

Report To:

4 A

JIM CORRIE

GeoChem, Incorporated

Environmental Laboratories

2500 Gate Way Centre Blvd., Suite 300

Morrisville, NC 27560

Bill To:

RC-A

win

Chain of Custody Record

[illegible]

GeoChem, Incorporated

Environmental Laboratories

October 28, 1993

Mr. Jim Cornette
Richard Catlin & Assoc.
P.O. Box 10279
Wilmington, NC 28405-3755

FILE COPY
93125C

Reference: AS410
93125
GCI# 9310-080

Dear Mr. Jim Cornette:

This is the analytical report for the above referenced project. On October 22, 1993 we received one soil sample for analysis. The analytical and quality control results are presented in separate tables for your convenience. Brief summaries of analytical methods employed are as follows. GeoChem analytical reports contain information based strictly on the analysis requested on the chain of custody (COC) accompanying this report. Non-target compounds are not identified or quantified.

pH

The pH is used to determine acidic or basic nature of the sample. The pH meter is calibrated with three NBS standards before each use. The calibration of the meter is checked periodically with one standard.

Flash Point

Sample is loaded into tog closed cup flash point tester. The temperature of the chamber is gradually elevated until sample flashes, corresponding to a rapid temperature rise. The flash point is the initial temperature before rapid temperature increase.

If there are any technical questions please feel free to call me at 919-460-8093. Thank you for allowing **GEOCHEM** to serve your analytical needs.

Sincerely,



Dean Gokel
President

GeoChem, Incorporated

Environmental Laboratories

Geochem (NC #336/SC #99008)
Project#9310-080

1

Site Name AS410

LAB ID. 5117
DATE SAMPLED 10/21/93
DATE ANALYZED 10/27/93
FIELD ID. AS410N-6

METHOD

ANALYTE pH pql

pH 6.16 1.28

LAB ID. 5117
DATE SAMPLED 10/21/93
DATE ANALYZED 10/27/93
FIELD ID. AS410N-6

METHOD

ANALYTE degrees Celsius

Flash Point >97*

soil water
parts per million = mg/kg mg/l

parts per billion = ug/kg ug/l

pql = practical quantitation limit due to matrix effects.

bdl = below method detection limit.

bql = below quantitation limit.

* = 97 degrees Celsius was the highest temperature achieved due to ambient heat losses.

REVIEWED BY

Laura Fogelman

REVIEWED BY

John Valeri G. Rosa

Bill To:

RC+A

Jim Cornette

**2500 Gate Way Centre Blvd., Suite 300
Morrisville, NC 27560**

Chain of Custody Record

1026

[illegible]

GeoChem, Incorporated

Environmental Laboratories

November 2, 1993

Mr. Jim Cornette
Richard Catlin & Assoc.
P.O. Box 10279
Wilmington, NC 28405-3755

FILE COPY
93125C

Reference: AS-410
93125-F
GCI# 9310-088

Dear Mr. Jim Cornette:

This is the analytical report for the above referenced project. On October 25, 1993 we received six soil samples for analysis. The analytical and quality control results are presented in separate tables for your convenience. Brief summaries of analytical methods employed are as follows. GeoChem analytical reports contain information based strictly on the analysis requested on the chain of custody (COC) accompanying this report. Non-target compounds are not identified or quantified.

TPH

Samples are analyzed by following the California U.S.T. manual. This methodology incorporates EPA purge and trap (meth. 5030) techniques for analysis of volatile fuels such as gasoline. Less volatile fuels such as diesel fuel and kerosene must be extracted using solvents prior to analysis (soils are sonicated, meth. 3550). A standard calibration curve is created from the pure fuel of interest. The standards serve two functions; they create a "finger print" pattern for comparisons and they allow the chemist to calculate the concentration of that fuel analyzed for.

pH

The pH is used to determine acidic or basic nature of the sample. The pH meter is calibrated with three NBS standards before each use. The calibration of the meter is checked periodically with one standard.

GeoChem, Incorporated

Environmental Laboratories

Flash Point

Sample is loaded into tog closed cup flash point tester. The temperature of the chamber is gradually elevated until sample flashes, corresponding to a rapid temperature rise. The flash point is the initial temperature before rapid temperature increase.

If there are any technical questions please feel free to call me at 919-460-8093. Thank you for allowing **GEOCHEM** to serve your analytical needs.

Sincerely,

Dean Gokel
President

GeoChem, Incorporated

Environmental Laboratories

Geochem (NC #336/SC #99008)

Project#9310-088

1

Site Name AS-410

LAB ID.	5138	5141
DATE SAMPLED	10/22/93	10/22/93
DATE ANALYZED	10/27/93	10/27/93
FIELD ID.	AS410N-7(10-12)	AS410N-8(10-12)

METHOD

ANALYTE	pH	pql	pH	pql
pH	9.34	1.28	6.32	1.28

LAB ID.	5138	5141
DATE SAMPLED	10/22/93	10/22/93
DATE ANALYZED	10/29/93	10/29/93
FIELD ID.	AS410N-7(10-12)	AS410-8(10-12)

METHOD

ANALYTE	degrees Celsius	degrees Celsius
Flash Point	>97*	>97*

soil water
parts per million = mg/kg mg/l
parts per billion = ug/kg ug/l
pql = practical quantitation limit due to matrix effects.
bdl = below method detection limit.
bql = below quantitation limit.
* = 97 degrees Celsius was the highest temperature achieved due to ambient heat losses.

GeoChem, Incorporated

Environmental Laboratories

Geochem (NC #336/SC #99008)

Project#9310-088

2

Site Name AS-410

LAB ID.	5136	5137	5139
DATE SAMPLED	10/22/93	10/22/93	10/22/93
DATE EXTRACTED	10/27/93	10/27/93	10/27/93
FIELD ID.	AS410N-7(2-4)	AS410N-7(4.5-6.5)	AS410N-8(2-4)

METHOD

ANALYTE	<u>mg/kg</u>	<u>pql</u>	<u>mg/kg</u>	<u>pql</u>	<u>mg/kg</u>	<u>pql</u>
TPH/diesel	BDL	5.0	BDL	5.0	BDL	5.0

LAB ID.	5136	5137	5139
DATE SAMPLED	10/22/93	10/22/93	10/22/93
DATE ANALYZED	10/26/93	10/26/93	10/26/93
FIELD ID.	AS410N-7(2-4)	AS410N-7(4.5-6.5)	AS410N-8(2-4)

METHOD

ANALYTE	<u>mg/kg</u>	<u>pql</u>	<u>mg/kg</u>	<u>pql</u>	<u>mg/kg</u>	<u>pql</u>
TPH/gas	BDL	1.0	BDL	1.0	BDL	1.0

soil water
parts per million = mg/kg mg/l
parts per billion = ug/kg ug/l
pql = practical quantitation limit due to matrix effects.
bdl = below method detection limit.
bql = below quantitation limit.

GeoChem, Incorporated

Environmental Laboratories

Geochem (NC #336/SC #99008)

Project#9310-088

3

Site Name AS-410

LAB ID.	5140
DATE SAMPLED	10/22/93
DATE EXTRACTED	10/27/93
FIELD ID.	AS410N-8(4.5-6.5)

METHOD

ANALYTE	mg/kg	pql
TPH/diesel	BDL	5.0

LAB ID.	5140
DATE SAMPLED	10/22/93
DATE ANALYZED	10/26/93
FIELD ID.	AS410N-8(4.5-6.5)

METHOD

ANALYTE	mg/kg	pql
TPH/gas	BDL	1.0

soil water
parts per million = mg/kg mg/l
parts per billion = ug/kg ug/l
pql = practical quantitation limit due to matrix effects.
bdl = below method detection limit.
bql = below quantitation limit.

GeoChem, Incorporated

Environmental Laboratories

QUALITY CONTROL RESULTS

METHOD	RECOVERY	METHOD DETECTION LIMIT
TPH/diesel	95 %	5.0 ppm
TPH/gas	100 %	1.0 ppm

REVIEWED BY

Laura Lyleman

REVIEWED BY

John E. Valeri, C. Beaumont

GeoChem, Incorporated

Report To: RC+A

Bill To: RC+A

JIM COZZINETTE

Environmental Laboratories

2500 Gate Way Centre Blvd., Suite 300
Morrisville, NC 27560

WLM

Chain of Custody Record

1028

PROJECT SITE NUMBER 93125-F		PO# 931007-8	ANALYSES		GEOCHEM PROJECT # 9310-088 UST	
SITE NAME AS-410			DATE DUE 10/25/93		DATE DUE 11/1/93	
COLLECTED BY (Signature) <i>Bud Mulard</i>			VERBAL/FAX/HARDCOPY		LAB ID NO. (for lab use only)	
FIELD SAMPLE ID	TURNAROUND IN DAYS	SAMPLE MATRIX	DATE AND TIME COLLECTED	NO. OF CONTAINERS PER LOCATION	REMARKS	LAB ID NO. (for lab use only)
STATION-7, 2-4	5 DAYS	SOIL	10/22/93 0930	1	UST	5136
-7, 15-4.5			0940	1		5137
-7, 10-12			0940	1		5138
-8, 2-4			1020	1		5139
-8, 4.5-4.5			1025	1		5140
-8, 10-12			1040	1		5141
REMARKS						
RELINQUISHED BY: <i>Bud Mulard</i>						
RECEIVED BY:	DATE	TIME	RELINQUISHED BY:	DATE	TIME	DATE
<i>[Signature]</i>	10/25	16:00	<i>[Signature]</i>	10/25	12:41	10/22/93 1500

GeoChem, Incorporated

Environmental Laboratories

FILE COPY

93125C

November 2, 1993

Mr. Jim Cornette
Richard Catlin & Assoc.
P.O. Box 10279
Wilmington, NC 28405-3755

Reference: AS 410
93125-F
GCI# 9310-092

Dear Mr. Jim Cornette:

This is the analytical report for the above referenced project. On October 26, 1993 we received five soil samples for analysis. The analytical and quality control results are presented in separate tables for your convenience. Brief summaries of analytical methods employed are as follows. GeoChem analytical reports contain information based strictly on the analysis requested on the chain of custody (COC) accompanying this report. Non-target compounds are not identified or quantified.

TPH

Samples are analyzed by following the California U.S.T. manual. This methodology incorporates EPA purge and trap (meth. 5030) techniques for analysis of volatile fuels such as gasoline. Less volatile fuels such as diesel fuel and kerosene must be extracted using solvents prior to analysis (soils are sonicated, meth. 3550). A standard calibration curve is created from the pure fuel of interest. The standards serve two functions; they create a "finger print" pattern for comparisons and they allow the chemist to calculate the concentration of that fuel analyzed for.

GeoChem, Incorporated

Environmental Laboratories

Flash Point

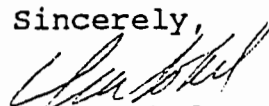
Sample is loaded into tog closed cup flash point tester. The temperature of the chamber is gradually elevated until sample flashes, corresponding to a rapid temperature rise. The flash point is the initial temperature before rapid temperature increase.

pH

The pH is used to determine acidic or basic nature of the sample. The pH meter is calibrated with three NBS standards before each use. The calibration of the meter is checked periodically with one standard.

If there are any technical questions please feel free to call me at 919-460-8093. Thank you for allowing **GEOCHEM** to serve your analytical needs.

Sincerely,



Dean Gokel
President

GeoChem, Incorporated

Environmental Laboratories

Geochem (NC #336/SC #99008)
Project#9310-092

1

Site Name AS 410

LAB ID.	5156	5157
DATE SAMPLED	10/25/93	10/25/93
DATE ANALYZED	10/27/93	10/27/93
FIELD ID.	AS410N-11 4.5-6.5	AS410N-11 2-4

METHOD

ANALYTE	mq/kg	pql	mq/kg	pql
TPH/gas	BDL	1.0	BDL	1.0

LAB ID.	5156	5157
DATE SAMPLED	10/25/93	10/25/93
DATE EXTRACTED	10/27/93	10/27/93
FIELD ID.	AS410N-11 4.5-6.5	AS410N-11 2-4

METHOD

ANALYTE	mq/kg	pql	mq/kg	pql
TPH/diesel	BDL	5.0	BDL	5.0

soil water
parts per million = mg/kg mg/l
parts per billion = ug/kg ug/l
pql = practical quantitation limit due to matrix effects.
bdl = below method detection limit.
bql = below quantitation limit.

GeoChem, Incorporated

Environmental Laboratories

Geochem (NC #336/SC #99008)

Project#9310-092

2

Site Name AS 410

LAB ID.	5155	5158	5159
DATE SAMPLED	10/25/93	10/25/93	10/25/93
DATE ANALYZED	10/27/93	10/27/93	10/27/93
FIELD ID.	AS410N-11 10-12	AS410-9 10-12	AS410N-10 10-12

METHOD

ANALYTE	pH	pql	pH	pql	pH	pql
pH	6.48	1.28	5.68	1.28	8.75	1.28

LAB ID.	5155	5158	5159
DATE SAMPLED	10/25/93	10/25/93	10/25/93
DATE ANALYZED	10/29/93	10/29/93	10/29/93
FIELD ID.	AS410N-11 10-12	AS410N-9 10-12	AS410N-10 10-12

METHOD

ANALYTE	degrees Celsius	degrees Celsius	degrees Celsius
Flash Point	>97*	>97*	>97*

soil water
parts per million = mg/kg mg/l
parts per billion = ug/kg ug/l
pql = practical quantitation limit due to matrix effects.
bdl = below method detection limit.
bql = below quantitation limit.
* = 97 degrees Celsius was the highest temperature achieved due to ambient heat losses.

GeoChem, Incorporated

Environmental Laboratories

QUALITY CONTROL RESULTS

METHOD	RECOVERY	METHOD DETECTION LIMIT
TPH/gas	75 %	1.0 ppm
TPH/diesel	95 %	5.0 ppm

REVIEWED BY

Ramona Logman

REVIEWED BY

Valeri G. Rose

rt To: RC+A

JIM CORNETTE

GeoChem, Incorporated

Environmental Laboratories

**2500 Gate Way Centre Blvd., Suite 300
Morrisville, NC 27560**

Bill To:

RC & A

Chain of Custody Record

828

PROJECT SITE NUMBER		PO#		GEOCHEM PROJECT #	
93125-F		931007-8		9310-092	
SITE NAME		AS410		DATE DUE	
COLLECTED BY (Signature)		Burd		11/1/93	
TURNAROUND IN DAYS		SAMPLE MATRIX		VERBAL/FAX/HARDCOPY	
FIELD SAMPLE ID		DATE AND TIME COLLECTED		LAB ID NO. (for lab use only)	
11-10-12	5	Soil	10/25/93	1430	5155
11-15-65				1420	5156
11-2-4				1410	5157
9-10-12				0910	5158
10-10-12				1030	5159
REMARKS					
USI					
3550-5030					
FLASH-PT-FH					
NO. OF CONTAINERS PER LOCATION					
ANALYSES					
RELINQUISHED BY: Burd					
RECEIVED BY: [Signature]					
DATE		TIME		DATE	
10/26/93		1230		10/26/93	

GeoChem, Incorporated

Environmental Laboratories

November 3, 1993

Mr. Jim Cornette
Richard Catlin & Assoc.
P.O. Box 10279
Wilmington, NC 28405-3755

FILE COPY
93125 C

Reference: AS 410
93125-F
GCI# 9310-094

Dear Mr. Jim Cornette:

This is the analytical report for the above referenced project. On October 27, 1993 we received three soil samples for analysis. The analytical and quality control results are presented in separate tables for your convenience. Brief summaries of analytical methods employed are as follows. GeoChem analytical reports contain information based strictly on the analysis requested on the chain of custody (COC) accompanying this report. Non-target compounds are not identified or quantified.

TPH

Samples are analyzed by following the California U.S.T. manual. This methodology incorporates EPA purge and trap (meth. 5030) techniques for analysis of volatile fuels such as gasoline. Less volatile fuels such as diesel fuel and kerosene must be extracted using solvents prior to analysis (soils are sonicated, meth. 3550). A standard calibration curve is created from the pure fuel of interest. The standards serve two functions; they create a "finger print" pattern for comparisons and they allow the chemist to calculate the concentration of that fuel analyzed for.

GeoChem, Incorporated

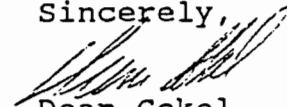
Environmental Laboratories

Metals

Metals testing entails several distinct tests. All groundwater samples are collected according to EPA Method 3030. All samples are digested in an acidic solution prior to analysis. There are several different digestion(s) performed depending on which metal(s) is (are) to be analyzed and the matrix of the sample(s). Metals such as lead and arsenic are then analyzed using a graphite furnace A.A. Many metals can be analyzed with a Flame A.A.

If there are any technical questions please feel free to call me at 919-460-8093. Thank you for allowing ~~GEOCHEM~~ to serve your analytical needs.

Sincerely,



Dean Gokel
President

GeoChem, Incorporated

Environmental Laboratories

Geochem (NC #336/SC #99008)

Project#9310-094

1

Site Name AS 410

LAB ID.	5163	5164
DATE SAMPLED	10/26/93	10/26/93
DATE ANALYZED	10/28/93	10/28/93
FIELD ID.	AS410N-13 (2-4)	AS410N-13 (4.5-6.5)

METHOD

ANALYTE	mg/kg	pql	mg/kg	pql
TPH/gas	BDL	1.0	BDL	1.0

LAB ID.	5163	5164
DATE SAMPLED	10/26/93	10/26/93
DATE EXTRACTED	10/28/93	10/28/93
FIELD ID.	AS410N-13 (2-4)	AS410N-13 (4.5-6.5)

METHOD

ANALYTE	mg/kg	pql	mg/kg	pql
TPH/diesel	BDL	5.0	BDL	5.0

soil water
parts per million = mg/kg mg/l
parts per billion = ug/kg ug/l
pql = practical quantitation limit due to matrix effects.
bdl = below method detection limit.
bql = below quantitation limit.

