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CORRECTIVE ACTION PLAN FOR ZONE F SITE 23 BUILDING 1175 SITE IDENTIFICATION
NUMBER 15405 CNC CHARLESTON SC
12/1/2000
J A JONES ENVIRONMENTAL SERVICES

**CORRECTIVE ACTION PLAN
FOR
ZONE F/ SITE 23-BUILDING 1175**

SITE IDENTIFICATION # 15405

Charleston Naval Complex
Charleston, South Carolina

**SOUTHERN DIVISION
NAVAL FACILITIES ENGINEERING COMMAND**

Contract Number N62467-99-C-0960

December 2000

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FOR
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Charleston, South Carolina**

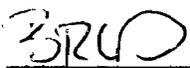
**Submitted to:
Southern Division
Naval Facilities Engineering Command
2155 Eagle Drive
Charleston, South Carolina 29406**

**Submitted by:
CH2M-JONES, LLC.
115 Perimeter Center Place NE
Suite 700
Atlanta, Georgia 30346-1278**

Contract Number: N62467-99-C-0960

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PREPARED BY:


12-18-00
**Brian R. Crawford
Engineer II
CH2M-JONES, LLC.**

APPROVED BY:


12-21-00
**Jed A. Heames
Site Superintendent
CH2M-JONES, LLC.**

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ACRONYMS AND ABBREVIATIONS

bls	below land surface
MTBE	Benzene, Toluene, Ethylbenzene, and Xylene Isomers
CAP	Corrective Action Plan
CNC	Charleston Naval Complex
EISOPQAM	Environmental Investigations Standard Operating Procedures and Quality Assurance Manual
EPA	Environmental Protection Agency
ft	foot
mg/kg	microgram per kilogram
mg/L	microgram per liter
MtBE	Methyl Tertiary Butyl Ether
OVA	Organic Vapor Analyzer
QA	Quality Assurance
QC	Quality Control
RBSL	Risk-Based Screening Level
RDA	Redevelopment Authority
SAP	Sampling and Analysis Plan
SCDHEC	South Carolina Department of Health and Environmental Control
SOUTHDIV	Southern Division Naval Facilities Engineering Command
SSTL	Site-Specific Target Level
TTNUS	Tetra Tech NUS
UST	Underground Storage Tank

1.0 INTRODUCTION

This Corrective Action Plan (CAP) has been prepared by CH2M-JONES, LLC. The plan is designed for Zone F/ Site 23-Building 1175; Underground Storage Tanks (UST) 1175-1, 1175-2, and 1175-3 located at the Charleston Naval Complex (CNC), Charleston, South Carolina.

The South Carolina Department of Health and Environmental Control (SCDHEC) has designated this site as Identification Number: 15405. This CAP provides methods to further evaluate the applicability of intrinsic remediation and monitoring well abandonment as a corrective action for USTs 1175-1, 1175-2, and 1175-3 in accordance with SCDHEC Corrective Action Guidance, June 1997.

1.1 General Site Description

The CNC is in the city of North Charleston, on the west bank of the Cooper River in Charleston County, South Carolina as shown in Figure 1. This installation consists of two major areas: an undeveloped dredge materials area on the east bank of the Cooper River on Daniel Island in Berkeley County, and a developed area on the west bank of the Cooper River. The developed portion of the base is on the peninsula bounded on the west by the Ashley River and on the east by the Cooper River. The site is located within the developed portion of the base as shown in Figure 2. (Tetra Tech, NUS [TTNUS], Rapid Assessment [RA] for UST 1175, February 2000).

The area surrounding CNC is "mature urban", having long been developed with commercial, industrial, and residential land use. Commercial areas are primarily west of CNC; industrial areas are primarily to the north of the base along Shipyard Creek. A site vicinity map, which exhibits adjacent properties and structures, vicinity roads, current utilities, and vicinity surface drainage, is included as Figure 2.

As described in the *Evaluation of Baseline Environmental Conditions at Proposed CPW Lease Areas*, by General Engineering Laboratory, 1996. Building 1175 was a single story structure, which was built in 1942 and originally used as a restroom for Navy personnel. This building was eventually converted to a maintenance shed for storage of old tires, forklifts, concrete and petroleum products, and mechanical equipment and parts. The UST system associated with the building consists of two 10,000-gallon unleaded gasoline tanks and one 10,000-gallon diesel tank located to the west of Building 1175. The system was installed in the late 1980s and was still in use at the time of the Rapid Assessment investigation (TTNUS 2000).

1.2 Objective

In the RA completed by TTNUS, eight groundwater and seven soil samples were collected. The only chemicals of concern above the Risk Based Screening Levels (RBSLs) were benzene and MtBE both of which are found in monitoring well CNC23-MW04 at levels of 140.0 $\mu\text{g/l}$ for benzene and levels of 4100 $\mu\text{g/l}$ for MtBE. The

duplicate sample for monitoring well CNC23-XMW04 showed MtBE concentrations at 50 $\mu\text{g}/\text{l}$, which were above the RBSIs of 40 $\mu\text{g}/\text{l}$. No soil samples exceeded their RBSLs for any of the chemical of concern. (see Tables 7 and 8).

This CAP presents the groundwater monitoring plan to attempt to demonstrate the ground water's assimilative capacity to provide for intrinsic biodegradation/ natural attenuation for the known contaminants through time in order to validate the assumptions and calculations used in the RA completed by TTNUS 2000.

2.0 RECEPTOR SURVEY

A receptor survey of the site vicinity was conducted by TTNUS to identify potential receptors for petroleum hydrocarbon contamination. Figure 2 depicts the public utilities located within 250 feet of the former UST 1175 study area. Specific information concerning the depth of utilities below land surface (bls) is currently unavailable, however, utilities at this site generally are between 2 to 6 feet (ft) bls. The following utility receptors were located:

UTILITY	ON-SITE OR DISTANCE/ DIRECTION FROM SITE	DEPTH TO UTILITY
Gas	~20 feet northeast of building 1175	2-6-ft bls
Electrical	Northeast of building 1175 ~20 feet	2-6-ft bls
Sewer	Southeast and northeast of 1175	2-6-ft bls
Storm Drain	N/A	2-6-ft bls
Compressed Air	Northeast side of building 1175 ~20 feet	2-6-ft bls

According to the RA report completed by TTNUS, a survey of groundwater users within a 7-mile radius of CNC was conducted by the South Carolina Water Resources Commission to ascertain the extent of any shallow groundwater usage. Results of the water use investigation revealed that no drinking water wells, which utilize the shallow aquifer, are located within a 4 mile radius of CNC. Irrigation wells are not identified within 1,000 feet of the site. Numerous monitoring wells are located within 1,000 feet of the site. The nearest surface water body to the site is the Cooper River located approximately 900 feet from the site (TTNUS, 2000).

2.1 Fate and Transport Modeling

The Dominico model was the fate and transport model used to determine groundwater site-specific target levels (SSTLs) in the risk analysis. The Dominico dilution/attenuation model is presented in the SCDHEC guidance document, *South Carolina Risk-Based Corrective Action for Petroleum Releases* (SCDHEC, 1988). This model is very conservative in that it assumes an infinite mass, aerial source condition through which groundwater flows. The model incorporates biological decay effects through a first-order decay process; however, this mechanism was ignored because SCDHEC guidance specifies that the decay rate must be assumed to be zero if site-specific decay rates have not been determined.

The impacted groundwater source area was modeled as 50 feet (15 meters) wide and 6.56 feet (2 meters) deep; these values are conservative defaults suggested by the American Society for testing and Materials (ASTM) *Standard Guide for Risk-Based Corrective Action Applied at Petroleum Release Sites* (ASTM 1997). The maximum Source concentrations are assumed to exist throughout the source area, further compounding the conservatism of the estimate.

3.0 PROPOSED REMEDIATION TECHNOLOGY

Based on the results of the RA modeling, an Intrinsic Remediation with a monitoring period of 9 months will be performed for the site. The monitoring program will consist of sampling initially a total of eight surrounding wells adjacent to the source point, and only sampling three selected wells thereafter. The proposed monitoring program is described in detail in Sections 4.0 and 5.0 of this plan. In order to support monitored natural attenuation for this site, CH2M-Jones, LLC must provide sufficient data to demonstrate the groundwater environment's assimilative capacity to provide for intrinsic biodegradation/ natural attenuation for the known contaminants through time. As stated in Section 1.2, the known contaminants are MtBE and benzene. All other contaminants are below the RBSLs. In addition to sampling the known contaminants, several other intrinsic parameters will be measured to support intrinsic biodegradation/ natural attenuation. As a general guidance, biodegradation of petroleum hydrocarbons most commonly occurs by means of aerobic, nitrate-reducing, Fe(III)-reducing, sulfate-reducing, and methanogenic respiration as shown in the tables below (Parsons Engineering Science, Inc. and USGS, 1998).