GeoChem, Incorporated

Environmental Laboratories

Geochem(NC #336/SC #99008)

Project#9310-094

2

Site Name AS 410

LAB ID.	5165
DATE SAMPLED	10/26/93
DATE EXTRACTED	10/27/93
FIELD ID.	AS410N-13 (10-12)

METHOD

ANALYTE	mg/l	pql

TCLP Metals

Arsenic	BQL	0.030
Barium	BQL	3.00
Cadmium	BQL	0.500
Chromium	BDL	0.500
Lead	BQL	0.500
Mercury	BQL	0.001
Selenium	BQL	0.020
Silver	BDL	0.500

soil water
parts per million = mg/kg mg/l
parts per billion = ug/kg ug/l
pql = practical quantitation limit due to matrix effects.
bdl = below method detection limit.
bql = below quantitation limit.

GeoChem, Incorporated

Environmental Laboratories

QUALITY CONTROL RESULTS

METHOD	RECOVERY	METHOD DETECTION LIMIT
TPH/gas	78 %	1.0 ppm
TPH/diesel	99 %	5.0 ppm

REVIEWED BY

Laura Fogelman

REVIEWED BY

J. G. Valen: C. Peas

$RC \perp A$

JIM CORNETTE

GeoChem, Incorporated

Environmental Laboratories

2500 Gate Way Centre Blvd., Suite 300

Morrisville, NC 27560

Bill To:

$$R_L + A$$

Chain of Custody Record

1101

[illegible]

GeoChem, Incorporated

Environmental Laboratories

FILE COPY

93125C

November 3, 1993

Mr. Jim Cornette
Richard Catlin & Assoc.
P.O. Box 10279
Wilmington, NC 28405-3755

Reference: AS 410
93125-F
GCI# 9310-101

Dear Mr. Jim Cornette:

This is the analytical report for the above referenced project. On October 28, 1993 we received three soil samples for analysis. The analytical and quality control results are presented in separate tables for your convenience. Brief summaries of analytical methods employed are as follows. GeoChem analytical reports contain information based strictly on the analysis requested on the chain of custody (COC) accompanying this report. Non-target compounds are not identified or quantified.

pH

The pH is used to determine acidic or basic nature of the sample. The pH meter is calibrated with three NBS standards before each use. The calibration of the meter is checked periodically with one standard.

Flash Point

Sample is loaded into tog closed cup flash point tester. The temperature of the chamber is gradually elevated until sample flashes, corresponding to a rapid temperature rise. The flash point is the initial temperature before rapid temperature increase.

GeoChem, Incorporated

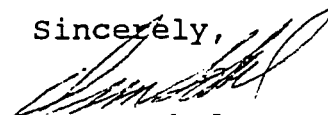
Environmental Laboratories

Metals

Metals testing entails several distinct tests. All groundwater samples are collected according to EPA Method 3030. All samples are digested in an acidic solution prior to analysis. There are several different digestion(s) performed depending on which metal(s) is (are) to be analyzed and the matrix of the sample(s). Metals such as lead and arsenic are then analyzed using a graphite furnace A.A. Many metals can be analyzed with a Flame A.A.

If there are any technical questions please feel free to call me at 919-460-8093. Thank you for allowing **GEOCHEM** to serve your analytical needs.

Sincerely,



Dean Gokel
President

GeoChem, Incorporated

Environmental Laboratories

Geochem (NC #336/SC #99008)

Project#9310-101

1

Site Name AS 410

LAB ID.	5189	5190
DATE SAMPLED	10/27/93	10/27/93
DATE ANALYZED	10/29/93	10/29/93
FIELD ID.	AS410N-14 (10-12)	AS410N-15 (10-12)

METHOD

ANALYTE	<u>pH</u>	<u>pql</u>	<u>pH</u>	<u>pql</u>
pH	6.65	0.77	5.63	0.77

LAB ID.	5189	5190
DATE SAMPLED	10/27/93	10/27/93
DATE ANALYZED	11/03/93	11/03/93
FIELD ID.	AS410N-14 (10-12)	AS410N-15 (10-12)

METHOD

ANALYTE	<u>degrees Celsius</u>	<u>degrees Celsius</u>
Flash Point	>97*	>97*

soil water
parts per million = mg/kg mg/l
parts per billion = ug/kg ug/l
pql = practical quantitation limit due to matrix effects.
bdl = below method detection limit.
bql = below quantitation limit.
* = 97 degrees Celsius was the highest temperature achieved due to ambient heat losses.

GeoChem, Incorporated

Environmental Laboratories

Geochem(NC #336/SC #99008)
Project#9310-101

2

Site Name AS 410

LAB ID.	5188	5189
DATE SAMPLED	10/27/93	10/27/93
DATE EXTRACTED	10/28/93	10/28/93
FIELD ID.	AS410N-12 (10-12)	AS410N-14 (10-12)

METHOD

ANALYTE	mg/l	pql	mg/l	pql
TCLP Metals				
Arsenic	BDL	0.030	BDL	0.030
Barium	BQL	3.00	BQL	3.00
Cadmium	BQL	0.500	BQL	0.500
Chromium	BQL	0.500	BQL	0.500
Lead	BQL	0.500	BQL	0.500
Mercury	BQL	0.001	BQL	0.001
Selenium	BDL	0.020	BDL	0.020
Silver	BQL	0.500	BQL	0.500

soil water
parts per million = mg/kg mg/l
parts per billion = ug/kg ug/l
pql = practical quantitation limit due to matrix effects.
bdl = below method detection limit.
bql = below quantitation limit.

REVIEWED BY

Laura Loggeman

REVIEWED BY

John Valeri, C. Res

GeoChem, Incorporated

Bill To:

RC-A

Timothy

Environmental Laboratories

**2500 Gate Way Centre Blvd., Suite 300
Morrisville, NC 27560**

Chain of Custody Record

1101

[illegible]

GeoChem, Incorporated

Environmental Laboratories

November 9, 1993

Mr. Jim Cornette
Richard Catlin & Assoc.
P.O. Box 10279
Wilmington, NC 28405-3755

FILE COPY

Reference: AS 410
93125-F
GCI# 9310-103

Dear Mr. Jim Cornette:

This is the analytical report for the above referenced project. On October 29, 1993 we received two soil samples for analysis. The analytical and quality control results are presented in separate tables for your convenience. Brief summaries of analytical methods employed are as follows. GeoChem analytical reports contain information based strictly on the analysis requested on the chain of custody (COC) accompanying this report. Non-target compounds are not identified or quantified.

pH

The pH is used to determine acidic or basic nature of the sample. The pH meter is calibrated with three NBS standards before each use. The calibration of the meter is checked periodically with one standard.

Flash Point

Sample is loaded into tog closed cup flash point tester. The temperature of the chamber is gradually elevated until sample flashes, corresponding to a rapid temperature rise. The flash point is the initial temperature before rapid temperature increase.

GeoChem, Incorporated

Environmental Laboratories

Metals

Metals testing entails several distinct tests. All groundwater samples are collected according to EPA Method 3030. All samples are digested in an acidic solution prior to analysis. There are several different digestion(s) performed depending on which metal(s) is (are) to be analyzed and the matrix of the sample(s). Metals such as lead and arsenic are then analyzed using a graphite furnace A.A. Many metals can be analyzed with a Flame A.A.

If there are any technical questions please feel free to call me at 919-460-8093. Thank you for allowing **GEOCHEM** to serve your analytical needs.

Sincerely,

Kevin Gokel
Dean Gokel
President

GeoChem, Incorporated

Environmental Laboratories

Geochem (NC #336/SC #99008)

Project#9310-103

1

Site Name AS 410

LAB ID.	5198	5199
DATE SAMPLED	10/28/93	10/28/93
DATE ANALYZED	11/05/93	11/05/93
FIELD ID.	AS410N-18(10-12)	AS410N-16(10-12)

METHOD

ANALYTE	pH	pql	pH	pql
pH	9.00	1.23	6.24	1.23

LAB ID.	5198	5199
DATE SAMPLED	10/28/93	10/28/93
DATE ANALYZED	11/05/93	11/05/93
FIELD ID.	AS410N-18(10-12)	AS410N-16(10-12)

METHOD

ANALYTE	degrees Celsius	degrees Celsius
Flash Point	>97*	>97*

soil water
parts per million = mg/kg mg/l
parts per billion = ug/kg ug/l
pql = practical quantitation limit due to matrix effects.
bdl = below method detection limit.
bql = below quantitation limit.
* = 97 degrees Celsius was the highest temperature achieved due ambient heat loss.

GeoChem, Incorporated

Environmental Laboratories

Geochem(NC #336/SC #99008)
Project#9310-103

2

Site Name AS 410

LAB ID.	5199
DATE SAMPLED	10/28/93
DATE EXTRACTED	11/01/93
FIELD ID.	AS410N-16(10-12)

METHOD

ANALYTE	mg/l	pql

TCLP Metals

Arsenic	BDL	0.030
Barium	BDL	3.00
Cadmium	BQL	0.500
Chromium	BQL	0.500
Lead	BQL	0.500
Mercury	BQL	0.001
Selenium	BDL	0.020
Silver	BQL	0.500

	<u>soil</u>	<u>water</u>
parts per million =	mg/kg	mg/l
parts per billion =	ug/kg	ug/l

pql = practical quantitation limit due to matrix effects.
bdl = below method detection limit.
bql = below quantitation limit.

REVIEWED BY

Raura Logleman

REVIEWED BY

Valeri G. Reed

ACD

11/3/93

This Chain of Custody is considered a written contract to perform the services requested in the analyses section of this document.

GeoChem, Incorporated

Environmental Laboratories

FILE COPY

93125C

November 16, 1993

Mr. Jim Cornette
Richard Catlin & Assoc.
P.O. Box 10279
Wilmington, NC 28405-3755

Reference: AS-410 (weekly summary 11/07/93-11/13/93)
93125-F
GCI# 9311-004M

Dear Mr. Jim Cornette:

This is the analytical report for the above referenced project. On November 9, 1993 we received two water samples for analysis. The analytical and quality control results are presented in separate tables for your convenience. Brief summaries of analytical methods employed are as follows. GeoChem analytical reports contain information based strictly on the analysis requested on the chain of custody (COC) accompanying this report. Non-target compounds are not identified or quantified.

EPA method 602

Samples are loaded into a specially designed purging chamber at ambient temperature. Helium is bubbled through the sample. This drives the organics onto a sorbent trap. Once purging has been completed the sorbent column is rapidly heated. This efficiently transfers the organics into the gas chromatograph which separates the components of the sample. The purgeable organics are then detected using flame ionization and photo ionization detectors.

If there are any technical questions please feel free to call me at 919-460-8093. Thank you for allowing **GEOCHEM** to serve your analytical needs.

Sincerely,



Dean Gokel
President

GeoChem, Incorporated

Environmental Laboratories

Geochem (NC # 336/SC # 99008)

Project mobile summary 1

Site Name AS-410

LAB ID.	181	182
DATE SAMPLED	11/09/93	11/09/93
DATE ANALYZED	11/10/93	11/10/93
FIELD ID.	AS410N-19	AS410N-19Dup

METHOD

ANALYTE	<u>ug/l</u>	<u>pql</u>	<u>ug/l</u>	<u>pql</u>
EPA 602				
Benzene	5700*	1.3	6100*	1.3
Toluene	2500*		2600*	
Chlorobenzene	BQL		BQL	
Ethylbenzene	1500*		1500*	
Xylenes	4100*		4300*	
1,3 Dichlorobenzene	BQL		BQL	
1,4 Dichlorobenzene	BQL		BQL	
1,2 Dichlorobenzene	BQL		BQL	

soil water
parts per million = mg/kg mg/l
parts per billion = ug/kg ug/l
pql = practical quantitation limit due to matrix effects.
bdl = below method detection limit.
bql = below quantitation limit.
* = exceeds calibration curve >20%.

GeoChem, Incorporated

Environmental Laboratories

QUALITY CONTROL RESULTS

METHOD	RECOVERY	METHOD DETECTION LIMIT
602		
Benzene	97 %	0.5 ppb
Toluene	99 %	
Chlorobenzene	98 %	
Ethylbenzene	101 %	
Xylenes	98 %	
1,3-Dichlorobenzene	93 %	
1,2-Dichlorobenzene	85 %	
1,4-Dichlorobenzene	93 %	

REVIEWED BY

Laura Logeman

REVIEWED BY

John Valeri C. Rao

GeoChem, Incorporated

Bill To:

Environmental Laboratories

**2500 Gate Way Centre Blvd., Suite 300
Morrisville, NC 27560**

Chain of Custody Record

PROJECT SITE NUMBER		PO#		ANALYSES		GEOCHEM PROJECT #	
SITE NAME		DATE		TIME		DATE	
93125-F		9311-DOX-m					
AS410							
COLLECTED BY (Signature)		DATE		TIME		DATE	
Matt Dunlap		11-9-93		1600		11-9-93	
TURNAROUND IN DAYS		SAMPLE MATRIX		DATE AND TIME COLLECTED		LAB ID NO. (for lab use only)	
AS410N-19		H ₂ O		11-9-93 1600		181	
AS410N-19		"		11-9-93 1600		182	
REMARKS		RELINQUISHED BY:		RECEIVED BY:		DATE	
RELINQUISHED BY: Matt Dunlap		RECEIVED BY:		DATE		TIME	
RELINQUISHED BY: Matt Dunlap		RECEIVED BY:		DATE		TIME	

GeoChem, Incorporated

Environmental Laboratories

FILE COPY

93125C

November 22, 1993

Mr. Jim Cornette
Richard Catlin & Assoc.
P.O. Box 10279
Wilmington, NC 28405-3755

Reference: AS-410 (weekly summary for 10/24/93-10/30/93)
93125-F
GCI# 9310-016M/9310-020M/9310-022M (corrected)

Dear Mr. Jim Cornette:

This is the analytical report for the above referenced project. On October 21-27, 1993 we received ten water and sixteen soil samples for analysis. The analytical and quality control results are presented in separate tables for your convenience. Brief summaries of analytical methods employed are as follows. GeoChem analytical reports contain information based strictly on the analysis requested on the chain of custody (COC) accompanying this report. Non-target compounds are not identified or quantified.

TPH

Samples are analyzed by following the California U.S.T. manual. This methodology incorporates EPA purge and trap (meth. 5030) techniques for analysis of volatile fuels such as gasoline. Less volatile fuels such as diesel fuel and kerosene must be extracted using solvents prior to analysis (soils are sonicated, meth. 3550). A standard calibration curve is created from the pure fuel of interest. The standards serve two functions; they create a "finger print" pattern for comparisons and they allow the chemist to calculate the concentration of that fuel analyzed for.

GeoChem, Incorporated

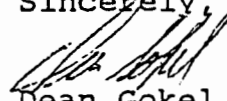
Environmental Laboratories

EPA method 602

Samples are loaded into a specially designed purging chamber at ambient temperature. Helium is bubbled through the sample. This drives the organics onto a sorbent trap. Once purging has been completed the sorbent column is rapidly heated. This efficiently transfers the organics into the gas chromatograph which separates the components of the sample. The purgeable organics are then detected using flame ionization and photo ionization detectors.

If there are any technical questions please feel free to call me at 919-460-8093. Thank you for allowing **GEOCHEM** to serve your analytical needs.

Sincerely,



Dean Gokel
President

GeoChem, Incorporated

Environmental Laboratories

Geochem (NC #336/SC #99008)

Project mobile summary

1

Site Name AS 410

LAB ID.	120	121	122
DATE SAMPLED	10/21/93	10/21/93	10/21/93
DATE ANALYZED	10/21/93	10/21/93	10/21/93
FIELD ID.	AS410N-4 (2-4)	AS410N-4 (4.5-6.5)	AS410N-5 (2-4)

METHOD

ANALYTE	mg/kg	pql	mg/kg	pql	mg/kg	pql
TPH/gas	BDL	1.0	BDL	1.0	BDL	1.0

LAB ID.	123	124	125
DATE SAMPLED	10/21/93	10/21/93	10/21/93
DATE ANALYZED	10/21/93	10/21/93	10/21/93
FIELD ID.	AS410N-5 (4.5-6.5)	AS410N-6 (2-4)	AS410N-6 (4.5-5.5)

METHOD

ANALYTE	mg/kg	pql	mg/kg	pql	mg/kg	pql
TPH/gas	BDL	1.0	BDL	1.0	BDL	1.0

soil water
parts per million = mg/kg mg/l
parts per billion = ug/kg ug/l
pql = practical quantitation limit due to matrix effects.
bdl = below method detection limit.
bql = below quantitation limit.