**Trends in Contaminant, Electron Acceptor, and
Metabolic Byproduct Concentrations During Biodegradation**

Analyte	Trend in Analyte Concentrations During Biodegradation	Terminal Electron Accepting Process Causing Trend
Petroleum Hydrocarbons	Decrease	Aerobic respiration, denitrification, Mn (IV) reduction, Fe (III) reduction, sulfate reduction, methanogenesis
Highly Chlorinated Solvents and Daughter Products	Parent compound concentrations decrease, daughter products increase initially and then may decrease	Reductive dechlorination and cometabolic oxidation
Lightly Chlorinated Products	Decrease	Aerobic respiration and Fe (III) reduction (direct oxidation) and cometabolism (indirect oxidation)
Dissolved Oxygen	Decrease	Aerobic respiration
Nitrate	Decrease	Denitrification
Mn (II)	Increase	Mn (IV) reduction
Fe (II)	Increase	Fe (III) reduction
Sulfate	Decrease	Sulfate reduction
Methane	Increase	methanogenesis
Chloride	Increase	Reductive dechlorination or direct oxidation of chlorinated compound
Oxidation/Reduction Potential	Decrease	Aerobic respiration, denitrification, Mn (IV) reduction, Fe (III) reduction, sulfate reduction, methanogenesis and halo-respiration
Dissolved Inorganic Carbon	Increase	Aerobic respiration, denitrification, Fe (III) reduction, and sulfate reduction

4.0 MONITORING WELL INSTALLATION AND ABANDONMENT

4.1 Monitoring Well Installation

Because of the amount of monitoring wells located in and around this site, no monitoring wells will be installed as part of this plan.

4.2 Monitoring Well Abandonment

Eight monitoring wells will be abandoned at Building 1175 following the South Carolina Well Standards and Regulations R.61-71. The well abandonment will include grouting wells, removing stick-ups and removing all guard posts.

4.3 Surveying

Because no monitoring wells will be installed at this site, a new survey will not be conducted.

4.4 Equipment Decontamination

All drilling equipment, augers, well casing and screens, and soil and groundwater sampling equipment involved in field sampling activities will be decontaminated according to the Environmental Protection Agencies (EPA) " Environmental Investigations Standard Operating Procedures and Quality Assurance Manual (EISOPQAM).

5.0 PROPOSED GROUNDWATER MONITORING PROGRAM

5.1 Monitoring Frequency and Reporting

The groundwater monitoring program proposed at Building 1175 will be performed in accordance with SCDHEC Corrective Action Guidance, June 1997, and consist of the following:

Sampling date or (Quarter)	Monitoring Wells Sampled	Field Measures	Laboratory Analytical
First quarter ¹ 2001	CNC-23-MW01 thru CNC-23-MW05 and CNC-23X-MW02, CNC-23X-MW03, and CNC-23X-MW04.	T°, pH, DO, Conductivity, Depth to water, Total depth, Turbidity	MtBE 8260 including Benzene 8260 In addition MW-04, MW-X04, & MW-02 will be sampled for Nitrate, sulfate, Fe II, Fe III, methane, alkalinity
Second quarter ² 2001	CNC23-MW04, CNC23-X-MW04, and CNC23-MW02	T°, pH, DO, Conductivity, Depth to water, Total depth, Turbidity	MtBE 8260 including Benzene 8260 Nitrate, sulfate, Fe II, Fe III, methane, alkalinity
Third quarter ³ 2001	CNC23-MW04, CNC23-X-MW04, and CNC23-MW02	T°, pH, DO, Conductivity, Depth to water, Total depth, Turbidity	MtBE 8260 including Benzene 8260 Nitrate, sulfate, Fe II, Fe III, methane, alkalinity

1. First quarter is defined as January February and March.
2. Second quarter is defined as April May and June
3. Third quarter is defined as July, August, and September

Frequency: Initially all monitoring wells at this site will be sampled. Thereafter, groundwater samples will be collected from wells MW-02, MW-04, and MWX-04.

Reporting: Semi-annual groundwater monitoring reports will be submitted to SCDHEC.

Included in the semi-annual reports will be field and analytical information from the certified laboratory indicating well numbers, analytical methods used, date sampled, date analyzed, and method detection limits.

At the end of the third quarter 2001 period, (or as necessary) a performance evaluation will be submitted to SCDHEC providing the effectiveness of the intrinsic biodegradation/natural attenuation occurring and any recommendations for the site if needed. It is possible that the levels are not above the RBSLs in the groundwater, which will result in a different approach to the closure of these tanks.

- **Groundwater Sampling**

Prior to any groundwater sampling, each well will be measured for water levels and total depth and each well will be purged in accordance the EPA EISOPQAM.

5.2 Analytical Parameters

The following constituents will be analyzed for each groundwater sample:

- MtBE and Benzene using method 8260.

The following parameters will be analyzed in order to evaluate the effectiveness of intrinsic remediation:

- Nitrate (NO^{-3})
- Sulfate (SO^{-4})
- Fe II
- Fe III
- Methane (CH_4)
- Alkalinity

5.3 Field Measurements

The following parameters will be sampled in the field:

- Temperature
- pH
- Dissolved Oxygen
- Depth to water table
- Depth of well
- Turbidity
- Specific Conductance

Field measurements will be recorded in the field book and in field forms.

5.4 Groundwater Level Measurements

Groundwater measurements will be taken from all monitoring wells at the site during each sampling event. All water level measurements will be taken on the same day as anticipated sampling.

Measurements will be taken with an electrical water level meter or interface probe if floating product is present using the highest part of the top of the casing as a reference point for determining depths to water and total depths. Water level measurements will be recorded to the nearest 0.01-foot in the field book.

5.5 Sample Handling

Field procedures and groundwater analysis will follow standard procedures found in the approved Corrective Action Sampling and Analysis Plan (CSAP) portion of the RFI Work Plan (Ensafe, Inc./ Allen & Hoshall, 1996). The CSAP outlines all monitoring procedures to be performed in during the investigation in order to characterize the environmental setting, source, and releases of hazardous constituents. In addition, the CSAP includes the Quality Assurance plan and Data Management Plan to verify that all information and data are valid and properly documented. Unless otherwise noted, the sampling strategy and procedures will be performed in accordance with the EPA Environmental Services Division

Sample Handling will be conducted in accordance with the following references:

EPA EISOPQAM (EPA May, 1996)
Comprehensive Sampling and Analysis Plan(Ensafe/Allen & Hoshall July, 1996)

5.6 Sample Packing and Shipping

The following forms will be compiled to complete the packing/shipping process:

- Sample labels
- Chain-of-custody labels
- Appropriate labels applied to shipping coolers
- Chain-of-custody forms
- Federal express air bills

5.7 Quality Check

Quality Control (QC) samples will be collected during sampling events. QC samples may include field blanks, field duplicates, and trip blanks. Definitions of each can be found below as described by the EISOPQAM:

- **Field Blank:** a sample collected using organic-free water, which has been run over/through sample collection equipment. These samples are used to determine if contaminants have been introduced by contact of the sample medium with sampling equipment. Equipment field blanks are often associated with collecting rinse blanks of equipment that has been field cleaned.
- **Field Duplicates:** Two or more samples collected from a common source. The purpose of a duplicate sample is to estimate the variability of a given characteristic or contamination associated with a population.
- **Trip Blank:** A sample, which is prepared prior to the sampling event in the actual container and is stored with the investigative samples throughout the sampling event. They are often packaged for shipment with the other samples and submitted for analysis. At no time after their preparation are trip blanks to be opened before they reach the laboratory. Trip blanks are used to determine if samples were contaminated during storage and/or transportation back to the laboratory (a measure of sample handling variability resulting in positive bias in contaminant concentration). If samples are to be shipped, trip blanks are to be provided with each shipment but not for each cooler.

5.8 Control Limits

Analysis	Control Parameter	Control Limit	Corrective Action
Air Monitoring	Check Calibration of OVA daily	Calibrate to manufactures specifications	Recalibrate. If unable to calibrate, replace.
pH of water	Continuing calibration check of pH 7.0 buffer	pH= 7.0	Recalibrate. If unable to calibrate, replace electrode.
Specific Conductance of water	Continuing calibration check of standard solution	> 1% of standard	Recalibrate.

5.9 Record keeping

In addition to records kept in logbooks, forms will be kept on log sheets for soil and groundwater.

5.10 Site Management and Base Support

Throughout the investigation activities, work on the CNC will be coordinated through SOUTHDIV and SCDHEC.

The primary contacts for each are as follows:

1. SOUTHDIV point of contact
Gabe Magwood
Southern Division Engineering Command
2155 Eagle Drive
North Charleston, SC 29406
(843) 820-7307

2. SOUTHDIV point of contact
Tony Hunt
Southern Division Engineering Command
2155 Eagle Drive
North Charleston, SC 29406
(843) 820-5525

3. SCDHEC point of contact
Mike Bishop
South Carolina Department of Health and Environmental Control
2600 Bull Street
Columbia, SC 29201
(843) 898-4339

REFERENCES

Ensafe/ Allen & Hoshall. July, 1996. Comprehensive Sampling and Analysis Plan.

Parsons Engineering Science, Inc. and United States Geological Survey. September 1998. Technical Guidelines for Evaluating Monitored Natural Attenuation of Petroleum Hydrocarbons and Chlorinated Solvents in Ground Water at Naval and Marine Corps Facilities.

South Carolina Department of Health and Environmental Control. 1997. Corrective Action Guidance.

Tetra Tech NUS, Inc.; 2000 Rapid Assessment for Site 23 (Building 1175), Charleston, South Carolina.

United States Environmental Protection Agency. 1990. Code of Federal Regulations 136.

United States Environmental Protection Agency. 1988. EPA Users Guide to Contract Laboratory Program.

United States Environmental Protection Agency. 1996. EPA Environmental Investigations Standard Operating Procedures for Quality Assurance Manual.