GeoChem, Incorporated

Environmental Laboratories

Geochem (NC #336/SC #99008)

Project mobile summary

2

Site Name AS 410

LAB ID.	142	143	144
DATE SAMPLED	10/25/93	10/25/93	10/25/93
DATE ANALYZED	10/25/93	10/25/93	10/25/93
FIELD ID.	AS410N-9 (2-4)	AS410N-9 (4.5-6.5)	AS410N- ~~9~~ (2-4)

10 MJO 12-9-93

METHOD

ANALYTE	<u>mg/kg</u>	<u>pql</u>	<u>mg/kg</u>	<u>pql</u>	<u>mg/kg</u>	<u>pql</u>
TPH/gas	BDL	1.0	BDL	1.0	BDL	1.0

LAB ID.	145	159	160
DATE SAMPLED	10/25/93	10/27/93	10/27/93
DATE ANALYZED	10/26/93	10/27/93	10/27/93
FIELD ID.	AS410N- ~~9~~ (4.5-6.5)	AS410N-12 (2-4)	AS410N-12 (4.5-6.5)

10 MJO 12-9-93

METHOD

ANALYTE	<u>mg/kg</u>	<u>pql</u>	<u>mg/kg</u>	<u>pql</u>	<u>mg/kg</u>	<u>pql</u>
TPH/gas	BDL	1.0	BDL	1.0	BDL	1.0

soil water
parts per million = mg/kg mg/l
parts per billion = ug/kg ug/l
pql = practical quantitation limit due to matrix effects.
bdl = below method detection limit.
bql = below quantitation limit.

GeoChem, Incorporated

Environmental Laboratories

Geochem (NC #336/SC #99008)

Project mobile summary

3

Site Name AS 410

LAB ID.	161	162	163
DATE SAMPLED	10/27/93	10/27/93	10/27/93
DATE ANALYZED	10/27/93	10/27/93	10/27/93
FIELD ID.	AS410N-14(2-4)	AS410N-14(4.5-6.5)	AS410N-15(2-4)

METHOD

ANALYTE	<u>mg/kg</u>	<u>pql</u>	<u>mg/kg</u>	<u>pql</u>	<u>mg/kg</u>	<u>pql</u>
TPH/gas	BDL	1.0	BDL	1.0	BDL	1.0

LAB ID.	164
DATE SAMPLED	10/27/93
DATE ANALYZED	10/27/93
FIELD ID.	AS410N-15(4.5-6.5)

METHOD

ANALYTE	<u>mg/kg</u>	<u>pql</u>
TPH/gas	BDL	1.0

soil water
parts per million = mg/kg mg/l
parts per billion = ug/kg ug/l
pql = practical quantitation limit due to matrix effects.
bdl = below method detection limit.
bql = below quantitation limit.

GeoChem, Incorporated

Environmental Laboratories

Geochem (NC #336/SC #99008)

Project mobile summary

4

Site Name AS 410

LAB ID.	120	121	122
DATE SAMPLED	10/21/93	10/21/93	10/21/93
DATE EXTRACTED	10/21/93	10/21/93	10/21/93
FIELD ID.	AS410N-4 (2-4)	AS410N-4 (4.5-6.5)	AS410N-5 (2-4)

METHOD

ANALYTE	<u>mg/kg</u>	<u>pql</u>	<u>mg/kg</u>	<u>pql</u>	<u>mg/kg</u>	<u>pql</u>
TPH/diesel	BDL	5.0	BDL	5.0	BDL	5.0

LAB ID.	123	124	125
DATE SAMPLED	10/21/93	10/21/93	10/21/93
DATE EXTRACTED	10/21/93	10/21/93	10/21/93
FIELD ID.	AS410N-5 (4.5-6.5)	AS410N-6 (2-4)	AS410N-6 (4.5-5.5)

METHOD

ANALYTE	<u>mg/kg</u>	<u>pql</u>	<u>mg/kg</u>	<u>pql</u>	<u>mg/kg</u>	<u>pql</u>
TPH/diesel	BDL	5.0	BDL	5.0	BDL	5.0

soil water
parts per million = mg/kg mg/l
parts per billion = ug/kg ug/l
pql = practical quantitation limit due to matrix effects.
bdl = below method detection limit.
bql = below quantitation limit.

GeoChem, Incorporated

Environmental Laboratories

Geochem (NC #336/SC #99008)

Project mobile summary

5

Site Name AS 410

LAB ID.	142	143	144
DATE SAMPLED	10/25/93	10/25/93	10/25/93
DATE EXTRACTED	10/25/93	10/25/93	10/25/93
FIELD ID.	AS410N-9(2-4)	AS410N-9 (4.5-6.5)	AS410N-8 (2-4)

10 MJD 12-9-93

METHOD

ANALYTE	mg/kg	pql	mg/kg	pql	mg/kg	pql
TPH/diesel	BDL	5.0	BDL	5.0	BDL	5.0

LAB ID.	145	159	160
DATE SAMPLED	10/25/93	10/27/93	10/27/93
DATE EXTRACTED	10/25/93	10/27/93	10/27/93
FIELD ID.	AS410N-8 (4.5-6.5)	AS410N-12(2-4)	AS410N-12(4.5-6.5)

10 12-9-93 MJD

METHOD

ANALYTE	mg/kg	pql	mg/kg	pql	mg/kg	pql
TPH/diesel	BDL	5.0	BDL	5.0	BDL	5.0

soil water
parts per million = mg/kg mg/l
parts per billion = ug/kg ug/l
pql = practical quantitation limit due to matrix effects.
bdl = below method detection limit.
bql = below quantitation limit.

GeoChem, Incorporated

Environmental Laboratories

Geochem (NC #336/SC #99008)

Project mobile summary

6

Site Name AS 410

LAB ID.	161	162	163
DATE SAMPLED	10/27/93	10/27/93	10/27/93
DATE EXTRACTED	10/27/93	10/27/93	10/27/93
FIELD ID.	AS410N-14(2-4)	AS410N-14(4.5-6.5)	AS410N-15(2-4)

METHOD

ANALYTE	<u>mg/kg</u>	<u>pql</u>	<u>mg/kg</u>	<u>pql</u>	<u>mg/kg</u>	<u>pql</u>
TPH/diesel	BDL	5.0	BDL	5.0	BDL	5.0

LAB ID.	164
DATE SAMPLED	10/27/93
DATE EXTRACTED	10/27/93
FIELD ID.	AS410N-15(4.5-6.5)

METHOD

ANALYTE	<u>mg/kg</u>	<u>pql</u>
TPH/diesel	BDL	5.0

soil water
parts per million = mg/kg mg/l
parts per billion = ug/kg ug/l
pql = practical quantitation limit due to matrix effects.
bdl = below method detection limit.
bql = below quantitation limit.

GeoChem, Incorporated

Environmental Laboratories

Geochem (NC # 336/SC # 99008)

Project mobile summary 7

Site Name AS 410

LAB ID.	114	115	116
DATE SAMPLED	10/21/93	10/21/93	10/21/93
DATE ANALYZED	10/21/93	10/21/93	10/21/93
FIELD ID.	MW-B	HP-2	HP-5

METHOD

ANALYTE	<u>ug/l</u>	<u>pql</u>	<u>ug/l</u>	<u>pql</u>	<u>ug/l</u>	<u>pql</u>
EPA 602						
Benzene	2000*	2.5	100	0.5	BDL	0.5
Toluene	460		110		BDL	
Chlorobenzene	1.8		BDL		BDL	
Ethylbenzene	1100*		36		BDL	
Xylenes	950*		170		BDL	
1,3 Dichlorobenzene	BQL		BDL		BDL	
1,4 Dichlorobenzene	BQL		BDL		BDL	
1,2 Dichlorobenzene	BQL		BDL		BDL	

LAB ID.	117	118	119
DATE SAMPLED	10/21/93	10/21/93	10/21/93
DATE ANALYZED	10/21/93	10/21/93	10/21/93
FIELD ID.	HP-7	RINS-1	HP-10

METHOD

ANALYTE	<u>ug/l</u>	<u>pql</u>	<u>ug/l</u>	<u>pql</u>	<u>ug/l</u>	<u>pql</u>
EPA 602						
Benzene	16	0.5	BDL	0.5	BDL	0.5
Toluene	BDL		BDL		BDL	
Chlorobenzene	BDL		BDL		BDL	
Ethylbenzene	11		BDL		BDL	
Xylenes	9.2		BDL		BDL	
1,3 Dichlorobenzene	BDL		BDL		BDL	
1,4 Dichlorobenzene	BDL		BDL		BDL	
1,2 Dichlorobenzene	BDL		BDL		BDL	

soil water
parts per million = mg/kg mg/l
parts per billion = ug/kg ug/l
pql = practical quantitation limit due to matrix effects.
bdl = below method detection limit.
bql = below quantitation limit.
* = exceeds calibration curve >20%.

GeoChem, Incorporated

Environmental Laboratories

Geochem (NC # 336/SC # 99008)

Project mobile summary 8

Site Name AS 410

LAB ID.	146	147	148
DATE SAMPLED	10/25/93	10/25/93	10/25/93
DATE ANALYZED	10/25/93	10/25/93	10/25/93
FIELD ID.	AS410N-4	AS410N-5	AS410N-6

METHOD

ANALYTE	ug/l	pql	ug/l	pql	ug/l	pql
EPA 602						
Benzene	BDL	0.5	BDL	0.5	BDL	0.5
Toluene	BDL		BDL		BDL	
Chlorobenzene	BDL		BDL		BDL	
Ethylbenzene	BDL		0.7		BDL	
Xylenes	BDL		3.3		BDL	
1,3 Dichlorobenzene	BDL		BDL		BDL	
1,4 Dichlorobenzene	BDL		BDL		BDL	
1,2 Dichlorobenzene	BDL		BDL		BDL	

LAB ID.	149
DATE SAMPLED	10/21/93
DATE ANALYZED	10/25/93
FIELD ID.	AS410N-7

METHOD

ANALYTE	ug/l	pql
EPA 602		
Benzene	BDL	0.5
Toluene	BDL	
Chlorobenzene	BDL	
Ethylbenzene	BDL	
Xylenes	BDL	
1,3 Dichlorobenzene	BDL	
1,4 Dichlorobenzene	BDL	
1,2 Dichlorobenzene	BDL	

soil water
parts per million = mg/kg mg/l
parts per billion = ug/kg ug/l
pql = practical quantitation limit due to matrix effects.
bdl = below method detection limit.
bql = below quantitation limit.

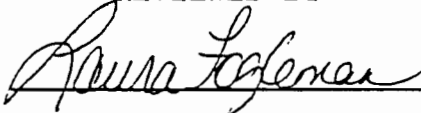
GeoChem, Incorporated

Environmental Laboratories

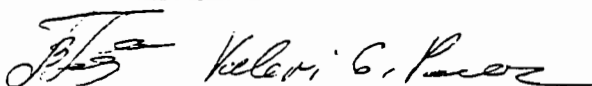
QUALITY CONTROL RESULTS

METHOD	RECOVERY	METHOD DETECTION LIMIT
TPH/gas	95 %	1.0 ppm
TPH/diesel	94 %	5.0 ppm
602		
Benzene	88 %	0.5 ppb
Toluene	82 %	
Chlorobenzene	75 %	
Ethylbenzene	79 %	
Xylenes	74 %	
1,3-Dichlorobenzene	89 %	
1,2-Dichlorobenzene	85 %	
1,4-Dichlorobenzene	80 %	

REVIEWED BY



REVIEWED BY



Report To:

RC4A

Jim CORNETTE

Bill To:

RC4A

GeoChem, Incorporated

Environmental Laboratories

2500 Gate Way Centre Blvd., Suite 300
Morrisville, NC 27560

Chain of Custody Record

PROJECT SITE NUMBER		PO#	ANALYSES		GEOCHEM PROJECT #		LAB ID # (for lab use only)		
SITE NAME		NO. OF CONTAINERS PER LOCATION	DATE AND TIME COLLECTED		DATE DUE		REMARKS		
FIELD SAMPLE ID	TURNAROUND IN DAYS	SAMPLE MATRIX	DATE	TIME	DATE	TIME	VERBAL/FAX/HARD COPY		
AS410-9 2-4	ASAP	Soil	10/25/93	0850	931007-8		142		
1 4.5-6.5	"	"	"	0900			143		
AS410-9 2-4	ASAP	Soil	10/25/93	1015			144		
1 4.5-6.5	"	"	"	1020			145		
AS410N-4	ASAP	GW	10/25/93	1200			146		
AS410N-5	"	"	"	1215			147		
AS410N-6	"	"	"	1155			148		
AS410N-7	"	"	"	1220			149		
REMARKS									
RECEIVED BY:			DATE	TIME	RELINQUISHED BY:			DATE	TIME
[Signature]			10/25/93	1:10	[Signature]			10/25/93	1:10

Report To: RCWA GeoChem, Incorporated
TIM CORNETTE Environmental Laboratories
2500 Gate Way Centre Blvd., Suite 300
Morrisville, NC 27560

Bill To: RCWA

Chain of Custody Record

PROJECT SITE NUMBER		PO#	GEOCHEM PROJECT #	
93125-1F		931007-8	9310-022m	
SITE NAME		DATE DUE		
45410		12/27/93		
COLLECTED BY (Signature)		VERBAL/FAX/HARDCOPY		
<i>David M. ...</i>				
FIELD SAMPLE ID	TURNAROUND IN DAYS	SAMPLE MATRIX	DATE AND TIME COLLECTED	LAB ID NO. (for lab use only)
1245-65	2-4	ASH	10/27/93 0900	159
142-4			0910	160
1445-65			1020	161
152-4			1030	162
1545-65			1130	163
			1140	164
REMARKS				
3550/5030				
NO. OF CONTAINERS PER LOCATION				
ANALYSES				
RELINQUISHED BY: <i>David M. ...</i>				
RECEIVED BY:	DATE	TIME	RELINQUISHED BY:	DATE
<i>...</i>	12/27/93	12:00	<i>David M. ...</i>	12/27/93

Port To: Rcd A

JIM CORNETTE

GeoChem, Incorporated

Environmental Laboratories

**2500 Gate Way Centre Blvd., Suite 300
Morrisville, NC 27560**

Bill To:

RCdA

Chain of Custody Record

PROJECT SITE NUMBER		PO#	GEOCHEM PROJECT #		
73125-F		731007-8	93016M 7310-06M		
SITE NAME		DATE DUE			
AS 410					
COLLECTED BY (Signature)					
Brad Noland					
FIELD SAMPLE ID	TURNAROUND IN DAYS	SAMPLE MATRIX	DATE AND TIME COLLECTED	LAB ID NO. (for lab use only)	
MW-B	ASAP	GW	10/21/93 1017	114	
HP-Z	"	"	10/21/93 0900	120/115	
HP-5	"	"	10/20/93 1400	116	
HP-7	"	"	10/20/93 1425	117	
RINS-1	"	TAP W	10/21/93 1320	118	
HP-10	"	GW	10/21/93 1200	119	
SA10N-4 Z-4	"	SOIL	10/21/93 1300	120	
" - " 4.5-6.5	"	"	1310	121	
SA10N-5 Z-4	"	"	1340	122	
" - 5.4.5-6.5	"	"	1348	123	
SA10N-6 Z-4	"	"	1420	124	
" - 6.4.5-5.5	"	"	1428	125	
REMARKS					
602					
3550/5737					
ANALYSES					
NO. OF CONTAINERS PER LOCATION					
RELINQUISHED BY: Brad Noland					
RECEIVED BY:		DATE	TIME	DATE	TIME
		3:50	10/21/93	10/21/93	1545

GeoChem, Incorporated

Environmental Laboratories

November 24, 1993

Mr. Jim Cornette
Richard Catlin & Assoc.
P.O. Box 10279
Wilmington, NC 28405-3755

Reference: AS410N
93125
GCI# 9311-046

FILE COPY
93125

Dear Mr. Jim Cornette:

This is the analytical report for the above referenced project. On November 11, 1993 we received ten water samples for analysis. The analytical and quality control results are presented in separate tables for your convenience. Brief summaries of analytical methods employed are as follows. GeoChem analytical reports contain information based strictly on the analysis requested on the chain of custody (COC) accompanying this report. Non-target compounds are not identified or quantified.

EPA method 602

Samples are loaded into a specially designed purging chamber at ambient temperature. Helium is bubbled through the sample. This drives the organics onto a sorbent trap. Once purging has been completed the sorbent column is rapidly heated. This efficiently transfers the organics into the gas chromatograph which separates the components of the sample. The purgeable organics are then detected using flame ionization and photo ionization detectors.

GeoChem, Incorporated

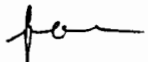
Environmental Laboratories

Metals

Metals testing entails several distinct tests. All groundwater samples are collected according to EPA Method 3030. All samples are digested in an acidic solution prior to analysis. There are several different digestion(s) performed depending on which metal(s) is (are) to be analyzed and the matrix of the sample(s). Metals such as lead and arsenic are then analyzed using a graphite furnace A.A. Many metals can be analyzed with a Flame A.A.

If there are any technical questions please feel free to call me at 919-460-8093. Thank you for allowing **GEOCHEM** to serve your analytical needs.

Sincerely,


Dean Gokel
President 

GeoChem, Incorporated

Environmental Laboratories

Geochem(NC #336/SC #99008)

Project#9311-046

1

Site Name AS410N

LAB ID.	5412	5413	5414
DATE SAMPLED	11/10/93	11/10/93	11/10/93
DATE DIGESTED	11/12/93	11/12/93	11/12/93
FIELD ID.	AS410N-8	AS410N-9	AS410N-10

METHOD

ANALYTE	mg/l	pql	mg/l	pql	mg/l	pql
RCRA Metals						
Lead	0.087	0.040	0.048	0.040	0.047	0.040

LAB ID.	5415	5416	5417
DATE SAMPLED	11/10/93	11/10/93	11/10/93
DATE DIGESTED	11/12/93	11/12/93	11/12/93
FIELD ID.	AS410N-11	AS410N-12	AS410N-13

METHOD

ANALYTE	mg/l	pql	mg/l	pql	mg/l	pql
RCRA Metals						
Lead	BQL	0.040	BQL	0.040	0.077	0.040

soil water
parts per million = mg/kg mg/l
parts per billion = ug/kg ug/l
pql = practical quantitation limit due to matrix effects.
bdl = below method detection limit.
bql = below quantitation limit.