TABLES

TABLE 1
GROUNDWATER ELEVATIONS
SITE 23, BUILDING 1175
ZONE F, CHARLESTON NAVAL BASE COMPLEX
NORTH CHARLESTON, SOUTH CAROLINA

Well #	Total Depth of Well (ft)	Top of Casing Elevation, ft (MSL)	Date Measured	Depth to Water, ft (BTOC)	Depth to Product, ft (BTOC)	Product Thickness (ft)	Groundwater Elevation (MSL)
CNC23-M01	12.50	9.43	9/9/99	3.05	ND	ND	6.38
CNC23-M02	12.37	9.38	9/9/99	2.85	ND	ND	6.53
CNC23-M03	11.70	8.90	9/9/99	4.42	ND	ND	4.48
CNC23-M04	12.21	8.56	9/9/99	1.85	ND	ND	6.71
CNC23-M05D	30.06	8.97	9/9/99	9.89	ND	ND	-0.92
CNC23-X02	14.15	8.78	9/9/99	2.46	ND	ND	6.32
CNC23-X03	13.25	8.39	9/9/99	1.81	ND	ND	6.58
CNC23-X04	13.35	7.90	9/9/99	2.05	ND	ND	5.85

Notes:

- MSL - Mean Sea Level
- BTOC - Below Top of Casing
- ND- Not Detected
- ft - Feet
- X - Existing

TABLE 2**GROUNDWATER FIELD MEASUREMENTS
SITE 23, BUILDING 1175
ZONE F, CHARLESTON NAVAL COMPLEX
NORTH CHARLESTON, SOUTH CAROLINA**

Well I.D.	Date Sampled	Purge method	Volume (gallons)	Temp (° C)	pH	Specific Conductivity (uMHOS/cm)	Turbidity (NTU)	Dissolved Oxygen (mg/L)
CNC23-M01	9/10/99	PP	9.00	31.5	6.53	2.41	94	0.44
CNC23-M02	9/10/99	PP	6.00	29.7	7.35	11.90	8	0.58
CNC23-M03	9/10/99	PP	5.00	28.8	8.70	6.20	103	3.21
CNC23-M04	9/10/99	PP	10.00	28.3	6.62	5.46	31	0.53
CNC23-M05	9/10/99	PP	17.00	27.7	6.65	0.0	161	7.67
CNC23-X02	9/10/99	PP	10.00	29.2	7.69	8.10	26	1.51
CNC23-X03	9/10/99	PP	10.00	29.9	6.90	1.21	37	0.51
CNC23-X04	9/10/99	PP	10.00	28.1	6.76	2.95	47	0.96

Notes:

(° C) - Degrees Celsius

PP - Peristaltic pump, low flow technique

uMHOS/cm - Micro MHOS per centimer

NTU - Nephelometric turbidity units

mg/L - milligrams per liter

X - Existing

TABLE 3

**GROUNDWATER NATURAL ATTENUATION FIELD MEASUREMENTS
SITE 23, BUILDING 1175
ZONE F, CHARLESTON NAVAL COMPLEX
NORTH CHARLESTON, SOUTH CAROLINA**

Well I.D.	Date Sampled	Dissolved Oxygen (mg/L)	Alkalinity (mg/L)	Carbon Dioxide (mg/L)	Sulfide (mg/L)	Ferrous Iron (mg/L)	Nitrite (mg/L)	Manganese (mg/L)	Nitrogen/Nitrate (mg/L)*	Sulfate (mg/L)*
CNC23-M02	9/10/99	0.40	1,440	940	0.04	5.10	NA	4.8	NA	NA
CNC23-M03	9/10/99	3.00	1,134	580	0.04	2.39	NA	2.3	NA	NA
CNC23-X02	9/10/99	NA	1,510	990	0.11	5.10	NA	11.7	NA	NA

Notes:

mg/l - Milligrams per liter

E- Estimated Concentration

NA - Not Analyzed

* Fixed base laboratory analysis

TABLE 4

**SUMMARY OF OVA SOIL SCREENING RESULTS
SITE 23, BUILDING 1175
ZONE F, FORMER CHARLESTON NAVAL COMPLEX
NORTH CHARLESTON, SOUTH CAROLINA**

Sample Location	Sample Identification	Sample Depth (feet)	Total Organic Vapor Headspace Concentration (ppm)
CNC23-B01	23SSB0105	5	1000
	23SSB0107	7	1300
CNC23-B02	23SSB0205	5	896
	23SSB0207	7	130
CNC23-B03	23SSB0302	2	2400
CNC23-B04	23SSB0405	5	70
	23SSB0407	7	1180
CNC23-B05	23SSB0507	7	6
	23SSB0510	10	130
CNC23-B06	23SSB0602	2	4
CNC23-B07	23SSB0703	3	770
	23SSB0710	10	580
CNC23-B08	23SSB0802	2	8
CNC23-B09	23SSB0903	3	70
CNC23-B10	23SSB1003	3	60
CNC23-B11	23SSB1103	3	270
CNC23-B12	23SSB1204	4	190
CNC23-B13	23SSB1303	3	71
CNC23-B14	23SSB1404	4	21

Notes:

OVA - organic vapor analyzer equipped with a flame ionization detector and charcoal filter when necessary

TABLE 5

**SUMMARY OF MOBILE LABORATORY SCREENING RESULTS FOR SOIL
SITE 23, BUILDING 1175
ZONE F, FORMER CHARLESTON NAVAL COMPLEX
NORTH CHARLESTON, SOUTH CAROLINA**

Sample Location	Sample Identification	Sample Depth (feet)	Laboratory Screening Data ⁽¹⁾					
			Benzene (µg/kg)	Toluene (µg/kg)	Ethylbenzene (µg/kg)	Total Xylenes (µg/kg)	Naphthalene (µg/kg)	Diesel Range Organics (mg/kg)
CNC23-B01	23SFB010506	5-6	ND	ND	ND	ND	ND	ND
CNC23-B02	23SFB020506	5-6	ND	ND	ND	ND	ND	ND
CNC23-B03	23SFB030203	2-3	ND	ND	ND	ND	ND	102
CNC23-B04	23SFB040812	8-12	ND	ND	ND	ND	ND	ND
CNC23-B05	23SFB051011	10-11	ND	ND	ND	ND	ND	ND
CNC23-B06	23SFB060203	2-3	ND	ND	ND	ND	ND	ND
CNC23-B07	23SFB070203	2-3	ND	ND	ND	ND	ND	ND
CNC23-B08	23SFB080203	2-3	ND	ND	ND	ND	ND	ND
CNC23-B09	23SFB090304	3-4	ND	ND	ND	ND	ND	ND
CNC23-B10	23SFB100304	3-4	ND	ND	ND	ND	ND	ND
CNC23-B11	23SFB110304	3-4	ND	ND	ND	ND	ND	ND
CNC23-B12	23SFB120405	4-5	ND	ND	ND	ND	ND	ND
CNC23-B13	23SFB130304	3-4	ND	ND	ND	ND	ND	ND
CNC23-B14	23SFB140304	3-4	ND	ND	ND	ND	ND	ND

NOTES:

⁽¹⁾ Laboratory screening data were analyzed using USEPA Method 8020/8015M. Compounds not detected are reported as less than the instrument detection limit.

µg/kg = micrograms per kilogram

mg/kg = milligrams per kilogram

* Soil samples collected above water table at time of boring installation.

TABLE 6

SUMMARY OF MOBILE LABORATORY SCREENING RESULTS FOR GROUNDWATER
 SITE 23, BUILDING 1175
 ZONE F, FORMER CHARLESTON NAVAL COMPLEX
 NORTH CHARLESTON, SOUTH CAROLINA

Sample Location	Sample Identification	Sample Depth (feet)	Laboratory Screening Data ⁽¹⁾					
			Benzene (µg/L)	Toluene (µg/L)	Ethylbenzene (µg/L)	Total Xylenes (µg/L)	Naphthalene (µg/L)	Diesel Range Organics (mg/L)
CNC23-B01	23GFB010712	7-12	ND	ND	ND	32.3	ND	1170E
CNC23-B02	23GFB020712	7-12	ND	ND	ND	ND	ND	ND
CNC23-B03	23GFB030308	3-8	ND	ND	ND	ND	ND	ND
CNC23-B04	23GFB040812	8-12	ND	ND	ND	ND	ND	ND
CNC23-B05	23GFB050820	8-20	ND	ND	ND	ND	ND	ND
CNC23-B06	23GFB060308	3-8	ND	ND	ND	ND	ND	ND
CNC23-B07	23GFB070312	3-12	ND	ND	ND	ND	ND	ND
CNC23-B08	23GFB080308	3-8	ND	ND	ND	ND	ND	ND
CNC23-B09	23GFB090305	3-5	ND	ND	ND	ND	ND	ND
CNC23-B10	23GFB100305	3-5	ND	ND	ND	ND	ND	ND
CNC23-B11	23GFB110305	3-5	ND	ND	ND	ND	ND	ND
CNC23-B12	23GFB120405	4-5	ND	ND	ND	ND	ND	ND
CNC23-B13	23GFB130305	3-5	ND	ND	ND	ND	ND	ND
CNC23-B14	23GFB140305	3-5	ND	ND	ND	ND	ND	ND

NOTES:

⁽¹⁾ Laboratory screening data were analyzed using USEPA Method 8020/8015M. Compounds not detected are reported as less than the instrument detection limit.

µg/L = micrograms per liter

mg/L = milligrams per liter

E = Estimated value-detection exceeded the upper calibration range of the instrument.

TABLE 7

SUMMARY OF FIXED-BASE LABORATORY ANALYTICAL RESULTS FOR CHEMICALS OF CONCERN IN SOIL
 SITE 23, BUILDING 1175
 ZONE F, CHARLESTON NAVAL COMPLEX
 NORTH CHARLESTON, SOUTH CAROLINA

Soil Boring / Sample No.	Sample Date	Benzene (ug/kg)	Toluene (ug/kg)	Ethyl-benzene (ug/kg)	Xylenes (total) (ug/kg)	Benzo(a) anthracene (ug/kg)	Benzo(b) fluoranthene (ug/kg)	Benzo(k) fluoranthene (ug/kg)	Chrysene (ug/kg)	Dibenzo(a,h) anthracene (ug/kg)	Naphthalene (ug/kg)
RBSL ⁽¹⁾		5	478	364	11119	17687	7042	55930	3146	21265	52
CNC23-B01 / 23SLB010203	24-Sep-99	< 10	< 10	< 10	< 10	< 560	< 560	< 560	< 560	< 560	< 10
CNC23-B03 / 23SLB030203	24-Sep-99	< 10	< 10	< 10	< 10	< 530	< 530	< 530	< 530	< 530	< 10
CNC23-B03 / 23SLB030203D ⁽²⁾	24-Sep-99	< 9	< 9	< 9	< 9	< 530	< 530	< 530	< 530	< 530	< 9
CNC23-B04 / 23SLB040203	24-Sep-99	< 7	< 7	< 7	< 7	< 500	< 500	< 500	< 500	< 500	< 7
CNC23-B05 / 23SLB050203	24-Sep-99	< 10	< 10	< 10	< 10	< 560	< 560	< 560	< 560	< 560	< 10
CNC23-B06 / 23SLB060001	24-Sep-99	< 5	< 5	< 5	< 5	< 400	< 400	< 400	< 400	< 400	< 5
CNC23-B08 / 23SLB080203	24-Sep-99	< 8	< 8	< 8	< 8	< 430	< 430	< 430	< 430	< 430	< 8
CNC23-B13 / 23SLB130203	24-Sep-99	< 11	< 11	< 11	< 11	< 590	< 590	< 590	< 590	< 590	< 11

All concentrations are in micrograms per kilograms (ug/kg).

NA - Not analyzed

⁽¹⁾ South Carolina Department of Health and Environmental Control Risk Based Screening Levels for clay-rich soils, depth to groundwater less than 5 feet

⁽²⁾ Duplicate

TABLE 8

**SUMMARY OF FIXED-BASE LABORATORY ANALYTICAL RESULTS FOR CHEMICALS OF CONCERN IN GROUNDWATER
SITE 23, BUILDING 1175
ZONE F, CHARLESTON NAVAL COMPLEX
NORTH CHARLESTON, SOUTH CAROLINA**

Monitoring Well/ Sample No.	Sample Date	Benzene (ug/L)	Ethyl- benzene (ug/L)	Toluene (ug/L)	Xylenes (total) (ug/L)	Naphthalene (ug/L)	Benzo(a) anthracene (ug/L)	Benzo(b) fluoranthene (ug/L)	Benzo(k) fluoranthene (ug/L)	Chrysene (ug/L)	Dibenzo(a,h) anthracene (ug/L)	MTBE (ug/L)	EDB (ug/L)	Lead (ug/L)
RBSL ⁽¹⁾		5	700	1000	10000	10 ⁽²⁾	10 ⁽²⁾	10 ⁽²⁾	10 ⁽²⁾	10 ⁽²⁾	10 ⁽²⁾	40	5	15
CNC23M-01 / 23GLM0101	10-Sep-99	< 5	< 5	< 5	< 5	< 5	< 10	< 10	< 10	< 10	< 10	38	< 5	< 1.2
CNC23M-02 / 23GLM0201	09-Sep-99	< 5	< 5	< 5	< 5	< 5	< 10	< 10	< 10	< 10	< 10	< 5	< 5	< 1.09
CNC23M-03 / 23GLM0301	09-Sep-99	< 5	< 5	< 5	< 5	< 5	< 10	< 10	< 10	< 10	< 10	10	< 5	< 1.3
CNC23M-04 / 23GLM0401	10-Sep-99	140	5 ⁽³⁾	11	3 ⁽³⁾	< 5	< 10	< 10	< 10	< 10	< 10	4100	< 5	< 4.8
CNC23M-05D / 23GLM05D01	10-Sep-99	< 5	< 5	< 5	< 5	< 5	< 10	< 10	< 10	< 10	< 10	< 5	< 5	< 1.09
CNC23M-02 / 23GLX0201	09-Sep-99	< 5	< 5	< 5	< 5	< 5	< 10	< 10	< 10	< 10	< 10	< 5	< 5	< 1.09
CNC23M-03 / 23GLX0301	10-Sep-99	< 5	< 5	< 5	< 5	< 5	< 10	< 10	< 10	< 10	< 10	< 5	< 5	< 1.7
CNC23M-04 / 23GLX0401	10-Sep-99	3 ⁽⁴⁾	< 5	< 5	< 5	3 ⁽⁴⁾	< 10	< 10	< 10	< 10	< 10	28	< 5	< 1.2
CNC23M-04 / 23GLX0401D	10-Sep-99	< 5	< 5	< 5	< 5	< 5	< 10	< 10	< 10	< 10	< 10	50	< 5	< 1.9
CNC23TL / 23TL00201 ⁽⁴⁾	10-Sep-99	< 5	< 5	< 5	< 5	< 5	NA	NA	NA	NA	NA	< 5	< 5	NA
CNC23TL / 23TL00101 ⁽⁴⁾	09-Sep-99	< 5	< 5	< 5	< 5	< 5	NA	NA	NA	NA	NA	< 5	< 5	NA

All concentrations are in ug/L.

NA - Not analyzed

⁽¹⁾ South Carolina Department of Health and Environmental Control Risk Based Screening Levels for ground water.

⁽²⁾ The Risk based screening level for individual PAH CoC is 10 ug/l or 25 ug/l for total PAHs.

⁽³⁾ Duplicate

⁽⁴⁾ Trip Blank

⁽⁴⁾ Indicates presence of analyte at a concentration less than the reporting limit and greater than the detection limit.

TABLE 9

FATE AND TRANSPORT INPUT PARAMETERS
 SITE 23, BUILDING 1175
 ZONE F, CHARLESTON NAVAL COMPLEX
 NORTH CHARLESTON, SOUTH CAROLINA

Parameter	Domenico Dilution/Attenuation Model ⁽¹⁾
Hydraulic Conductivity [m/sec]	3.52E-06
Hydraulic Gradient	0.0023
Porosity ^(a)	0.55
Estimated Plume Length [ft]	NA
Soil Bulk Density ^(a) [kg/L]	1.2
Partition Coefficient [L/kg]	chemical specific
Fraction of Organic Carbon in soil [g/g]	1.79E-02
First Order Decay Rate [sec ⁻¹]	0
Modeled Plume Length [ft]	NA
Modeled Plume Width [ft]	NA
Source Width ^(b) [m]	15
Source Thickness ^(b) [m]	2
Soluble Mass [kg]	Infinite ^(c)

Notes:

- (1) - *South Carolina Risk-Based Corrective Action for Petroleum Releases*, South Carolina Department of Health and Environmental Control, 1998
- (a) - Determined from SCDHEC 1998 Tables C1 and C3
- (b) - Default value
- (c) - Assumption of the Domenico model

TABLE 10

COMPARISON OF MAXIMUM CONCENTRATIONS TO RBSLs
 SITE 23, BUILDING 1175
 ZONE F, CHARLESTON NAVAL COMPLEX
 NORTH CHARLESTON, SOUTH CAROLINA

Chemical of Concern	Maximum Concentration Soil (mg/kg)	Soil Leaching RBSLs (mg/kg) ^(a)	Maximum Concentration GW (mg/L)	Tier 1 RBSLs GW (mg/L) ^(b)	Minimum Site RBSL ^(c)
Benzene	ND	0.005	0.14	0.005	0.15
Toluene	ND	0.478	0.011	1	5.38
Ethylbenzene	ND	0.364	0.005	0.7	6.05
Xylenes	ND	1.119	0.003 (J)	10	102.33
Benzo(a)anthracene	ND	17.687	ND	0.010	-
Benzo(b)fluoranthene	ND	7.042	ND	0.010	-
Benzo(k)fluoranthene	ND	5.593	ND	0.010	-
Chrysene	ND	3.146	ND	0.010	-
Dibenzo(a,h)anthracene	ND	21.265	ND	0.010	-
MTBE	NA	NA	4.1	0.400	5.23
Naphthalene	ND	0.052	0.003 (J)	0.010	1.63

(a) - From Risk-Based Corrective Action for Petroleum Releases, Table B4, Depth to GW - <5 ft, SCDHEC RBCA Guidelines, 1998.

(b) - From Risk-Based Corrective Action for Petroleum Releases, Table B1, SCDHEC RBCA Guidelines, 1998.

(c) - Calculated for dermal, incidental ingestion, and inhalation routes for the on-site construction worker and migration to the Cooper River (see Section 3.5.1 of the text and Appendix H).

GW - Groundwater

J - Estimated value detection was above instrument minimum detection limit, but below the practical quantification limit.