GeoChem, Incorporated

Environmental Laboratories

Geochem(NC #336/SC #99008)
Project#9311-046

2

Site Name AS410N

LAB ID.	5418	5419	5420
DATE SAMPLED	11/10/93	11/10/93	11/10/93
DATE DIGESTED	11/12/93	11/12/93	11/12/93
FIELD ID.	AS410N-14	AS410N-15	AS410N-19

METHOD

ANALYTE	<u>mg/l</u>	<u>pql</u>	<u>mg/l</u>	<u>pql</u>	<u>mg/l</u>	<u>pql</u>
RCRA Metals						
Lead	0.098	0.040	BQL	0.040	0.078	0.040

soil water
parts per million = mg/kg mg/l
parts per billion = ug/kg ug/l
pql = practical quantitation limit due to matrix effects.
bdl = below method detection limit.
bql = below quantitation limit.

GeoChem, Incorporated

Environmental Laboratories

Geochem (NC # 336/SC # 99008)

Project#9311-046

3

Site Name AS410N

LAB ID.	5412	5413	5414
DATE SAMPLED	11/10/93	11/10/93	11/10/93
DATE ANALYZED	11/13/93	11/13/93	11/13/93
FIELD ID.	AS410N-8	AS410N-9	AS410N-10

METHOD

ANALYTE	ug/l	pql	ug/l	pql	ug/l	pql
EPA 602						
Benzene	BDL	0.5	BQL	2.5	BDL	0.5
Toluene	1.0		6.9		BDL	
Chlorobenzene	BDL		BQL		BDL	
Ethylbenzene	BDL		BQL		BDL	
Xylenes	BDL		8.5		BDL	
1,3 Dichlorobenzene	BDL		BQL		BDL	
1,4 Dichlorobenzene	BDL		BQL		BDL	
1,2 Dichlorobenzene	BDL		BQL		BDL	

LAB ID.	5415	5416	5417
DATE SAMPLED	11/10/93	11/10/93	11/10/93
DATE ANALYZED	11/13/93	11/13/93	11/13/93
FIELD ID.	AS410N-11	AS410N-12	AS410N-13

METHOD

ANALYTE	ug/l	pql	ug/l	pql	ug/l	pql
EPA 602						
Benzene	BDL	0.5	3700*	5.0	BDL	0.5
Toluene	BDL		1400		1.3	
Chlorobenzene	BDL		810		BDL	
Ethylbenzene	BDL		1500		BDL	
Xylenes	BDL		3700		BDL	
1,3 Dichlorobenzene	BDL		810		BDL	
1,4 Dichlorobenzene	BDL		840		BDL	
1,2 Dichlorobenzene	BDL		710		BDL	

soil water

parts per million = mg/kg mg/l

parts per billion = ug/kg ug/l

pql = practical quantitation limit due to matrix effects.

bdl = below method detection limit.

bql = below quantitation limit.

* = exceeds calibration curve >20%.

GeoChem, Incorporated

Environmental Laboratories

Geochem (NC # 336/SC # 99008)
Project#9311-046

4

Site Name AS410N

LAB ID.	5418	5419	5421
DATE SAMPLED	11/10/93	11/10/93	11/10/93
DATE ANALYZED	11/13/93	11/13/93	11/13/93
FIELD ID.	AS410N-14	AS410N-15	AS410N-TB

METHOD

ANALYTE	<u>ug/l</u>	<u>pql</u>	<u>ug/l</u>	<u>pql</u>	<u>ug/l</u>	<u>pql</u>
EPA 602						
Benzene	BDL	0.5	BDL	0.5	BDL	0.5
Toluene	0.5		0.7		BDL	
Chlorobenzene	BDL		BDL		BDL	
Ethylbenzene	BDL		BDL		BDL	
Xylenes	BDL		BDL		BDL	
1,3 Dichlorobenzene	BDL		BDL		BDL	
1,4 Dichlorobenzene	BDL		BDL		BDL	
1,2 Dichlorobenzene	BDL		BDL		BDL	

soil water
parts per million = mg/kg mg/l
parts per billion = ug/kg ug/l
pql = practical quantitation limit due to matrix effects.
bdl = below method detection limit.
bql = below quantitation limit.

GeoChem, Incorporated

Environmental Laboratories

QUALITY CONTROL RESULTS

METHOD	RECOVERY	METHOD DETECTION LIMIT
602		
Benzene	94 %	0.5 ppb
Toluene	92 %	
Chlorobenzene	94 %	
Ethylbenzene	91 %	
Xylenes	84 %	
1,3-Dichlorobenzene	97 %	
1,2-Dichlorobenzene	95 %	
1,4-Dichlorobenzene	91 %	
Metals (flame)		
Lead	101 %	0.040 ppm

REVIEWED BY

Aura T. Blexan

REVIEWED BY

Valerie C. Blexan

Report To: Jim Cornette

RC+A

GeoChem, Incorporated

Environmental Laboratories

2500 Gate Way Centre Blvd., Suite 300

Morrisville, NC 27560

Bill To:

RC+A

Chain of Custody Record

1118

PROJECT SITE NUMBER	93125	PO#	931110-1	ANALYSES		GEOCHEM PROJECT #	9311-046	
SITE NAME	AS410N			NO. OF CONTAINERS PER LOCATION		DATE DUE	11-26-93	
COLLECTED BY (Signature)	Matt Durlap			EPA 602 EPA 339.2		VERBAL/FAX/HARDCOPY		
FIELD SAMPLE ID	TURNAROUND IN DAYS	SAMPLE MATRIX	DATE AND TIME COLLECTED	LAB ID NO. (for lab use only)				
AS410N-8	10	H ₂ O	11-10-93 11:30	3	✓	REMARKS	5412	
" 9	"	"	" 11:30	3	✓		5413	
" 10	"	"	" 12:45	3	✓		5414	
" 11	"	"	" 12:15	3	✓		5415	
" 12	"	"	" 11:15	3	✓		5416	
" 13	"	"	" 13:15	3	✓		5417	
" 14	"	"	" 12:00	3	✓		5418	
" 15	"	"	" 12:30	3	✓		5419	
" 19	"	"	" 3:20	1	✓		5420	
" - TB	"	"	" 6:00	2	✓		5421	
REMARKS								
RECEIVED BY:	DATE	TIME	RELINQUISHED BY:	DATE	TIME	RECEIVED BY:	DATE	TIME
Joe	11/11	14:30	Bellie Walker	11/11/93	11:35	Faith Travers	11/11/93	11:35
						RELINQUISHED BY: Matt Durlap	DATE	TIME
							11-16	6:00 pm

GeoChem, Incorporated

Environmental Laboratories

FILE COPY

#93025C

November 29, 1993

Mr. Jim Cornette
Richard Catlin & Assoc.
P.O. Box 10279
Wilmington, NC 28405-3755

Reference: AS410N (weekly summary 11/21/93-11/27/93)
93125
GCI# 9311-018M

Dear Mr. Jim Cornette:

This is the analytical report for the above referenced project. On November 22, 1993 we received two soil and one water sample for analysis. The analytical and quality control results are presented in separate tables for your convenience. Brief summaries of analytical methods employed are as follows. GeoChem analytical reports contain information based strictly on the analysis requested on the chain of custody (COC) accompanying this report. Non-target compounds are not identified or quantified.

EPA method 602

Samples are loaded into a specially designed purging chamber at ambient temperature. Helium is bubbled through the sample. This drives the organics onto a sorbent trap. Once purging has been completed the sorbent column is rapidly heated. This efficiently transfers the organics into the gas chromatograph which separates the components of the sample. The purgeable organics are then detected using flame ionization and photo ionization detectors.

GeoChem, Incorporated

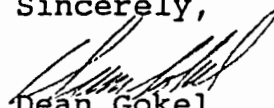
Environmental Laboratories

TPH

Samples are analyzed by following the California U.S.T. manual. This methodology incorporates EPA purge and trap (meth. 5030) techniques for analysis of volatile fuels such as gasoline. Less volatile fuels such as diesel fuel and kerosene must be extracted using solvents prior to analysis (soils are sonicated, meth. 3550). A standard calibration curve is created from the pure fuel of interest. The standards serve two functions; they create a "finger print" pattern for comparisons and they allow the chemist to calculate the concentration of that fuel analyzed for.

If there are any technical questions please feel free to call me at 919-460-8093. Thank you for allowing **GEOCHEM** to serve your analytical needs.

Sincerely,



Dean Gokel
President

GeoChem, Incorporated

Environmental Laboratories

Geochem (NC # 336/SC # 99008)

Project mobile summary 1

Site Name AS410N

LAB ID.	227
DATE SAMPLED	11/22/93
DATE ANALYZED	11/22/93
FIELD ID.	AS410N-WC

METHOD

ANALYTE	<u>ug/l</u>	<u>pql</u>

EPA 602

Benzene	5.7	0.5
Toluene	9.8	
Chlorobenzene	BDL	
Ethylbenzene	0.7	
Xylenes	0.6	
1,3 Dichlorobenzene	BDL	
1,4 Dichlorobenzene	BDL	
1,2 Dichlorobenzene	BDL	

soil water
parts per million = mg/kg mg/l
parts per billion = ug/kg ug/l
pql = practical quantitation limit due to matrix effects.
bdl = below method detection limit.
bql = below quantitation limit.

GeoChem, Incorporated

Environmental Laboratories

Geochem (NC #336/SC #99008)

Project mobile summary

2

Site Name AS410N

LAB ID.	225	226
DATE SAMPLED	11/22/93	11/22/93
DATE ANALYZED	11/22/93	11/22/93
FIELD ID.	AS410N-SC1	AS410N-SC2

METHOD

ANALYTE	mg/kg	pql	mg/kg	pql
TPH/gas	78	1.0	BQL	1.0

LAB ID.	225	226
DATE SAMPLED	11/22/93	11/22/93
DATE EXTRACTED	11/22/93	11/22/93
FIELD ID.	AS410N-SC1	AS410N-SC2

METHOD

ANALYTE	mg/kg	pql	mg/kg	pql
TPH/diesel	BDL	5.0	BDL	5.0

soil water
parts per million = mg/kg mg/l
parts per billion = ug/kg ug/l
pql = practical quantitation limit due to matrix effects.
bdl = below method detection limit.
bql = below quantitation limit.

GeoChem, Incorporated

Environmental Laboratories

QUALITY CONTROL RESULTS

METHOD	RECOVERY	METHOD DETECTION LIMIT
602		
Benzene	106 %	0.5 ppb
Toluene	109 %	
Chlorobenzene	108 %	
Ethylbenzene	108 %	
Xylenes	107 %	
1,3-Dichlorobenzene	100 %	
1,2-Dichlorobenzene	100 %	
1,4-Dichlorobenzene	101 %	
TPH/gas	82 %	1.0 ppm
TPH/diesel	87 %	5.0 ppm

REVIEWED BY

Raina Lyman

REVIEWED BY

Kevin Baker

Bill To: RC7A

Chain of Custody Record

[illegible]

GeoChem, Incorporated

Environmental Laboratories

November 30, 1993

Mr. Jim Cornette
Richard Catlin & Assoc.
P.O. Box 10279
Wilmington, NC 28405-3755

Reference: AS410N
93125
GCI# 9311-062

FILE COPY
12/1/93
#93125C

Dear Mr. Jim Cornette:

This is the analytical report for the above referenced project. On November 17, 1993 we received three water samples for analysis. The analytical and quality control results are presented in separate tables for your convenience. Brief summaries of analytical methods employed are as follows. GeoChem analytical reports contain information based strictly on the analysis requested on the chain of custody (COC) accompanying this report. Non-target compounds are not identified or quantified.

EPA method 602

Samples are loaded into a specially designed purging chamber at ambient temperature. Helium is bubbled through the sample. This drives the organics onto a sorbent trap. Once purging has been completed the sorbent column is rapidly heated. This efficiently transfers the organics into the gas chromatograph which separates the components of the sample. The purgeable organics are then detected using flame ionization and photo ionization detectors.

GeoChem, Incorporated

Environmental Laboratories

Metals

Metals testing entails several distinct tests. All groundwater samples are collected according to EPA Method 3030. All samples are digested in an acidic solution prior to analysis. There are several different digestion(s) performed depending on which metal(s) is (are) to be analyzed and the matrix of the sample(s). Metals such as lead and arsenic are then analyzed using a graphite furnace A.A. Many metals can be analyzed with a Flame A.A.

If there are any technical questions please feel free to call me at 919-460-8093. Thank you for allowing **GEOCHEM** to serve your analytical needs.

Sincerely,


Dean Gokel
President

GeoChem, Incorporated

Environmental Laboratories

Geochem (NC # 336/SC # 99008)

Project#9311-062

1

Site Name AS410N

LAB ID.	5483	5484	5485
DATE SAMPLED	11/16/93	11/16/93	11/16/93
DATE ANALYZED	11/17/93	11/17/93	11/17/93
FIELD ID.	AS410-16	AS410-17	AS410-18

METHOD

ANALYTE	<u>ug/l</u>	<u>pql</u>	<u>ug/l</u>	<u>pql</u>	<u>ug/l</u>	<u>pql</u>
EPA 602						
Benzene	1.6	0.5	0.9	0.5	BDL	0.5
Toluene	BDL		BDL		0.5	
Chlorobenzene	BDL		BDL		BDL	
Ethylbenzene	BDL		BDL		BDL	
Xylenes	BDL		BDL		BDL	
1,3 Dichlorobenzene	BDL		BDL		BDL	
1,4 Dichlorobenzene	BDL		BDL		BDL	
1,2 Dichlorobenzene	BDL		BDL		BDL	

soil water
parts per million = mg/kg mg/l
parts per billion = ug/kg ug/l
pql = practical quantitation limit due to matrix effects.
bdl = below method detection limit.
bql = below quantitation limit.

GeoChem, Incorporated

Environmental Laboratories

Geochem(NC #336/SC #99008)

Project#9311-062

2

Site Name AS410N

LAB ID.	5483
DATE SAMPLED	11/16/93
DATE DIGESTED	11/18/93
FIELD ID.	AS410-16

METHOD

ANALYTE	mg/l	pql

RCRA Metals

Lead	BQL	0.040

soil water
parts per million = mg/kg mg/l
parts per billion = ug/kg ug/l
pql = practical quantitation limit due to matrix effects.
bdl = below method detection limit.
bql = below quantitation limit.

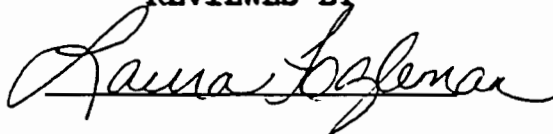
GeoChem, Incorporated

Environmental Laboratories

QUALITY CONTROL RESULTS

METHOD	RECOVERY	METHOD DETECTION LIMIT
602		
Benzene	90 %	0.5 ppb
Toluene	91 %	
Chlorobenzene	86 %	
Ethylbenzene	87 %	
Xylenes	93 %	
1,3-Dichlorobenzene	83 %	
1,2-Dichlorobenzene	92 %	
1,4-Dichlorobenzene	86 %	
Metals (flame)		
Lead	96 %	0.040 ppm

REVIEWED BY



REVIEWED BY



$R_C + A$

**2500 Gate Way Centre Blvd., Suite 300
Morrisville, NC 27560**

1124

This Chain of Custody is considered a written contract to perform the services requested in the analyses section of this document.

GeoChem, Incorporated

Environmental Laboratories

December 7, 1993

Mr. Jim Cornette
Richard Catlin & Assoc.
P.O. Box 10279
Wilmington, NC 28405-3755

RECEIVED
DATE 12/8/93

Reference: AS410N
93125
GCI# 9311-084

Dear Mr. Jim Cornette:

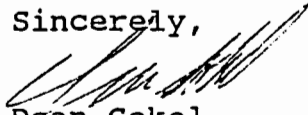
This is the analytical report for the above referenced project. On November 23, 1993 we received one soil sample for analysis. The analytical and quality control results are presented in separate tables for your convenience. Brief summaries of analytical methods employed are as follows. GeoChem analytical reports contain information based strictly on the analysis requested on the chain of custody (COC) accompanying this report. Non-target compounds are not identified or quantified.

Metals

Metals testing entails several distinct tests. All groundwater samples are collected according to EPA Method 3030. All samples are digested in an acidic solution prior to analysis. There are several different digestion(s) performed depending on which metal(s) is (are) to be analyzed and the matrix of the sample(s). Metals such as lead and arsenic are then analyzed using a graphite furnace A.A. Many metals can be analyzed with a Flame A.A.

If there are any technical questions please feel free to call me at 919-460-8093. Thank you for allowing **GEOCHEM** to serve your analytical needs.

Sincerely,


Dean Gokel
President

GeoChem, Incorporated

Environmental Laboratories

Geochem(NC #336/SC #99008)

Project#9311-084

1

Site Name AS410N

LAB ID.	5561
DATE SAMPLED	11/22/93
DATE EXTRACTED	11/29/93
FIELD ID.	AS410N-SC3

METHOD

ANALYTE	<u>mg/l</u>	<u>pql</u>

TCLP Metals

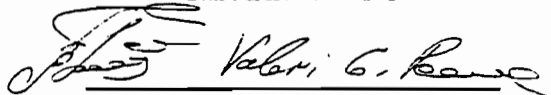
Arsenic	BQL	0.030
Barium	BQL	3.00
Cadmium	BQL	0.500
Chromium	BDL	0.500
Lead	BQL	0.500
Mercury	BQL	0.001
Selenium	BDL	0.020
Silver	BQL	0.500

soil water
parts per million = mg/kg mg/l
parts per billion = ug/kg ug/l
pql = practical quantitation limit due to matrix effects.
bdl = below method detection limit.
bql = below quantitation limit.

REVIEWED BY



REVIEWED BY



GeoChem, Incorporated
Environmental Laboratories
2500 Gate Way Centre Blvd., Suite 300
Morrisville, NC 27560

Bill To: RC+A

Chain of Custody Record

0.10

[illegible]

APPENDIX J
ANALYTICAL DATA REVIEW REPORT

Data Management-Jacksonville Lab

All GeoChem SOPs and QA Procedures are applicable to the mobile laboratory.

- 1) Chemists will run morning standards and MeCl blanks first thing every morning as normal. All blanks, calibration verifications and spikes are faxed to Raleigh as generated.
- 2) As samples are received and checked-in the corresponding Chain of Custody is faxed to the Raleigh lab immediately.
- 3) The chemists will analyze the samples as soon as possible (always on the day received unless an extraction is necessary.)
- 4) The chemists (at the Jacksonville lab) will complete the projects received as soon as possible (within 24-36 hours) and fax the summary data sheets to the Raleigh lab upon completion. The chemist may also be required to fax the results to a client if this agreement is reached between the individual client and Geochem (only acceptable if approved by Dean Gokel).
- 5) The completed project folders will be brought to Raleigh every Friday afternoon by the chemist from the mobile lab and given to Data Management in order for the hard copy of the report to be issued by the following Tuesday to the client.

Transferring Data from Jacksonville to Raleigh:

- 1) Every Friday afternoon a chemist will archive the data directories for volatiles and semivolatiles.
- 2) Then they will transfer the archived file from the volatile computer to the semivolatile computer directory C:\FER.
- 3) The chemist will then connect the modem to the semivolatile computer and exit the HP-Chem software and enter the Anywhere ver. 4.5 software used to operate the modem.
- 4) The modem will be left in the HOST mode and fully connected in order for the Raleigh lab to transfer by modem the files for the previous week to the Geochem network in Raleigh.
- 5) The files will be located in their own directory which will be accessible to the chemists and Quality Assurance Officer through the network at the Raleigh lab.
- 6) The mobile lab files will be deleted from the network just as all other files on the Geochem network every two months onto a timed backup tape which is kept by Dean Gokel (President) for at least three years.

GeoChem, Incorporated

Environmental Laboratories

QUALITY ASSURANCE PROGRAM PLAN

GENERAL QA/QC PROCEDURES FOR GEOCHEM, INC. MORRISVILLE ANALYTICAL FACILITY

Prepared by:
Steven Branch
Dean Gokel

Date January 1, 1992

Reviewed and Approved by:

Laboratory Manager

Kevin Behen

(K. Behen)

Quality Assurance
Officer

Dean Gokel

(D. Gokel)

Extraction and
Inorganic Supervisor

Steven A. Branch

(S. Branch)

GeoChem President

Dean Gokel

(D. Gokel)

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3.0 QUALITY ASSURANCE OBJECTIVES FOR MEASUREMENT DATA	5-7	12/14/90
4.0 ANALYTICAL PROCEDURES	8-10	12/14/90
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Appendix I - Tables and Figures

Appendix A - Method Detection Limits

Standard Operating Procedures referenced in this manual are under separate cover titled GeoChem, Inc. Standard Operating Procedures.

**APPENDIX I
TABLES AND FIGURES**

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1.0 INTRODUCTION

The purpose of this document is to describe the Quality Assurance Program for all analytical measurements performed by GeoChem Analytical Laboratory. This plan outlines the policies, organization, functional responsibilities, and general procedures designed to ensure that every measurement effort results in valid, defensible data of known quality. For convenience, this plan is presented in the general format prescribed for Quality Assurance Project Plans (EPA Document QAMS-005/80).

GeoChem is dedicated to maintaining a Quality Assurance/Quality Control program which will provide data of known quality with respect to accuracy, precision, completeness, comparability, and representativeness. Although the Laboratory Manager is ultimately responsible for all technical work on projects and for all aspects of the QA/QC program, this responsibility may be delegated to QA/QC Coordinators.

Due to the diversity of GeoChem's technical endeavors, there is no single, all inclusive QA/QC protocol for the various programs. Instead, GeoChem's QA/QC program consists of a centrally-administered effort, coordinated by the QA Officer. Under his direction, specific approaches are implemented for each work assignment. In formulating QA/QC strategies, GeoChem establishes specific data quality objectives for each measurement parameter. These objectives provide the framework for designing an effective QA/QC system which is responsive to the needs of the projects and contracts.

2.0 PROJECT ORGANIZATION AND RESPONSIBILITY

GeoChem's overall system for generating data of high quality involves integrating both QA and QC activities which may include:

- proper specification of program objectives,
- sufficient analytical performance to meet the program's objectives,
- inspection of resulting product to determine if specifications are met, and
- review of activities to provide for any necessary specification changes.

As the delegated manager of the GeoChem QA program, all efforts expended by the QA Officer are defined as QA functions.

2.1 LABORATORY MANAGER

Lab personnel and office management are responsible for organizing, managing, and directing the project's technical activities as well as for presenting data to the client. Therefore, the Laboratory Manager is ultimately responsible for development, implementation, and documentation of all aspects of the QC program to ensure that data quality objectives are met. For effective management, this responsibility may be shared with designated QC coordinators for specific technical areas and involve day-to-day interactions with the technical staff.

The Laboratory Manager has both QA and QC responsibilities. He has the overall responsibility for managing the GeoChem QA Program by coordination with the QA Officer. The Laboratory Manager makes the final decision(s) on QA related matters.

2.2 QA OFFICER

The QA Officer is responsible for the supervising of QA activities in all phases of analysis, including test/QA plan design, execution, data reduction, and reporting. Thus, he/she is the one who ensures that the overall QC system is operating effectively. Some activities that the QA Officer may perform include:

- (1) coordinating preparation of the Quality Assurance Project Plan which documents the project-specific policies, organization, objectives, functional activities, and specific QA/QC procedures to achieve data quality goals or requirements;
- (2) conducting an independent performance assessment through QA audits;
- (3) reviewing data packages and/or deliverables leaving the lab;
- (4) providing a mechanism whereby quality problems may be brought to the attention of the management and assisting in implementing corrective action;
- (5) documenting results of all QA/QC activities in reports to GeoChem Management and to clients;
- (6) evaluating all external audit reports;
- (7) implementing and approving GeoChem Standard Operating Procedures (SOP's);
- (8) maintaining a master listing of available GeoChem SOP's;
- (9) recommending QA policy changes to the GeoChem Laboratory Manager; and
- (10) revising the GeoChem QA Program Plan as required.

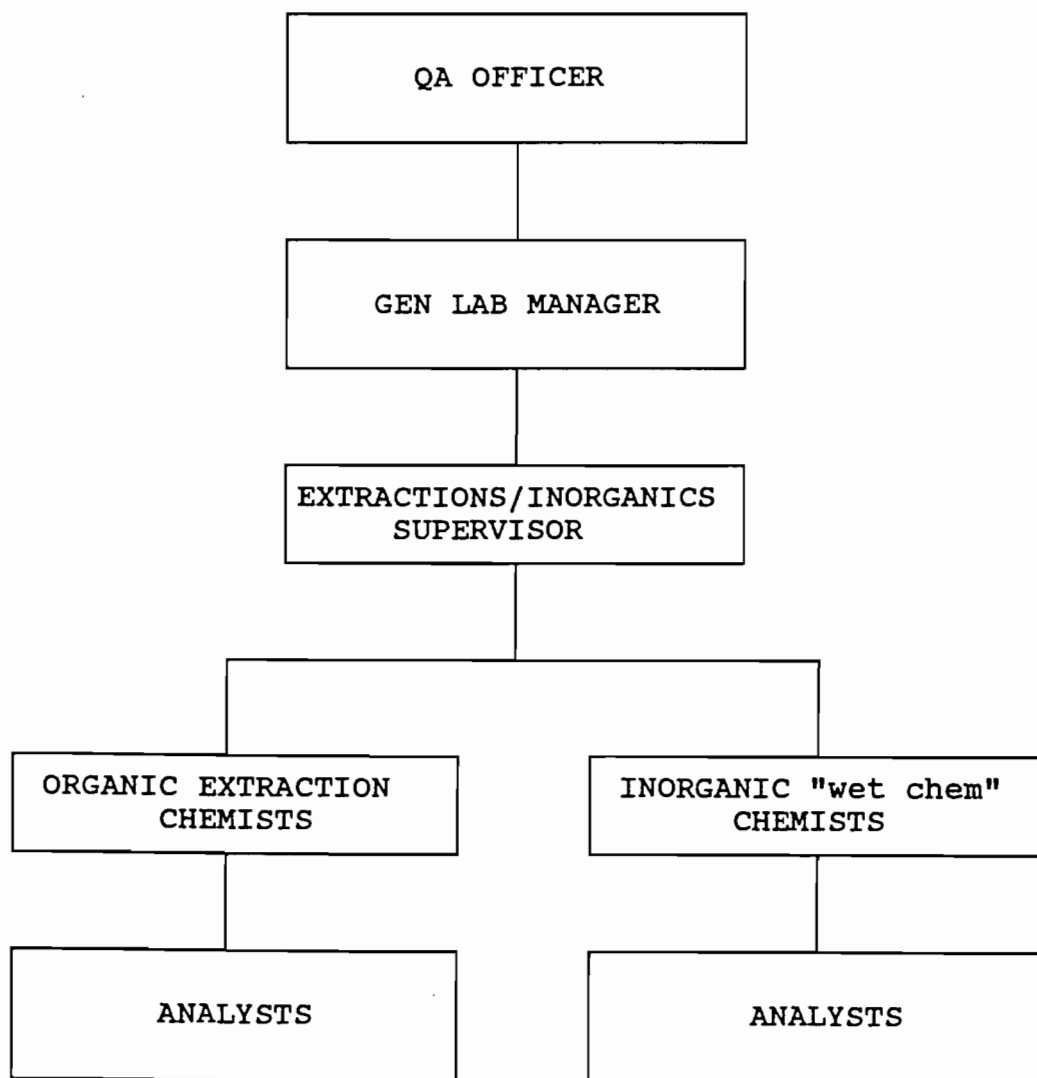


Figure 2.1. Data Quality Program Organization.

3.0 QUALITY ASSURANCE OBJECTIVES FOR MEASUREMENT DATA

GeoChem's corporate comprehensive QA/QC program is designed to assure the accuracy and validity of data collected in all areas of environmental measurements. The primary objective of the QA/QC program is to provide data of known quality with respect to:

- accuracy,
- precision;
- completeness,
- representativeness, and
- comparability.

These data quality indicators are defined as follows:

Accuracy - degree of agreement of a measurement (or an average of measurements of the same thing), X , with an accepted reference or true value, T , usually expressed as the difference between the two values, $X-T$, or the difference as a percentage of the reference or true value, $100 (X-T)/T$, and sometimes expressed as a ratio, X/T . Accuracy is a measure of the bias in a system.

Precision - a measure of mutual agreement among individual measurements of the same property, usually under prescribed similar conditions. Precision is best expressed in terms of the standard deviation. Various measures of precision exist depending upon the "prescribed similar conditions."

Completeness - a measure of the amount of valid data obtained from a measurement system compared to the amount that was required to be able to meet specified objectives.

Representativeness - the degree to which data accurately and precisely represent a characteristic of a population, parameter variations at a sampling point, a process condition, or an environmental condition.

Comparability - the confidence with which one data set can be compared to another.

The QA/QC effort for each GeoChem contract is tailored for (1) the nature of the services provided, (2) the client's needs, and (3) the technical objectives of the project. For measurement programs which require routine analyses using standard methods, the QA/QC approach focuses heavily on the control of measurement data quality within the established acceptance limits. However, when programs require the validation or use of a new or modified measurement technique, the QA/QC effort emphasizes the assessment of the method including evaluation and data validation.

When formulating QA/QC strategies, GeoChem establishes specific data quality objectives for each measurement parameter. Table 3-1 is an example summary of several QA objectives for a field testing program. Included are typical objectives for precision, accuracy, and completeness of the measurement data.

All analytical measurements are made so that results are representative of the media and conditions being measured. Unless otherwise specified, all data are reported in units consistent with other organizations reporting similar data so that data bases may be compared at some future time.

TABLE 3-1. EXAMPLE SUMMARY OF QA OBJECTIVES FOR DATA PRECISION, ACCURACY, AND COMPLETENESS

		Precision (%)	Accuracy (%)	Completeness (%)
Method 602 (BTEX)	Benzene	+/- 5	+/- 8	90
	Toluene	+/- 6	+/- 3	95
	Ethylbenzene	+/- 3	+/- 5	98
	Total Xylenes	+/- 7	+/- 6	98

$$\text{Accuracy} = \frac{\text{Measured Value} - \text{Actual Value}}{\text{Actual Value}} \times 100\%$$

$$\text{Precision} = \frac{\text{Standard Deviation}}{\text{Mean}} \times 100\%$$

Valid data percentage of total tests conducted.

4.0 ANALYTICAL PROCEDURES

GeoChem maintains state-of-the-art analytical facilities which are responsive to a wide variety of environmental measurement programs and applications. Standard reference methods (EPA, ASTM, or NIOSH) are used whenever possible so that measurement data may be compared. Routine analytical procedures are discussed below.

4.1 REAGENTS AND SOLVENTS

For most inorganic analyses, analytical reagent (AR) grade chemicals are used. For other analyses such as trace metals and trace organics, special ultra pure reagents are required. Whenever available, lot analyses of chemicals being purchased are requested by the purchaser and kept on file at the GeoChem laboratory. As a control check, all untested reagents are checked for background contaminants. Additionally, a method blank and standard are prepared and analyzed using both the new and old reagents for comparison. If the new reagent is found to contain interfering substances, the reagent is replaced or purified before use.

All chemical or reagent containers are labeled to indicate the date of receipt and expiration date. Out-of-date reagents are discarded. Chemical/reagent inventories are maintained on a first-in, first-out basis. Reagents and solvents are stored according to the manufacturer's instructions. Light sensitive materials are stored in dark bottles and in a dark place. Labile reagents are stored in refrigerator or freezers, as required, to prevent deterioration or evaporation.

4.2 CHEMICAL STANDARDS

Reagents certified as traceable to the National Bureau of Standards (NBS) are used as primary standards, whenever available. Alternately, standards are prepared from analytical grade chemicals and standardized with NBS standards, if available. In either case, the purity of standards is measured and documented. The EPA quality control standards are used for comparison with internally prepared standards whenever applicable.

All standards purchased for atomic absorption and emission spectroscopy are certified as spectroquality by the vendor. Ultrapure nitric and hydrochloric acids, used to stabilize trace metal standards and to digest samples, may also be prepared by distillation in borosilicate glass.

Organic compounds used as reference standards are assayed and/or purified to meet the required 98 percent or higher purity. Stock solutions of these reference materials are prepared in high-boiling, inert solvent, if possible, to minimize errors due to evaporation or solvent induced decomposition.

4.3 STANDARD OPERATING PROCEDURES

GeoChem Standard Operating Procedures (SOP's) are documented methods for performing certain routine or repetitive tasks, see the Appendix for detailed discussions on each. These tasks involve such operations as instrument or method calibrations, preventive and corrective maintenance, internal quality control, and data reduction and analysis. The format presented in Table 4-1 for GeoChem SOP's is used throughout the laboratory to ensure uniform formatting for easy use and understanding by any user within the laboratory. The SOP's are prepared in document control format and are maintained on file by the QA Officer, the Laboratory Supervisors, and the Laboratory Managers.

4.4 GLASS CLEANING PROCEDURES

The general procedures used by the GeoChem Laboratory for cleaning all glassware are discussed in detail in Appendix II, Standard Glassware Cleaning Procedures (SOP 102).

TABLE 4-1. STANDARD FORMAT FOR GEOCHEM SOPs

Section Number	Title	Items to be Included
1.0	Purpose	Purpose of SOP, scope of procedure, applicability of procedure.
2.0	Apparatus & Materials,	Equipment, instrumentation & expendable materials.
3.0	Reagents	Reagents and standards.
4.0	Procedure	Detailed, step-by-step procedure, with sufficient detail to permit two or more people with an appropriate technical background, without additional information or guidance, to perform the procedure in the same manner and produce virtually identical products or results.
5.0	Documentation	Specific documentation requirements, recommended formats, standardized forms, data sheets, etc.
6.0	Quality Control	Analytical QC procedures (e.g., spikes, blanks, duplicates, etc.), cross-check against reference standards.
7.0	Review and Validation	Review procedures and responsibilities, validation procedures and responsibilities.

5.0 SAMPLE CUSTODY PROCEDURES

A stringent chain-of-custody system is important in assuring the future usefulness of measurement data. A documented, traceable link between any given measurement and the sample and parameter which it is reported to represent are necessary. The chain-of-custody system provides a definitive link between the program results (i.e. data output) and the measurement parameters involved. This documented history represents a legally acceptable record which covers all aspects of the presampling preparation, sample collection, post-sampling handling, storage, and analysis process. This record will originate with the preparation of any sample containers which are used and will indicate "who did what and when" until final disposition of the sample. The custody procedures used will also provide assurance that the integrity of the sample is maintained throughout the course of the collection, handling, and analysis process, i.e. that there is no opportunity for inadvertent contamination, etc.