RBSLs - Risk-Based Screening Levels

ND - Not detected

NA - Not analyzed

Shaded cell indicates the concentration exceeded one of the RBSLs

TABLE 11

**EXPOSURE PATHWAY ASSESSMENT - CURRENT USE
SITE 23, BUILDING 1175
ZONE F, CHARLESTON NAVAL COMPLEX
NORTH CHARLESTON, SOUTH CAROLINA**

Media	Exposure Route	Pathway Selected for Evaluation? (Yes or No)	Exposure point or Reason for Non-Selection	Data Requirements (if pathway selected)
Air	Inhalation	No	No volatilization to enclosed space. No explosion hazard.	
	Explosion Hazard	No		
Groundwater	Ingestion	No	No water supply well downgradient or residential basements.	
	Dermal contact	No		
	Inhalation	No		
Surface Water	Ingestion	No	Cooper River 900 feet downgradient	
	Dermal contact	No		
	Inhalation	No		
Surficial Soil	Ingestion	No	No impacted surface soil	
	Dermal contact	No		
	Inhalation	No		
Subsurface Soil	Ingestion -	No	No impacted subsurface soil	
	Dermal contact	No		
	Inhalation	No		

TABLE 12

**EXPOSURE PATHWAY ASSESSMENT - FUTURE USE
SITE 23, BUILDING 1175
ZONE F, CHARLESTON NAVAL COMPLEX
NORTH CHARLESTON, SOUTH CAROLINA**

Media	Exposure Route	Pathway Selected for Evaluation? (Yes or No)	Exposure point or Reason for Non-Selection	Data Requirements (if pathway selected)
Air	Inhalation	No	No volatilization to enclosed space. No explosion hazard.	
	Explosion Hazard	No		
Groundwater	Ingestion	Yes	Future use of property expected to be industrial or commercial. Utility located within 100 feet; therefore, construction worker exposure possible.	No additional data required
	Dermal contact	Yes		
	Inhalation	Yes		
Surface Water	Ingestion	Yes	Cooper River 900 feet downgradient	No additional data required
	Dermal contact	No		
	Inhalation	No		
Surficial Soil	Ingestion	No	No impacted surface soil	
	Dermal contact	No		
	Inhalation	No		
Subsurface Soil	Ingestion	No	No impacted subsurface soil	
	Dermal contact	No		
	Inhalation	No		

TABLE 13

COMPARISON OF MAXIMUM GROUNDWATER CONCENTRATIONS TO SSTLs
 SITE 23, BUILDING 1175
 ZONE F, CHARLESTON NAVAL COMPLEX
 NORTH CHARLESTON, SOUTH CAROLINA

Chemical of Concern	Source Area Concentration (mg/L)	SSTLs Protective of Surface Water (Cooper River)		SSTLs Protective of Construction Workers	Minimum On-Site SSTLs ^(a)
		SSTL _{SOURCE} (mg/L)	SSTL _{COMP} (mg/L)	SSTL _{SOURCE} (mg/L)	(mg/L)
Benzene	0.14	1.02	0.93	0.15	0.15
MTBE	4.10	8.161	7.454	25.9	8.161

mg/L - milligrams per liter

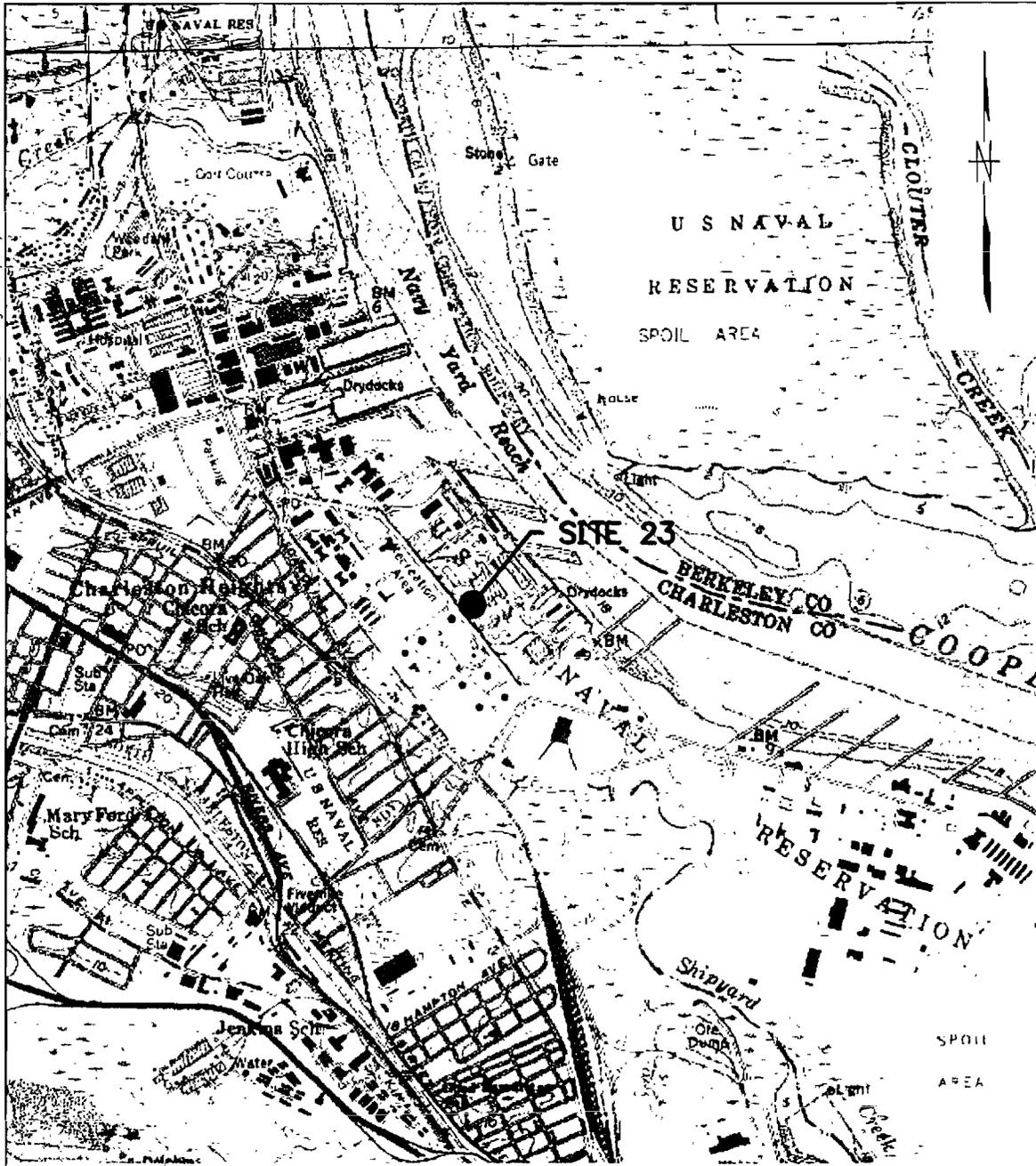
GW - Groundwater

Shaded cell indicates the concentration exceeded the SSTL.

(a) The minimum on-site SSTLs are chosen as those SSTLs protective of both surface water (the Cooper River) and the on-site construction worker.