The types of documentation which are typically associated with environmental measurement programs include:

- dated instrument hardcopy (e.g. strip chart records, chromatograms, etc.);
- field data sheets;
- field notes, dated and initialed;
- analytical data sheets;
- "raw" analytical data, dated and initialed;
- summary data sheets;
- sample logbooks;
- records of maintenance activities;
- records of equipment and apparatus calibration;
- records of audit activities;
- chain-of-custody records; and
- records of deviations from and/or modifications to any measurement protocol.

While all of the above types of documentation together comprise a record of the measurement process, some aspects of this recordkeeping process are discussed in the following sections of this document.

5.1 TRANSFER OF CUSTODY FROM FIELD TO LABORATORY (fig 5.1)

All sample shipments are conveyed to GeoChem's analytical laboratory following the protocol below:

- (1) All samples are accompanied by the original chain-of-custody forms which are signed and dated by the transferor and transferee.
- (2) The field sampler is responsible for packaging and dispatching samples to the analytical laboratory. The sampler also retains a copy of all chain-of-custody sheets.
- (3) All post office receipts and bills of lading are retained as part of the permanent chain-of-custody documentation.
- (4) Upon receipt at GeoChem's analytical laboratory, all samples are placed in the proper storage area.

5.2 ANALYTICAL LABORATORY CUSTODY (fig 5.2)

The following custody procedures are adhered to for all samples received by GeoChem's analytical laboratory:

- (1) All incoming sample custody sheets are received, signed and filed by the designated sample custodian.
- (2) Upon receipt, all samples are cross-checked with their enclosed chain-of-custody sheets, and checked for damage and/or leaks. Any abnormalities are documented and immediately brought to the attention of the Quality Assurance Officer.
- (3) The sample custodian ensures that all samples are properly logged into the laboratory's master sample log and computerized sample tracking system immediately upon receipt.
- (4) All samples are stored in a clean, dry, isolated storage room or refrigerator.
- (5) Samples are handled by the minimum number of persons possible.

- (6) All pertinent information associated with each sample analysis is recorded by the analyst in his designated laboratory notebook. Entries are signed and dated by the analyst. Sample travelers are filled out to accompany sample through laboratory.
- (7) Following sample analyses, remaining sample portions are retained in their designated storage area until sample disposal, or upon return to the customer.

All laboratory personnel are responsible for the care and custody of samples received by the laboratory. The laboratory area is maintained as a secured area restricted at all times to authorized personnel.

5.4 COMPUTERIZED PROJECT, SAMPLE AND ANALYSIS TRACKING SYSTEM (fig 5.3)

GeoChem's analytical laboratory has a computer system designed to track and handle information generated by an analytical chemistry laboratory. This system is able to track and control samples by the following basis:

- (1) GCI project numbering system; year month -sequential project for that month. Each month starts - 001.
Example: 9010-001, the first report for Oct. 1990.
- (2) Analysis requested for each sample.
- (3) Sample numbering; chronological numbering up to 9999.
Once up to 9999 for a year, count restarts at 0001.
Each sample number also contains matrix indicated on the chain-of-custody. Example: 2000 soil.
- (4) Earliest hold time expiration date.
- (5) Date project is required to be completed.

All samples received at GeoChem will be immediately logged into the system.

(A)	(B)	(C)	(D)	(E)	(F)
Date Receive	GCI #	Site Identification	GCI Sample #	Matrix	Due Date
4-7-90	9004-008		0110	water	4-20-90
4-11-90	9004-009		0111-0114	water	5-1-90
4-11-90	9004-010		0115	air	5-1-90
4-19-90	9004-023		0165-0168	soil	5-2-90

- (A) Date that sample was received with completed chain-of-custody. Log book and samples are color coded by month.
- (B) Project number assigned by GeoChem for tracking purposes in the laboratory.
- (C) Origin of samples taken from chain-of custody including client firm requesting work to be performed.
- (D) Laboratory sample number in a sequential numbering system providing a "blind analysis" for lab personnel. Samples are also color coded for ease in sample location in refrigerators.
- (E) Physical classification of sample for tracking.
- (F) Data that data and complete report due.

Figure 5.2 GeoChem Master Logbook

(A)	(B)	(C)	(D)	(E)
Project	Analysis	Lab # soil/water	Date Collected	Due
9011-060	btex, mtbe	2000 water	11-21-90	12-13-90
9011-060	fuel #2	2000 water	11-21-90	12-13-90
9011-062	fuel oil	2012 soil	11-21-90	12-13-90
9011-062	pH	2012 soil	11-21-90	12-13-90
9011-062	tclp metals	2012 soil	11-21-90	12-13-90
9011-063	gas	2013 soil	11-21-90	12-13-90

- (A) Project number assigned to chain-of-custody when samples are received.
- (B) Method of analysis to be performed on sample.
- (C) Laboratory sample number assigned to sample when checked in and physical classification of sample.
- (D) Date that samples were collected.
- (E) Date that completed written report is due to client.

Figure 5.3 GeoChem Computerized
Sample Tracking Sheet

6.0 CALIBRATION PROCEDURES

Information is presented in this section pertaining to the calibration of the analytical systems. Included is a description of typical procedures or a reference to applicable standard operating procedures.

6.1 ANALYTICAL CALIBRATION PROCEDURES

Calibration of an analytical system involves systematic quantitation of the system response to an accepted reference standard for the analyte of interest. The calibration procedures and standards used directly influence the validity of the resulting measurement data. Most standard analytical methods, including EPA, ASTM, and NIOSH methods, specify specific calibration procedures and/or requirements. These standard procedures are followed whenever applicable. When circumstances dictate the use of alternate procedures, or when an analytical technique is used for which there is no single set of "accepted" calibration procedures, a calibration protocol is devised and documented prior to initiation of sample analyses. Detailed calibration procedures are typically documented in a test plan and/or in a Quality Assurance Project Plan.

6.2 TYPICAL INSTRUMENT CALIBRATION TECHNIQUES

The most common type of calibration for analytical instrumentation is some form of multipoint calibration. The multipoint calibration effectively establishes the working range of the method. In order to carry out a regression analysis consistent with a linear function, several different concentrations of the calibration standards should be measured (in duplicate or triplicate for some types of analyses). The concentrations chosen should bracket the expected concentration of the analyte in the field sample. The lowest standard should be at or near the limit of quantitation of the analytical method, and the highest standard usually should have a concentration 10 to 20 times that of the lowest standard.

The data set generated by a multipoint instrument calibration may consist of pairs of values for the calibration concentrations (plotted as X_i) and the instrument responses (Y_i). These data pairs can be plotted and inspected visually for linearity and subsequently analyzed by linear regression techniques. The measured net signal, Y , should be a linear function

of the analyte concentration. The equation of the resulting straight line can be expressed as $Y = mX + b$, where m is the slope of the line and b the intercept of the Y axis.

After the calibration curve is plotted and observed to be reasonably linear, the correlation coefficient, slope, and intercept can be calculated, using the method of least squares linear regression analysis. The resulting equation is used to calculate the concentrations of the analyte in the samples analyzed.

The relative variability of analytical measurements decreases as the analyte concentration increases. The three regions of reliability, listed in order of increasing reliability, are the regions of uncertain detection, of detection, and of quantitation.

The limit of detection (LOD) is the lowest concentration of an analyte that the analytical process can reliably detect. The LOD in instrumental methods is based on the relationship between the net signal S_x , resulting from the presence of analyte x , and the variability of the field blank. S_x , in turn, is the difference between the total or gross signal S_t and the blank signal S_b . $S_x = S_t - S_b$.

If field blanks are not available, or if a single sample is being analyzed for which there are no field blank data, then the limit of detection is based on the peak-to-peak noise (), measured on the base line closest to the analyte peak.

The limit of detection can be defined in terms of the extent to which the gross signal S_t exceeds the field blank signal S_b .

$$S_x = S_t - S_b > K_b$$

where

As the analyte signal increases, the numerical significance of the apparent analyte concentration also increases, until, at some point clearly above the LOD, the limit of quantitation (LOQ) is reached. The LOQ can be defined by the expression:

$$S_t - S_b > K_q$$

GeoChem generally uses minimum values of $K_b = 3$ and $K_q = 10$, as recommended by the ACS Committee on Environmental Improvement. Thus, the LOD is located at 3 and the LOQ at 10 above the gross blank signal S_b .

Signals below 3 should be reported as below detection limit (BDL) with the limit of detection given in parenthesis. Signals in the region of detection between 3 and 10 should be measured and reported as "detected" or with an approximate concentration, e.g., "0.1 ppm".

7.0 DATA REDUCTION, VALIDATION, AND REPORTING

7.1 DATA REDUCTION

Typically, raw data reduction responsibilities fall upon those who collect or generate the data. The person who performs the analysis usually reduces the raw analytical data to units of concentration at the time of analysis.

Following initial data reduction, data summaries are prepared by the analyst. These data summaries then may be used in the reporting task.

7.2 DATA VALIDATION

Measurement data are typically validated based upon representative process conditions during testing procedures, consistency with expected and/or other results, adherence to prescribed QC procedures, and the specific acceptance criteria. The calibration procedures section and the internal quality control checks section of the applicable Quality Assurance Project Plan define limits of acceptability for calibrations and routine QC procedures (e.g. control samples, replicate analyses, etc.).

Identification of outliers is also a part of the data validation process. An outlier is an unusually large (or small) value in a set of observations. There are many possible reasons for outliers. Among them are:

- faulty instrument or component;
- inaccurate reading of a record, dial, etc.;
- error in transcribing data; or
- calculational errors.

Sometimes analysts or operators can identify outliers by noting the above types of occurrences when they record observations. These faulty observations may then be removed from the data set before it is summarized.

7.3 REPORTING

Written reports are generated in two basic manners. The first type are general correspondence, proposals, form letters etc. The second type of report is generated by GeoChem technical report staff. These people possess the skills required to perform the analytical tests they are reporting. This technical background minimizes reporting errors as far as units, decimal placement etc.

Internal laboratory documentation is vital to defensible data. Permanent laboratory notebooks and laboratory tracking sheets provide the documentation necessary to trace every thing done to a particular sample. Laboratory tracking sheets are filled out for each parameter being tested, these physically accompany the sample throughout the laboratory. Laboratory notebooks serve as permanent records of what has happened in the laboratory, there are separate notebooks for each lab function. See figures 7.1 through 7.8 for inspection of each.

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SAMPLE WORKSHEET FOR MASS SPEC

GeoChem Lab No. _____ Analyst _____

Field ID No. _____ Extraction Solvent _____

Date Extracted _____

Sample Size _____ grams

Surrogate Spike:

Volume Acid _____ mL Volume B/N _____ mL

Compound(s)/Concentration of Spiking Solution _____

Fractions: Solvent/Final Volume

(1) _____ / _____ Sample in Notebook # _____

(2) _____ / _____

(3) _____ / _____ Notebook Page(s) _____

(4) _____ / _____

(5) _____ / _____

Comments: _____

File No. _____ Date Injected ____/____/____ Analyst _____

Sample Dilution: _____ mL diluted to _____ mL

Internal Standard: Phenanthrene-d₁₀ Other _____

Concentration, ug/mL 20, 50, Other _____

Comments: _____

Figure 7.1 Sample Tracking Form GC/MS.

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SAMPLE WORK SHEET FOR GC

SAMPLE ID

EXTRACTION DATE

GC RUN #

FINAL VOLUME

INITIAL SAMPLE AMOUNT

SPIKE GC RUN #

EXTRACTION METHOD

LIQUID/LIQUID

SONICATION

PURGE & TRAP

MICRO-VOLATILE

NOTES/CALCULATIONS

Figure 7.2 Sample Tracking Form - GC.

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(A)	(B)	(C)	(D)	(E)	(F)
Date	GCI #	Sample ID(s)	Matrix	Extracted	Spike
1/20/90	9011-085	1975-1977	soil	SB	SB
	9011-086	1991, 1992	water	SB	-
1/21/90	9011-088	2010-2018	soil	SB	SB
	9011-090	2036	water	SB	-
	9011-093	2055, 2057	water	SB	SB
Supervisor's approval (signed and dated)					

- (A) Date sample was extracted.
- (B) Project number obtained from Sample Tracking Sheet.
- (C) Laboratory sample number assigned when sample was checked in.
- (D) Physical classification of sample.
- (E) Person performing extraction.
- (F) Person responsible for placing spike in sample.

Figure 7.3 GeoChem Extraction Log Book.

(A)	(B)	(C)	(E)	(F)
9011-085	Soil Sample for 3550 Method	11-21-90		
(D) 1975	<u>initial wt.</u> 50.32 g	<u>Na₂SO₄ wt.</u> 25.11 g	<u>final vol.</u> 2.0 mL	
1976	49.78 g	28.34 g	2.0 mL	
1977	50.16 g	30.01 g	2.0 mL	
matrix spike1976 2.0 ul of 15.2 ug/ul GC-50	50.08 g	27.85 g	2.0 mL	SRB
9011-086	Water Samples for 610 Analysis	11-21-90		
1991	<u>initial vol.</u> 995 mL	<u>final vol.</u> 2.0 mL		
1992	1000 mL	2.0 mL		SRB

- (A) Project number obtained from Sample Tracking Sheet.
- (B) Method that was used to extract sample.
- (C) Date that extraction was performed.
- (D) Laboratory sample number assigned when sample was checked in.
- (E) Raw data recorded during extraction.
- (F) Person performing extraction.

Figure 7.4 GeoChem Organic
Chemistry Notebook.

11-18-90

Performed pH measurement on following samples, after calibration of pH meter with buffers 7.00 +/- 0.01 and 10.00 +/- 0.01.

2048 pH 6.74

2049 pH 5.32

2050 pH 7.04

SRB

Performed fluoride ion analysis on following samples, after calibration of fluoride ion selective electrode with NaF standard prepared 11-16-90.

2150 1.74 ppm

2151 0.91 ppm

2153 1.32 ppm

SRB

(A) Date	(B) Run #	(C) Auto Sample	(D) Sample ID	(E) Notes	(F) Method	(G)	(H)
12/8/90	768	1	2232		TPH-diesel	2uL	BAM
12/8/90	769	2	2233		TPH-diesel	2uL	BAM
12/8/90	770	3	2234		TPH-diesel	2uL	BAM
12/8/90	771	4	2235	1:20 dilution	TPH-diesel	2uL	BAM
12/8/90	772	5	2236		TPH-diesel	2uL	BAM
12/8/90	773	6	2237		TPH-diesel	2uL	BAM

- (A) Date injection of sample was performed.
- (B) Chronological numbering of instrument runs including standards and blanks.
- (C) Position sample was located in run sequence.
- (D) Laboratory sample number assigned when sample was checked in.
- (E) Notes of any abnormalities or observations.
- (F) Method of analysis for sample.
- (G) The amount of sample that was injected.
- (H) Analyst performing sample injection.

Figure 7.6. GeoChem GC injection log.

GC-8 BTEX STOCK @ 10,000 ng/ul
To a 10 ml volumetric flask, added

Benzene d=0.874 added 114.4 ul
Toluene d= 0.867 added 115.3 ul
Ethylbenzene d= 0.867 added 115.3 ul
m-xylene d= 0.866 added 115.2 ul

diluted to volume with methanol

GC-21 BTEX STANDARD @ 50.0 ng/ul
To a 5 ml volumetric flask added

25 ul of GC-8

diluted to volume with methanol

Figure 7.7 GeoChem Organic Standards Prep
Notebook.

(A) Sodium Fluoride stock solution 11-16-90 (C)
(B) [221.0 mg of NaF lot # _____
dissolved in 1.0 L reagent water lot # _____
1.00 mL = 100 ug F⁻

Sodium Fluoride standard solution
Diluted 100 mL of stock NaF
to 1.0 L with reagent water lot # _____
1.00 mL = 10.0 ug F⁻

SRB (D)

(1.0 N) Sodium hydroxide 11-18-90
Dissolved 40.0 g NaOH lot # _____
in 1.0 L of reagent water lot # _____
SRB

(E) _____ Supervisor's Approval
(signed and dated)

- (A) Description of solution that was prepared.
- (B) Solution which was prepared.
- (C) Raw data including weights, total volume and lot numbers.
- (D) Person who prepared solution.
- (E) Immediate supervisor of analyst preparing solution.

8.0 INTERNAL QUALITY CONTROL CHECKS

An internal quality control (QC) system is a set of routine internal procedures for measuring and defining the quality of the data output. A well-defined QC program must be capable of controlling and measuring the quality of the data in terms of precision and accuracy. Precision reflects the influence of the inherent variability in any measurement system. Accuracy reflects the degree to which the measured value represents the actual or "true" value for a given parameter, and includes elements of both bias and precision.

Generally, internal QC procedures fall into two categories:

- (1) control of data quality, and
- (2) quantitative assessment of data quality.

Each assesses data in terms of precision, accuracy, and completeness. Some internal QC procedures, by their nature, fall into both categories.

8.1 TYPES OF SAMPLES USED TO CONTROL AND ASSESS DATA QUALITY

The types of samples which are most often used for both control and assessment of data quality are defined below.

8.1.1 Replicates

A replicate is a sample which has been divided into aliquots (in the field or preparation laboratory) and is carried through the analytical process at different times, by different people and/or using different instruments.

8.1.2 Blanks

8.1.2.A Field Blank. A blank sample has been carried to the sampling site and exposed to sampling conditions (bottle caps removed, etc.), sample preparation, and the measurement system.

8.1.2.B Instrument Blank. The signal derived from a measurement device when no materials other than those normally in the instrument are present while the instrument is cycled through the measurement sequence, i.e., baseline instrument signal level.

8.1.2.C Method Blank. A "clean" sample which has been carried through all steps of the analytical procedures using all reagents, glassware, and equipment used for preparation and measurement.

8.1.2.D Reagent Blank. A sample of chemical reagent used in sample preparation analyzed for contamination.

8.1.2.E Trip Blank. A blank sample which has been carried to the sampling site and transported to the analysis laboratory without being exposed to sampling conditions.

8.1.3 Check Standards

Most methods call for control or check standard analyses at prescribed intervals to verify that the standard curve remains in effect. The standard curve is the result of standardization and is usually presented in the form of an equation or a graph of target parameter versus instrument output.

8.1.4 Matrix Spikes

A matrix spike is a sample which has been spiked in either the field or the laboratory with a known amount of target parameters in order to determine the recovery efficiency of the analytical method and to estimate matrix effects.

8.1.5 Audit Spikes

A sample which contains known quantities of target parameters and is presented to the analytical laboratory disguised as a field sample.

8.1.6 Surrogates

A non-target parameter added to all samples in order to estimate recovery of target parameters. Surrogates are usually compounds which are not normally expected in the matrix being analyzed, but which are expected to mimic target parameters in the analytical method.

8.2 ADDITIONAL DATA QUALITY CONTROL PROCEDURES

The control procedures or checks discussed previously are quantitative. However, other types of QC checks exist which are more qualitative than quantitative. Strict adherence to prescribed measurement protocols falls into this category. Examples of qualitative QC checks include:

- training of personnel,
- preventive maintenance procedures,
- strict calibration procedures,
- strict documentation procedures,
- use of formatted data worksheets,
- strict adherence to Standard Operating Procedures (SOP's),
- consistent data reduction procedures,
- adequate statistical data evaluation, and
- careful data review and validation.

The procedures listed above are often the most important QC checks in terms of overall impact on measurement data quality.

9.0 PERFORMANCE AND SYSTEMS AUDITS

A quality assurance (QA) audit is an independent assessment of a measurement system which typically includes

- (1) a performance audit, and,
- (2) a systems audit.

The performance audit consists of independently obtaining quantitative data for comparison with routinely obtained data in the measurement system. The performance evaluation is quantitative and is conducted using apparatus and/or standards that are independent of those used for the project. The systems audit is qualitative and consists of an on-site review of a laboratory quality assurance system.

9.1 THE QA OFFICER

The QA Officer designs and may also perform QA performance and systems audits. It is especially important to be able to identify which components of the system are critical to overall data quality. The auditor's technical background and experience should also provide a basis for appropriate audit standard selection, audit design, and data interpretation.

9.2 AUDIT ACTIVITIES

9.2.1 Systems Audit

Generally, the auditor observes and documents the overall procedures and techniques used in the various measurement efforts. This may include a check of the following procedures:

- (1) calibration documentation,
- (2) adherence to prescribed QC (including SOPs),
- (3) document control,
- (4) data validation and review,
- (5) data storage and filing,
- (6) sample logging,
- (7) sample custody, and
- (8) equipment maintenance.

Checklists which delineate the critical aspects of each methodology are used by the GeoChem auditor during the audit to document all observations.

9.2.2 Performance Audit

Although the systems audit is a qualitative evaluation, the performance audit represents a quantitative assessment of the data quality. Audit standards and test equipment which are traceable to acceptable reference standards are used to assess the performance of each analytical method and/or measurement device. If properly designed, they provide a direct, point-in-time evaluation of the accuracy of the various measurement systems. The key functions of a QA performance audit are to:

- (1) challenge the various measurement systems with audit standards,
- (2) assess the overall data quality, and
- (3) identify and correct any weaknesses in the analytical approach.

9.3 QA AUDIT REPORTS

Upon completion of the audit, the auditor discusses any specific weaknesses with office management and makes recommendations for corrective action. This report outlines the audit approach and presents a summary of results and recommendations.

10.0 PREVENTIVE MAINTENANCE

The primary objective of a comprehensive preventive maintenance program is to help ensure the timely and effective completion of a measurement effort. GeoChem's preventive maintenance program is designed to minimize the down time of crucial sampling and/or analytical equipment due to component failure. Preventive maintenance efforts focus on:

- maintenance responsibilities, and
- maintenance schedules for major and/or critical instrumentation and apparatus.

Each is discussed in detail in the following sections.

10.1 MAINTENANCE RESPONSIBILITIES

Maintenance responsibilities for the laboratory are assigned to the respective laboratory supervisor who then establishes maintenance procedures and schedules for each major piece of equipment. Maintenance responsibilities for as-needed equipment are coordinated through the laboratory manager.

10.2 MAINTENANCE SCHEDULES

The effectiveness of any maintenance program depends to a large extent on adherence to specific maintenance schedules for each major piece of equipment. A schedule is established for all routine maintenance activities. Other maintenance activities are identified on an as-needed basis. Manufacturer's recommendations provide the primary basis for establishing maintenance schedules. Maintenance activities are documented in a maintenance log which indicates the required maintenance frequency and provides for dated entries. An example of a maintenance log format is shown in Figure 11-1.

12-15-90

Changed UHP Helium (He) gas cylinder with
full cylinder. KJB

Replaced DB-624 column in gasoline GC with
new 30 m DB-624 column. KJB

Replaced septa on Diesel GC before analysis
of diesel standard. KJB

Figure 10.1. Example Maintenance Log.

11.0 ASSESSMENT OF DATA PRECISION, ACCURACY, AND COMPLETENESS

Performance audits and QC analyses conducted during an environmental measurement program are designed to provide a quantitative assessment of the data. Two aspects of data quality which are of primary concern are precision and accuracy. As explained in Section 9, precision is a measure of the variability associated with the measurement system. Accuracy reflects the degree to which the measured value represents the actual or "true" value for a given parameter, and includes elements of both bias and precision. Completeness of the data is typically evaluated based upon the valid data percentage of the total number of tests conducted. Each of these aspects of data quality is discussed in the following sections.

11.1 PRECISION

Precision, by the definition presented in the EPA Quality Assurance Handbook for Air Pollution Measurement Systems, Volume I, Principles (EPA-600/9-76-005), is "a measure of mutual agreement among individual measurements of the same property, usually under prescribed similar conditions." Different measures of precision exist, depending upon these "prescribed similar conditions." GeoChem typically uses the EPA definitions for replicability, repeatability, and reproducibility, taken from the EPA Quality Assurance Handbook referred to above.

Quality control procedures, such as control sample analyses and replicate analyses are the primary mechanism for evaluating measurement data variability, or precision. Replicate analyses are used to define analytical replicability, while results for replicate analyses may be used to define the total variability (replicability) of the sampling/analytical system as a whole. Control sample analyses are typically used to measure day-to-day variability, or repeatability. Reproducibility data consist primarily of results from interlaboratory comparisons and/or method comparisons. Using special techniques such as nested sampling and analysis design and analysis of variance techniques, the relative influence of different sources of variability may be individually measured. (Nested designs are designs in which some factors (i.e., variability sources) are subsamples of other factors.)

11.1.1 Measures of Dispersion/Variability

Two commonly used summary statistics for measuring dispersion or variability are the standard deviation and the range.

11.1.1.A Standard Deviation. The standard deviation is a measure of the average distance of individual observations from the mean. It is usually denoted s and defined as:

where n is the sample size,
 X_i is the i th observation in the sample, and
 $\bar{X}$ is the sample mean.

11.1.1.B Range. The range is the largest observation in a data set minus the smallest observation in the data set. It is often denoted R .

For samples from a normal distribution, the range can be used to estimate the standard deviation. This is done by dividing the range by a factor denoted d_2 . d_2 values for given sample sizes are listed below:

n	d_2
2	1.128
3	1.693
4	2.059
5	2.326
6	2.534
7	2.704
8	2.847
9	2.970
10	3.078
11	3.173
12	3.258

11.1.1.C Coefficient of Variation (CV) and Percent Difference. There are two other commonly used measures of variability which are adjusted for the magnitude of the values in the sample. One is the coefficient of variation (CV), or relative standard deviation, which is defined as:

$$\% \text{ CV} = \frac{\text{Standard Deviation}}{\text{Mean}} \times 100\%$$

The coefficient of variation is used most often when the size of the standard deviation changes with the size of the mean. When individual measurements of CV or standard deviation are combined (pooled) to obtain an overall measure of variability for a given type of analysis or measurement, the following technique may be used:

Pooled CV =

where x_i = CV of data set i (e.g., CV for one duplicate pair, i)

DF_i = degrees of freedom for data set i ($k_i - 1$)

n = total number of data sets (e.g., total number of duplicate pairs)

k_i = number of data points in set i (e.g., $k=2$ for duplicates)

i = data set 1, 2, 3 . . . n

The other measure of variability which adjusts for the magnitude of the measured values is percent difference. This measure is used when the sample contains only two observations and is defined as:

$$\%D = \frac{X_1 - X_2}{(X_1 + X_2)/2} \times 100$$

The percent difference is especially useful when duplicate tests are done on sets of samples.

In addition to summary statistics, graphical presentations are often used to illustrate variability.

11.1.1.D Variance and Interquartile Range. Two other measures of variability are used less often but deserve a brief discussion. One is the variance, which is the square of the standard deviation. The other is the interquartile range, defined as the 75th percentile minus the 25th percentile of a data set. (The 75th percentile is the value which has 75 percent of the observations in a data set below it and 25 percent of the observations above it.)

11.2 ACCURACY

Accuracy, according to the EPA definition presented in the Quality Assurance Handbook for Air Pollution Measurement Systems, is "the degree of agreement of a measurement (or an average of measurements of the same thing), with an accepted reference or true value T." In the case of accuracy of individual measurements equates accuracy with bias and precision (i.e., both systematic and random error). On the other hand, accuracy of the average of individual measurements equates accuracy with bias and represents an attempt to quantitate systematic error (bias) independent of random error (precision). Under this approach, a set of measurements could be said to be accurate without being precise. Under the other approach, where individual measurements are considered, precision is a requisite of accuracy since random variability is a component of the total measurement error and does not get "averaged out." The validity, or significance, of the estimate of bias is directly related to the number of individual measurements used to compute the average. It is based on the principle that as the number of individual measurements is increased indefinitely, the same mean, $\bar{X}$, approaches a definite value, μ . The difference between μ and the true value, T, represents the magnitude of the measurement bias, or systematic error. The error in each individual represents this systematic bias plus random error due to imprecision.

11.2.1 Performance Audit Samples

The choice of definitions of accuracy is made based on the specific applications and the meaningfulness of the choice in the context of the application. Regardless of the definition chosen, it is important to remember that performance audit results provide only a point-in-time measure of accuracy and actually reflect only the capability of the system. In most cases, the results provide some insight into the precision, as well as the bias of measurements. These data supplement data generated by the internal QC procedures. Extrapolation of the audit and QC data to actual samples and measurements is the primary mechanism whereby error limits for various measurements may be estimated and the confidence in the measurement data defined.

11.2.2 Control Sample Analyses

Control sample analyses are used to assess measurement bias. While performance audit results represent a point-in-time assessment of measurement error, the average degree of agreement between measured values and actual values for control samples provides a long-term, or average estimate of measurement bias, as well as precision (repeatability).

11.3 COMPLETENESS

Measurement data completeness measures the extent to which the data base resulting from a measurement effort fulfills objectives for the amount of data required. Completeness is typically expressed in the following way:

$$\% \text{ Completeness} = \frac{\text{Amount of Valid Data Collected}}{\text{Total Amount of Data Collected}} \times 100$$

12.0 CORRECTIVE ACTION

During the course of a measurement program, the laboratory manager will initiate corrective action in the event that QC results or QA audit sample results exceed prescribed acceptance limits.

Corrective action for GeoChem's laboratory is categorized as either (1) on-the-spot, or (2) long-term. Both types of corrective action are discussed below. The type of corrective action taken (1 or 2) depends on the nature of the problem.

- (1) On-The-Spot. On-the-spot corrective actions are usually immediate in nature and are implemented by the analyst. Whenever possible, such actions are taken as part of the normal operating procedure. Since on-the-spot actions such as instrument recalibration and reanalysis of QC samples are an everyday part of the QA/QC system they are noted only in laboratory notebooks.
- (2) Long-Term. Long-term actions are most often identified through standard QC procedures, control charts, and audits. Any problem that cannot be solved by on-the-spot corrective action falls into this category, including problems which require external services (i.e., instrument repair). Long-term action calls for more formal documentation than notation in laboratory notebooks. A "Correction Action Notice" (Figure 13-1) is processed by the person who detected the problem.

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**GEOCHEM
CORRECTIVE ACTION NOTICE**

Date: _____

Name of Person Who
Identified the
Problem: _____

Signature: _____

I. Summary of Problem:

II. Recommended Action:

Distribution: Laboratory Manager
Laboratory Supervisor
QA Officer
Project File

Figure 12.1. Corrective Action Notice

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III. PROBLEM RESOLUTION

Date: _____

Summary of Corrective Action:

(Signature of person responsible
for correcting the problem)

Date: _____

Distribution: Laboratory Manager
Laboratory Supervisor
QA Officer
Project File

Figure 12.1. (Continued).

13.0 QUALITY ASSURANCE REPORTING

At a minimum, this report includes monthly QC data summaries and test data summaries. Laboratory managers are responsible for submitting these reports to the QA Officer. These status reports address some or all of the following:

- summary of calibration data,
- summary of unscheduled maintenance activities,
- summary of corrective action notices,
- status of any unresolved problems,
- assessment and summary of data completeness, and
- summary of any significant QA/QC problems and recommended and/or implemented solutions not included above.

The QA Officer prepares audit reports following each performance and systems audit which addresses data quality, and the qualitative assessment of overall system performance. This includes a separate QA/QC section which summarizes the audit results, as well as the QC data collected for the period in question.

GeoChem, Incorporated

Environmental Laboratories

EQUIPMENT LIST

MANUFACTURER	MODEL	SERIAL
Milton Roy Co. Spec 21 D	332278	3152138011
Orion 720A pH/mV meter	720A	1175
Paragon Electric Kiln	TNK233	284647
Gallenkamp	100.130M	89/10/576
Glas-Col 1000mL stir mantle	TEM108	238976
Glas-Col 1000mL stir mantle	TEM108	238973
Glas-Col stir control	EMC4	238980
Glas-Col minitrol	PL-312	320042
Glas-Col minitrol	PL-312	319809
Gelman Sciences ZHE	15400	P1234
Gelman Sciences ZHE	15400	P1236
Glas-Col 1000mL mantle	408	1369409
Glas-Col 1000mL mantle	408	1369408
Electrothermal mantle 5L	EM5000/CE	
Nitrate electrode	93-07	
Double junction reference electrode	90-02	
Fluoride/com. fluoride electrode	94-09,96-09	
Oxygen electrode	97-08	
Ross sure-flow electrode	81-72	
Thermolyne stir hot plate	SP46925	469900918321
Thermolyne stir hot plate	SP46925	469900918320
CMS digital conductivity meter		22948
Corning pH meter	M106	4795
Ohaus top loader balance	E400D	3049
Ohaus analytical balance	GA200D	4021
Tekmar sonic disrupter	TM600-2	12415
Sonics & Materials tungston horn	V1A	V01422
Sonics & Materials tungston horn	V1A	V91141
Equatherm environmental incubator	273791	990-003
Lars Lande rotator extractor		
Tekmar auto sampler	14-2962-200	90047023
Tekmar purge & trap	14-2000-0000	90038030
Hewlett Packard integrater	33968	2841A12050
OI Corp - ELCD	4420ELCD	90-165
Hewlett Packard analog digital converter	35900	
Hewlett Packard 5890 series II gas chromatograph		2950A25959
Hewlett Packard 5890 series II gas chromatograph		2950A27461

GeoChem, Incorporated

Environmental Laboratories

EQUIPMENT LIST continued

Hewlett Packard laser jet printer	HP33471A	2937J87987
Hewlett Packard computer Vectra/QS/20	D1430A	3029A18593
Tekmar purge & trap	14-2000-0000	90187003
Hewlett Packard integrater	33968	2841P03235
Hewlett Packard gauge controller	59822B	3411
Hewlett Packard mass spectrometer	5971A	3022A01250
Hewlett Packard 5890 series II gas chromatograph		3033A30960
Elroy-Somer vacuum pump		3320
Edwards 2 stage vacuum pump	E2M2	33245
Hewlett Packard computer Vectra/QS/20	D1430A	3029A18634
Hewlett Packard color moniter	D1182A	90 25 J42283
Hewlett Packard color moniter	D1182A	90 15 J29875
Hewlett Packard integrater	33968	2841A12046
Equatherm vacuum pump	92308-001	10049001

Appendix A

Definition and Procedure for the Determination of the Method Detection Limit

The method detection limit (MDL) is defined as the minimum concentration of a substance that can be identified, measured and reported with 99% confidence that the analyte concentration is greater than zero and determined from analysis of a sample in a given matrix containing analyte.

Scope and Application

This procedure is designed for applicability to a wide variety of sample types ranging from reagent (blank) water containing analyte to wastewater containing analyte. The MDL for an analytical procedure may vary as a function of sample type. The procedure requires a complete, specific and well defined analytical method. It is essential that all sample processing steps of the analytical method be included in the determination of the method detection limit.

The MDL obtained by this procedure is used to judge the significance of a single measurement of a future sample.

The MDL procedure was designed for applicability to a broad variety of physical and chemical methods. To accomplish this, the procedure was made device-or instrument-independent.

Procedure

1. Make an estimate of the detection limits using one of the following:
 - (a) The concentration value that corresponds to an instrument signal/noise ratio in the range of 2.5 to 5. If the criteria for qualitative identification of the analyte is based upon pattern recognition techniques, the least abundant signal necessary to achieve identification must be considered in making the estimate.
 - (b) The concentration value that corresponds to three times the standard deviation of replicate instrumental measurements for the analyte in reagent water.
 - (c) The concentration value that corresponds to known instrumental limitations.