FIGURES

ACAD-0219CM14.dwg 11/09/99 HJP



SOURCE: QUADRANGLE MAP SOUTH CAROLINA, REVISED 1979
 QUADRANGLE MAP NORTH CHARLESTON, REVISED, 1979

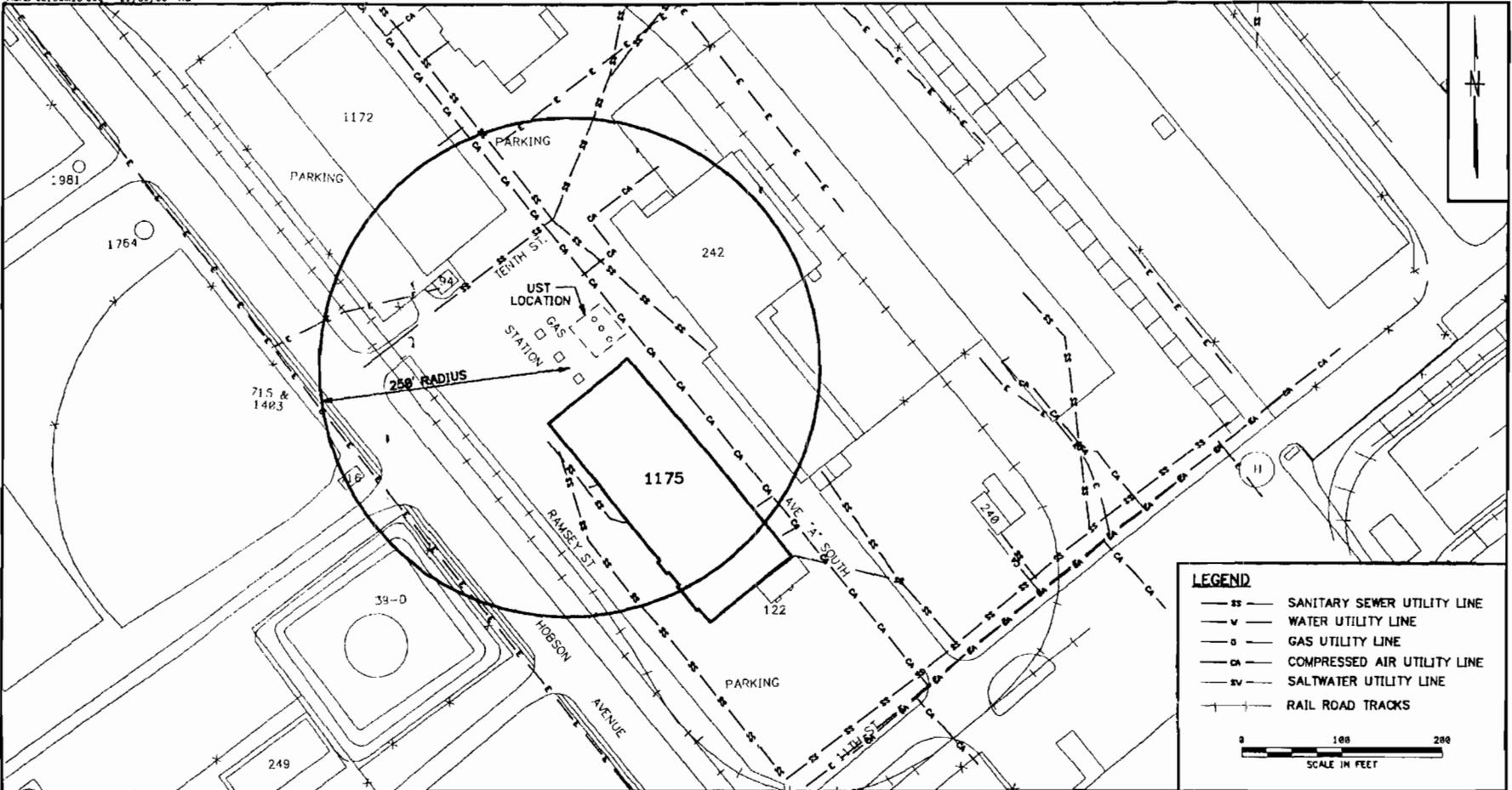


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HJP	11/4/99
CHECKED BY	DATE
COST/SCHED-AREA	
SCALE AS NOTED	



SITE LOCATION MAP
SITE 23, BUILDING 1175
ZONE F, CHARLESTON NAVAL COMPLEX
NORTH CHARLESTON, SOUTH CAROLINA

CONTRACT NO. 0219	
APPROVED BY	DATE
APPROVED BY	DATE
DRAWING NO. FIGURE 1	REV. 0



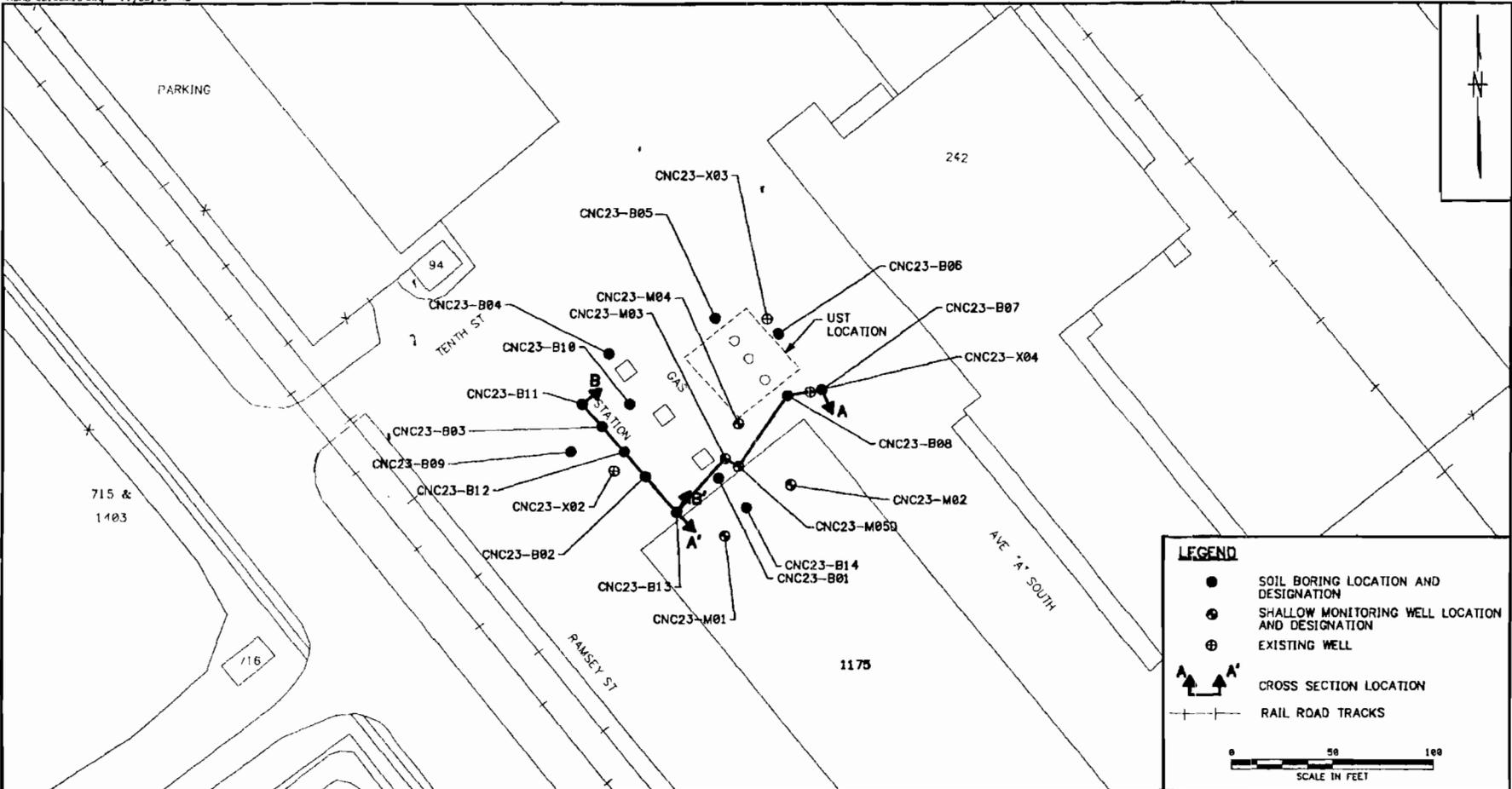
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DRAWN BY HJP DATE 11/3/99
 CHECKED BY DATE
 COST/SCHED-AREA
 SCALE AS NOTED



SITE VICINITY MAP
 SITE 23, BUILDING 1175
 ZONE F, CHARLESTON NAVAL COMPLEX
 NORTH CHARLESTON, SOUTH CAROLINA

CONTRACT NO. 0219	
APPROVED BY	DATE
APPROVED BY	DATE
DRAWING NO. FIGURE 2	REV. 0



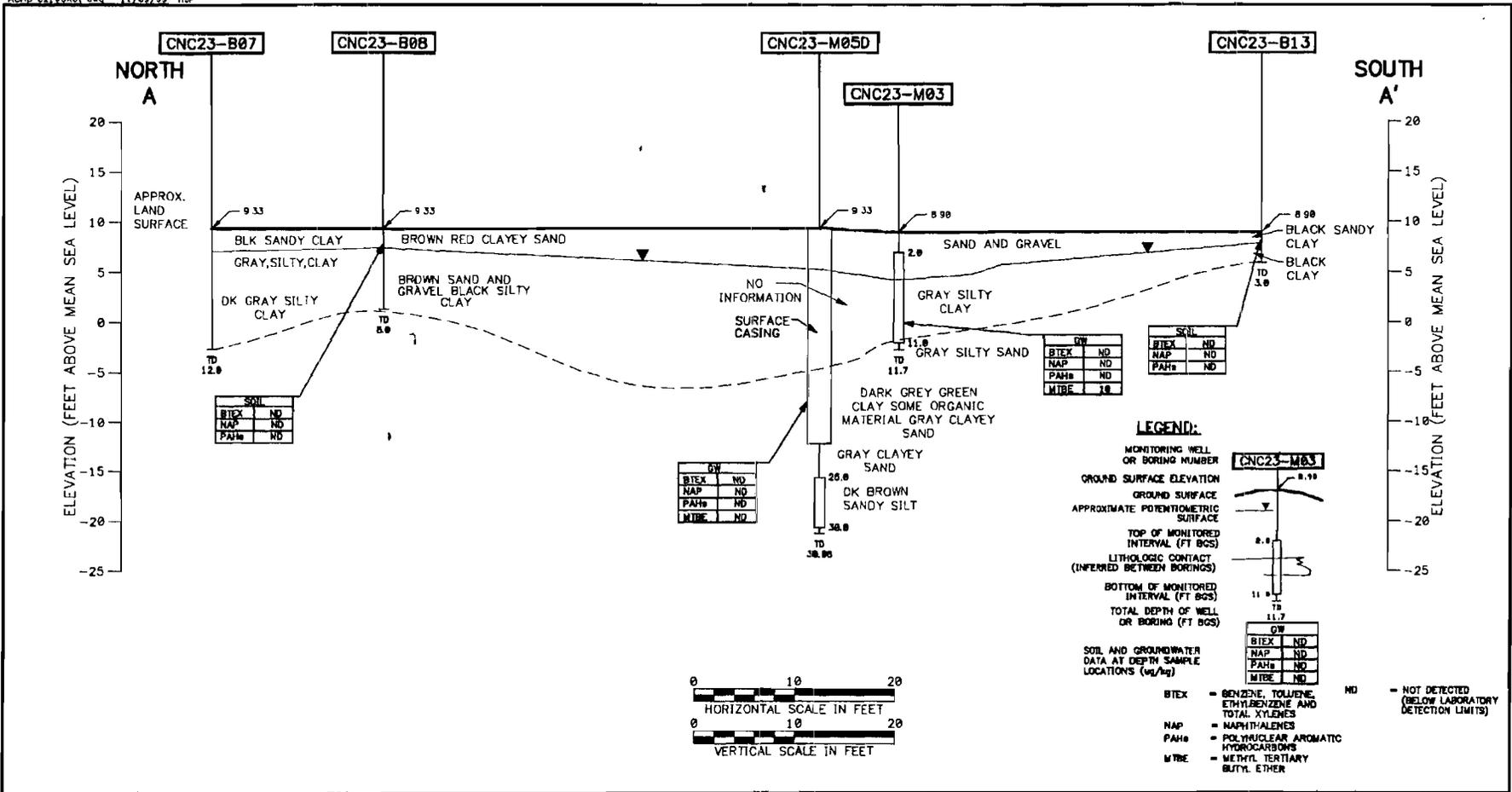
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DRAWN BY HJP DATE 11/3/99
 CHECKED BY DATE
 COST/SCHED-AREA
 SCALE AS NOTED