It is recognized that the experience of the analyst is important to this process. However, the analyst must include the above considerations in the estimate of the detection limit.

2. Prepare reagent (blank) water that is as free of analyte as possible. Reagent or interference free water is defined as a water sample in which analyte and interferant concentrations are not detected at the method detection limit of each analyte of interest. Interferences are defined as systematic errors in the measured analytical signal of an established procedure caused by the presence of interfering species (interferant). The interferant concentration is presupposed to be normally distributed in representative samples of a given matrix.
3. (a) If the MDL is to be determined in reagent water (blank), prepare a laboratory standard (analyte in reagent water) at a concentration which is at least equal to or in the same concentration range as the estimated MDL. (Recommend between 1 and 5 times the estimated MDL). Proceed to Step 4.
- (b) If the MDL is to be determined in another sample matrix, analyze the sample. If the measured level of the analyte is in the recommended range of one to five times the estimated MDL, proceed to Step 4.

If the measured concentration of analyte is less than the estimated MDL, add a known amount of analyte to bring the concentration of analyte to between one and five times the MDL. In the case where an interference is co-analyzed with the analyte.

If the measured level of analyte is greater than five times the estimated MDL, there are two options:

- (1) Obtain another sample of lower level of analyte in sample matrix if possible.
 - (2) The sample may be used as is for determining the MDL if the analyte level does not exceed 10 times the MDL of the analyte in reagent water. The variance of the analytical method changes as the analyte concentration increases from the MDL, hence the MDL determined under these circumstances may not truly reflect method variance at lower analyte concentrations.
4. (a) Take a minimum of seven aliquots of the sample to be used to calculate the MDL and process each through the entire analytical method. Make all computations according to the defined method with final results in the method reporting units. If blank measurements are required to calculate the measured level of analyte, obtain separate blank measurements for each sample aliquot analyzed. The average blank measurement is subtracted from the respective sample measurements.

- (b) It may be economically and technically desirable to evaluate the estimated MDL before proceeding with 4a. This will: (1) prevent repeating this entire procedure when the costs of analyses are high and (2) insure that the procedure is being conducted at the correct concentration. It is quite possible that an incorrect MDL can be calculated from data obtained at many times the real MDL even though the background concentration of analyte is less than five times the calculated MDL. To insure that the estimate of the MDL is a good estimate, it is necessary to determine that a lower concentration of analyte will not result in a significantly lower MDL. Take two aliquots of the sample to be used to calculate the MDL and process each through the entire method, including blank measurements as described above in 4a. Evaluate these data:

- (1) If these measurements indicate the sample is in the desirable range for determining the MDL, take five additional aliquots and proceed. Use all seven measurements to calculate the MDL.
- (2) If these measurements indicate the sample is not in the correct range, reestimate the MDL, obtain new sample as in 3 and repeat either 4a or 4b.

5. Calculate the variance (S^2) and standard deviation (S) of the replicate measurements, as follows:

$$S^2 = \frac{1}{n-1} \left[\sum_{i=1}^n x_i^2 - \left(\frac{\sum_{i=1}^n x_i}{n} \right)^2 \right]$$

$$S = (S^2)^{1/2}$$

where: the x_i , $i = 1$ to n are the analytical results in the final method reporting units obtained from the n sample aliquots and $\sum_{i=1}^n x_i^2$ refers to the sum of the X values from $i = 1$ to n .

6. (a) Compute the MDL as follows:

$$MDL = T_{(n-1, 1-\alpha = .99)} (S)$$

where:

MDL = the method detection

$t_{(n-1, 1-\alpha = .99)}$ = The students' t value appropriate for a 99% confidence level and a standard deviation estimate with $n-1$ degrees of freedom. See Table.

S = Standard deviation of the replicate analyses.

- (b) The 95% confidence limits for the MDL derived in 6a are computed according to the following equations derived from percentiles of the chi square over degrees of freedom distribution (χ^2/df) and calculated as follows:

$$\begin{aligned} MDL_{LCL} &= 0.69 \text{ MDL} \\ MDL_{UCL} &= 1.92 \text{ MDL} \end{aligned}$$

where MDL_{LCL} are the lower and upper 95% confidence limits respectively based on seven aliquots.

7. Optional iterative procedure to verify the reasonableness of the estimated MDL and calculated MDL of subsequent MDL determinations.

- (a) If this is the initial attempt to compute MDL based on the estimated MDL in Step 1, take the MDL as calculated in Step 6, spike in the matrix at the calculated MDL and proceed through the procedure starting with Step 4.
- (b) If the current MDL determination is an iteration of the MDL procedure for which the spiking level does not permit qualitative identification, report the MDL as that concentration between the current spike level and the previous spike level which allows qualitative identification.
- (c) If the current MDL determination is an iteration of the MDL procedure and the spiking level allows qualitative identification, use S^2 from the current MDL calculation and S^2 from the previous MDL calculation to compute the F ratio.

$$\text{if } \frac{S^2_A}{S^2_B} < 3.05$$

then compute the pooled standard deviation by the following equation:

$$S_{\text{pooled}} = \left[\frac{6S^2_A + 6S^2_B}{12} \right]^{1/2}$$

if $\frac{S^2_A}{S^2_B} > 3.05$, respoke at the last calculated MDL and process the samples through the procedure starting with Step 4.

- (d) Use the S_{pooled} as calculated in 7b to compute the final MDL according to the following equation:

$$MDL = 2.681 (S_{\text{pooled}})$$

where 2.681 is equal to $t_{(12, 1-\alpha = .99)}$.

APPENDIX K

AQUIFER TEST DATA AND CALCULATIONS

STEP DOWN AQUIFER TEST

**BUILDING AS-410
PUMPING WELL AS410N-19**

**MARINE CORPS AIR STATION NEW RIVER
JACKSONVILLE, NORTH CAROLINA**

Depth to Water In Feet	Time In Minutes	Flow Rate In Gallons Per Minute
5.82 (static)	0	0
10.82	10	1.42
15.82	20	1.34
15.82	30	1.35

**PUMPING TEST RESULTS (PAGE 1 OF 4)
DRAWDOWN INFLUENCE IN FEET**

**BUILDING AS-410
MARINE CORPS AIR STATION NEW RIVER
JACKSONVILLE, NORTH CAROLINA**

ELAPSED TIME (IN HOURS)	PW AS410N-19	AS410N-4	AS410N-5	AS410N-6
0	5.78	5.83	6.42	6.41
.5		5.83	6.42	6.38
1	~16	5.83	6.42	6.41
1.5		5.83	6.45	6.43
2	~16	5.80	6.45	6.44
2.5		5.82	6.45	6.42
3	~16	5.82	6.45	6.44
3.5		5.82	6.44	6.42
4	~16	5.82	6.43	6.42
4.5		5.81	6.43	6.42
5	~16	5.81	6.43	6.42
5.5		5.81	6.44	6.42
6	~16	5.81	6.44	6.42
6.5		5.81	6.44	6.42
7	~16	5.81	6.44	6.42
7.5		-	-	-
8	17.40	5.81	6.44	6.44
NET INFUENCE	-11.62	+0.02	-0.02	-0.03

PW = Pumping Well

~ = Approximately

Average Flow Rate = 1.34 gallons per minute

All measurements taken from top of casing elevations.

**PUMPING TEST RESULTS (PAGE 2 OF 4)
DRAWDOWN INFLUENCE IN FEET**

**BUILDING AS-410
MARINE CORPS AIR STATION NEW RIVER
JACKSONVILLE, NORTH CAROLINA**

ELAPSED TIME (IN HOURS)	AS410N-7	AS410N-8	AS410N-9	AS410N-10
0	5.87	5.23	6.05	6.39
.5	5.92	5.23	6.08	6.39
1	5.92	5.23	6.08	6.39
1.5	5.92	5.23	6.10	6.40
2	5.92	5.23	6.13	6.40
2.5	5.92	5.22	6.13	6.42
3	5.94	5.22	6.11	6.41
3.5	5.92	5.20	6.12	6.41
4	5.94	5.20	6.12	6.41
4.5	5.98	5.22	6.11	6.40
5	5.98	5.22	6.11	6.40
5.5	5.98	5.21	6.11	6.40
6	6.07	5.19	6.09	6.40
6.5	6.07	5.19	6.09	6.40
7	6.07	5.19	6.09	6.40
7.5	-	-	-	-
8	6.03	5.20	6.08	6.40
NET INFUENCE	-16	+03	-.03	-.01

Average Flow Rate = 1.34 gallons per minute
All measurements taken from top of casing elevations.

**PUMPING TEST RESULTS (PAGE 3 OF 4)
DRAWDOWN INFLUENCE IN FEET**

**BUILDING AS-410
MARINE CORPS AIR STATION NEW RIVER
JACKSONVILLE, NORTH CAROLINA**

ELAPSED TIME (IN HOURS)	AS410N-11	AS410N-12	AS410N-13	AS410N-14
0	7.00	6.06	5.82	5.03
.5	7.00	6.41	5.84	5.12
1	7.00	6.41	5.87	5.12
1.5	7.02	6.44	5.88	5.12
2	7.02	6.44	5.88	5.08
2.5	6.98	6.44	5.88	5.08
3	7.02	6.46	5.87	5.11
3.5	7.02	6.46	5.88	5.08
4	7.00	6.46	5.91	5.09
4.5	7.00	6.46	5.89	5.11
5	7.00	6.46	5.88	5.08
5.5	7.01	6.46	5.90	5.10
6	7.02	6.46	5.87	5.09
6.5	7.02	6.46	5.87	5.09
7	7.02	6.46	5.87	5.09
7.5	-	-	-	-
8	7.02	6.44	5.88	5.11
NET INFUENCE	-0.02	-0.38	-0.06	-0.08

Average Flow Rate = 1.34 gallons per minute
All measurements taken from top of casing elevations.

**PUMPING TEST RESULTS (PAGE 4 OF 4)
DRAWDOWN INFLUENCE IN FEET**

**BUILDING AS-410
MARINE CORPS AIR STATION NEW RIVER
JACKSONVILLE, NORTH CAROLINA**

ELAPSED TIME (IN HOURS)	AS410N-15	AS410N-16	AS410N-17	AS410N-18
0	6.65	5.90	5.67	6.40
.5	6.65	6.05	5.70	6.52
1	6.65	5.88	5.71	6.52
1.5	6.66	5.98	5.71	6.50
2	6.66	5.92	5.70	6.62
2.5	6.66	5.92	5.70	6.63
3	6.66	5.92	5.70	6.54
3.5	6.66	5.92	5.72	6.54
4	6.66	5.94	5.71	6.51
4.5	6.65	5.92	5.71	6.52
5	6.65	5.92	5.71	6.52
5.5	6.66	5.92	5.70	6.52
6	6.66	5.92	5.70	6.52
6.5	6.66	5.92	5.70	6.52
7	6.66	5.92	5.70	6.52
7.5	-	-	-	-
8	6.66	5.92	5.70	6.54
NET INFUENCE	-01	-02	-03	-14

Average Flow Rate = 1.34 gallons per minute
All measurements taken from top of casing elevations.

JOB: AS-410 COMPUTED BY: JC DATE: 1/11/94
DESCRIPTION: Pump Test Cales CHECKED BY: JMP DATE: 1/12/94

CALCULATE HYDRAULIC CONDUCTIVITY Page 1 of 2

UTILIZING DUPUIT ASSUMPTIONS

Calculations 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.

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

Where: K = Hydraulic Conductivity (Ft/day)

Q = Well Discharge (gallons/day)

h_1 = Head in Well AS410N-12 (feet)

h_2 = Head in Well AS410N-7 (feet)

r_1 = Radius From Pumping Well to Well AS410N-12 (feet)

r_2 = Radius From Pumping Well to Well AS410N-7 (feet)

JOB: AS-410 COMPUTED BY: JC DATE: 1/11/94
DESCRIPTION: Pump Test Calc CHECKED BY: JMP DATE: 1/12/94

Page 2 of 2

$$K = \frac{1930}{\pi (13.47^2 - 13.06^2)} \ln \frac{78}{18}$$

$$K = 82.81 \text{ Ft/day}$$

NOTE: No aquiclude was identified; therefore, the total pumping well depth (19.5 feet) was used for aquifer thickness.

JOB: AS-410 COMPUTED BY: JC DATE: 1/11/94
DESCRIPTION: Pump Test Calcs CHECKED BY: JMP DATE: 1/12/94

CALCULATE TRANSMISSIVITY USING
DISTANCE-DRAWDOWN PLOT

$$T = \frac{528Q^*}{\Delta s}$$

Where: T = Transmissivity (gpd/ft)

Q = Well Discharge (gpm)

Δs = Slope of the Distance-Drawdown Graph Expressed as the Change in Drawdown, in Feet, Between Any Two Values of Distance on the Log Scale Whose Ratio is 10.

$$T = \frac{528(1.34)}{0.35}$$

$$T = 2,021 \text{ gpd/ft}$$

* Equation From Driscoll, 1986.

JOB: AS-410 COMPUTED BY: JC DATE: 1/11/94
DESCRIPTION: Pump Test Calcs CHECKED BY: JMP DATE: 1/12/94

CALCULATE STORAGE COEFFICIENT USING DISTANCE-DRAWDOWN PLOT

$$S = \frac{0.3 T t^*}{r_0^2}$$

Where: S = Storage Coefficient (unitless)

T = Transmissivity (gpd/ft.)

t = Time Since Pumping Started
(in days)

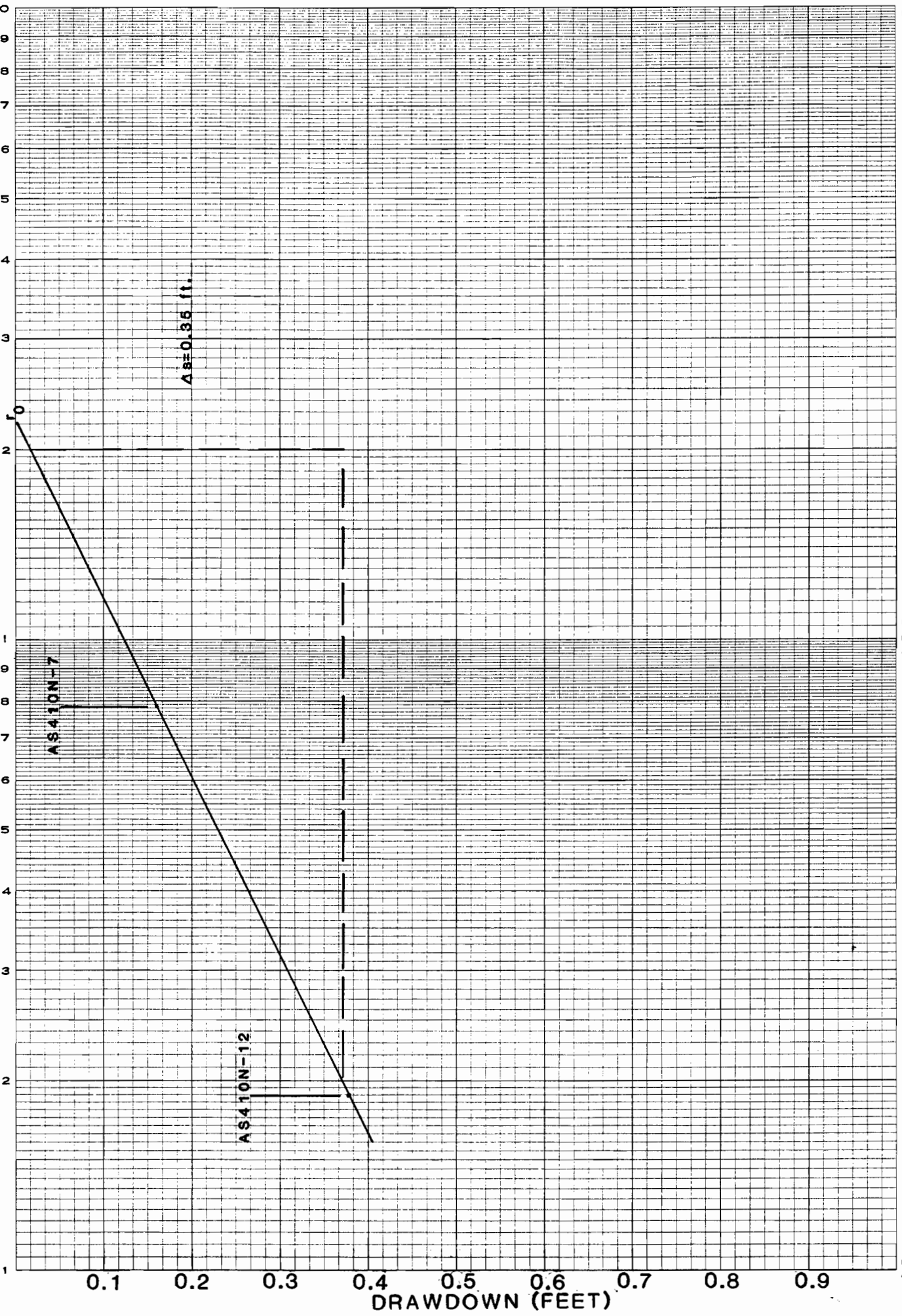
r_0 = Intercept of Extended Straight
line at Zero Drawdown (ft.)

$$S = \frac{0.3 (2,021) (0.333)}{220^2}$$

$$S = 4.17 \times 10^{-3}$$

* Equation from Driscoll, 1986.

DISTANCE FROM PUMPING WELL (FEET)



DRAWDOWN (FEET)

1000

100

10