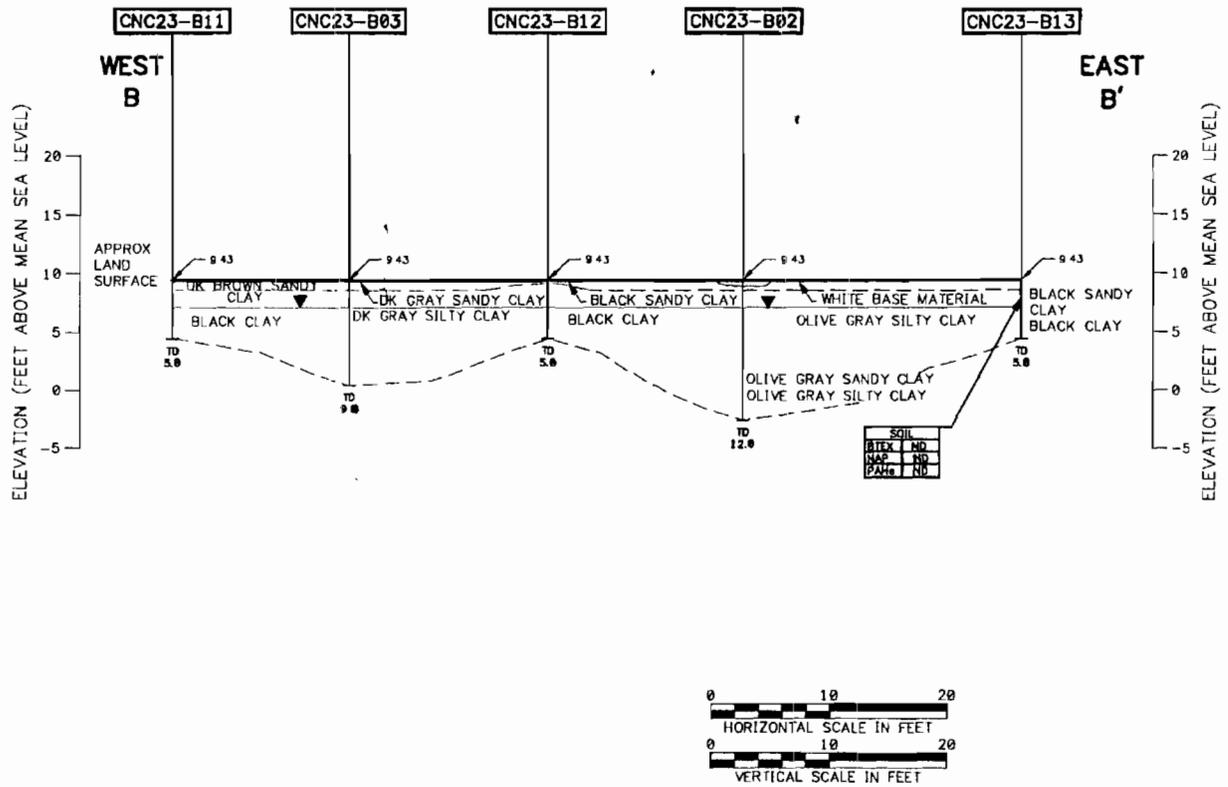


SITE MAP AND SAMPLING LOCATIONS
 SITE 23, BUILDING 1175
 ZONE F, CHARLESTON NAVAL COMPLEX
 NORTH CHARLESTON, SOUTH CAROLINA

CONTRACT NO. 0219	
APPROVED BY	DATE
APPROVED BY	DATE
DRAWING NO. FIGURE 3	REV. 0



NO.	DATE	REVISIONS	BY	CRKD	APPD	REFERENCES	DRAWN BY HJP	DATE 11/4/99		GEOLOGIC CROSS SECTION A-A' SITE 23, BUILDING 1170 ZONE F, CHARLESTON NAVAL COMPLEX NORTH CHARLESTON, SOUTH CAROLINA	CONTRACT NO. 0219	
							CHECKED BY	DATE			APPROVED BY	DATE
							COST/SCHED-AREA				APPROVED BY	DATE
							SCALE AS NOTED				DRAWING NO. FIGURE 4	REV. 0



LEGEND:

MONITORING WELL OR BORING NUMBER **CNC23-B11**

GROUND SURFACE ELEVATION

GROUND SURFACE

APPROXIMATE POTENTIOMETRIC SURFACE

TOP OF MONITORED INTERVAL (FT BOS)

LITHOLOGIC CONTACT (INFERRED BETWEEN BORINGS)

BOTTOM OF MONITORED INTERVAL (FT BOS)

TOTAL DEPTH OF WELL OR BORING (FT BOS)

SOIL AND GROUNDWATER DATA AT DEPTH SAMPLE LOCATIONS (µg/kg)

SOIL	
BTEX	ND
NAP	ND
PAHs	ND

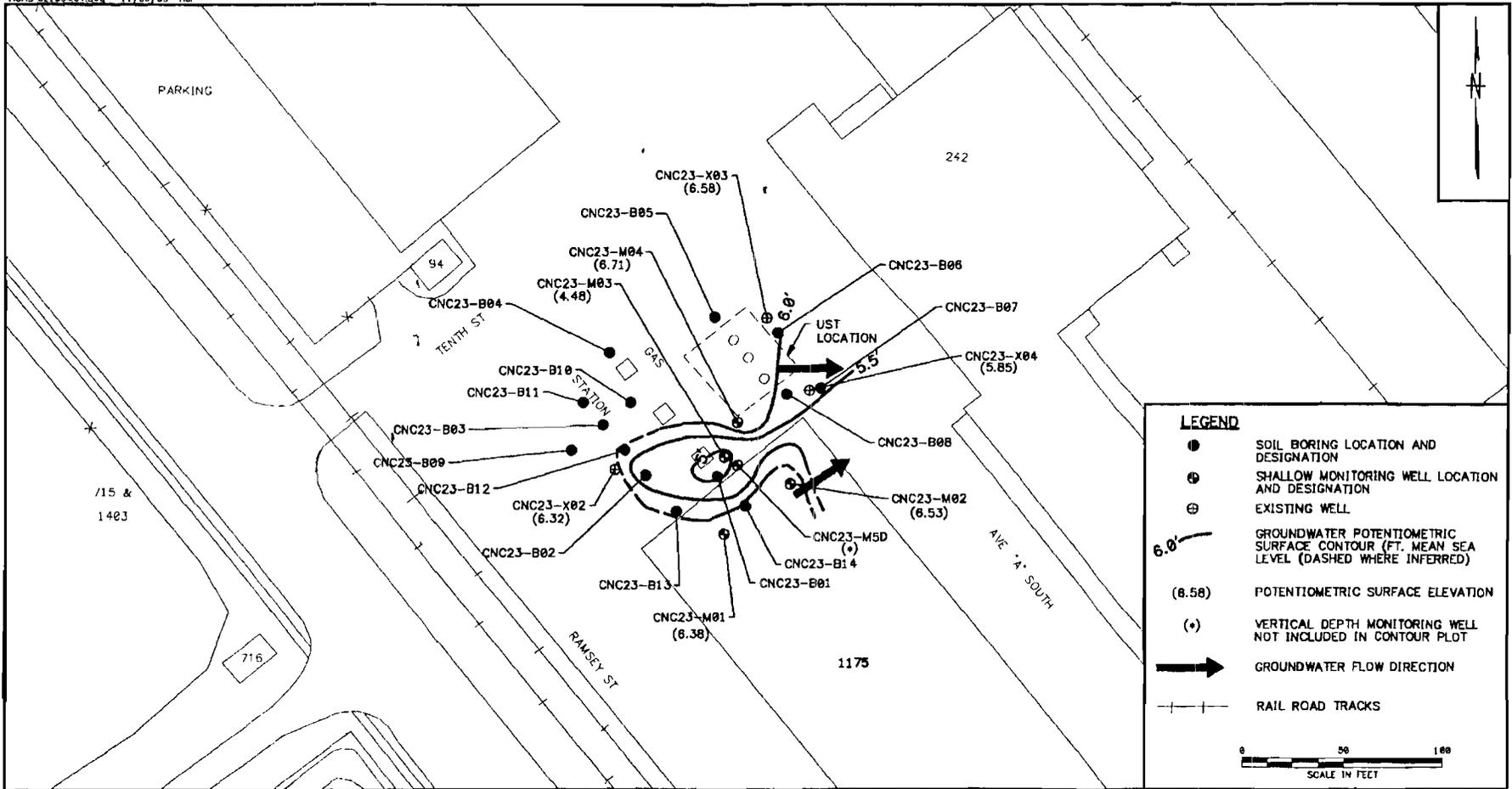
BTEX = BENZENE, TOLUENE, ETHYLBENZENE AND TOTAL XYLENES

NAP = NAPHTHALENES

PAHs = POLYNUCLEAR AROMATIC HYDROCARBONS

ND = NOT DETECTED (BELOW LABORATORY DETECTION LIMITS)

NO.	DATE	REVISIONS	BY	CHKD	APPD	REFERENCES	DRAWN BY	DATE		GEOLOGIC CROSS SECTION B-B' SITE 23, BUILDING 1175 ZONE F, CHARLESTON NAVAL COMPLEX NORTH CHARLESTON, SOUTH CAROLINA	CONTRACT NO.	
							HJP	11/4/99			0219	
							COST/SCHED-AREA				APPROVED BY	DATE
							SCALE	AS NOTED			APPROVED BY	DATE
											DRAWING NO.	REV.
											FIGURE 5	0



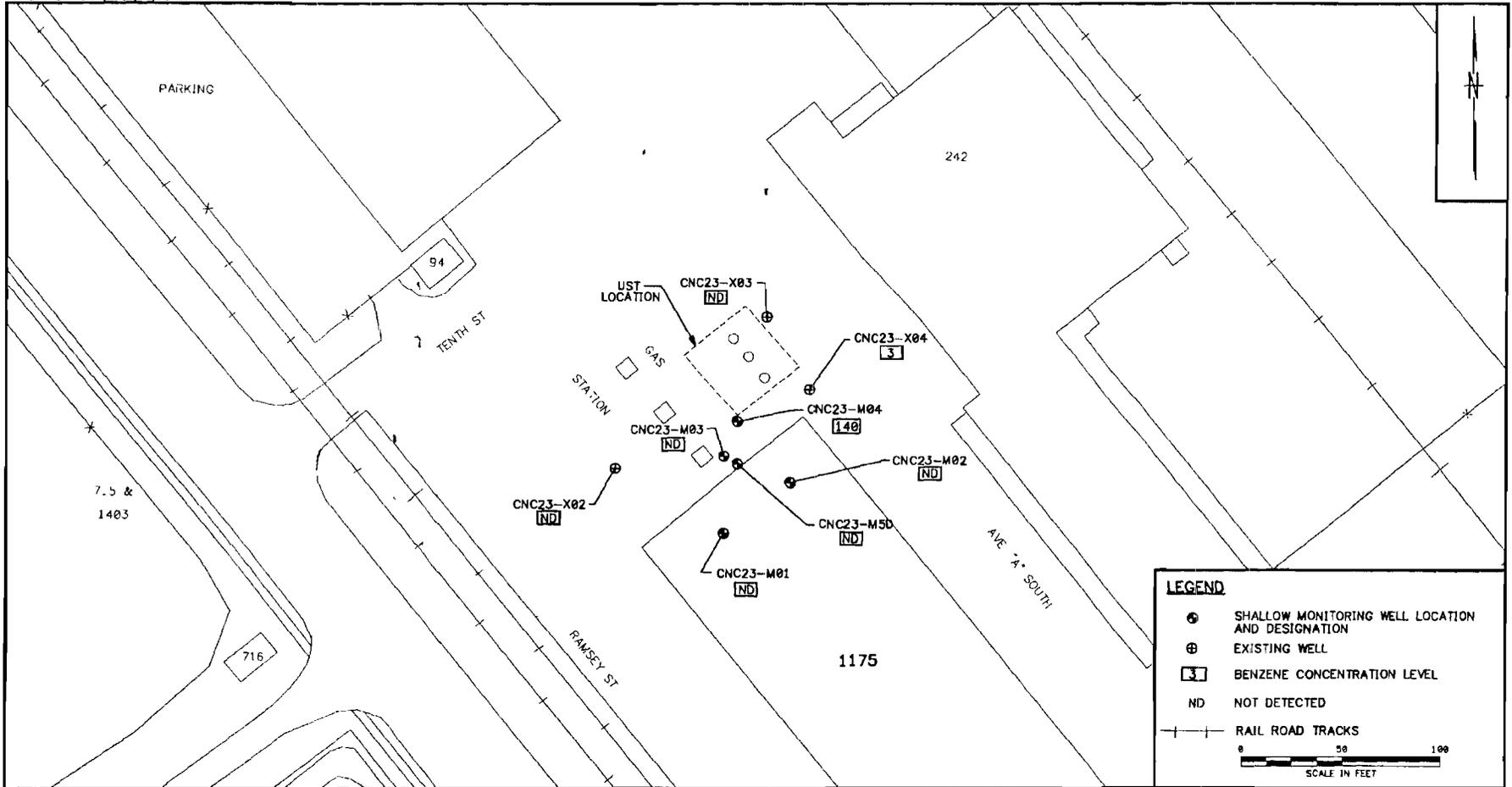
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DRAWN BY: HJP DATE: 11/3/99
 CHECKED BY: DATE: _____
 COST/SCHED-AREA: _____
 SCALE: AS NOTED



GROUNDWATER POTENTIOMETRIC MAP
 (SEPTEMBER 9, 1999)
 SITE 23, BUILDING 1175
 ZONE F, CHARLESTON NAVAL COMPLEX
 NORTH CHARLESTON, SOUTH CAROLINA

CONTRACT NO. 0219	
APPROVED BY	DATE
APPROVED BY	DATE
DRAWING NO. FIGURE 6	REV. 0



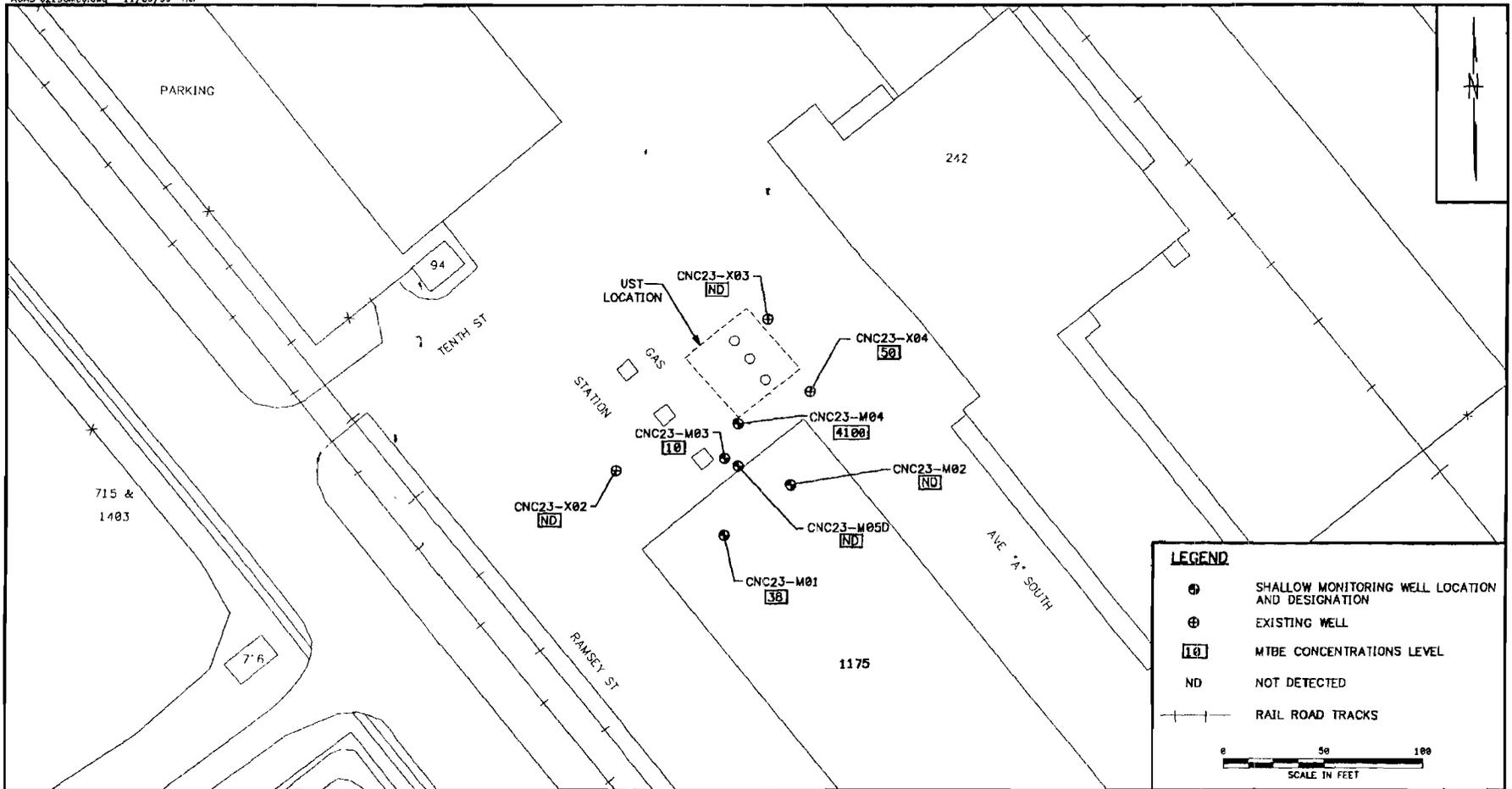
NO.	DATE	REVISIONS	BY	CHKD	APPD	REFERENCES

DRAWN BY HJP DATE 11/3/99
 CHECKED BY DATE
 COST/SCHED-AREA
 SCALE AS NOTED



GROUNDWATER BENZENE CONCENTRATION MAP
 (SEPTEMBER 10, 1999)
 SITE 23, BUILDING 1175
 ZONE F, CHARLESTON NAVAL COMPLEX
 NORTH CHARLESTON, SOUTH CAROLINA

CONTRACT NO. 0219	
APPROVED BY	DATE
APPROVED BY	DATE
DRAWING NO. FIGURE 7	REV. 0



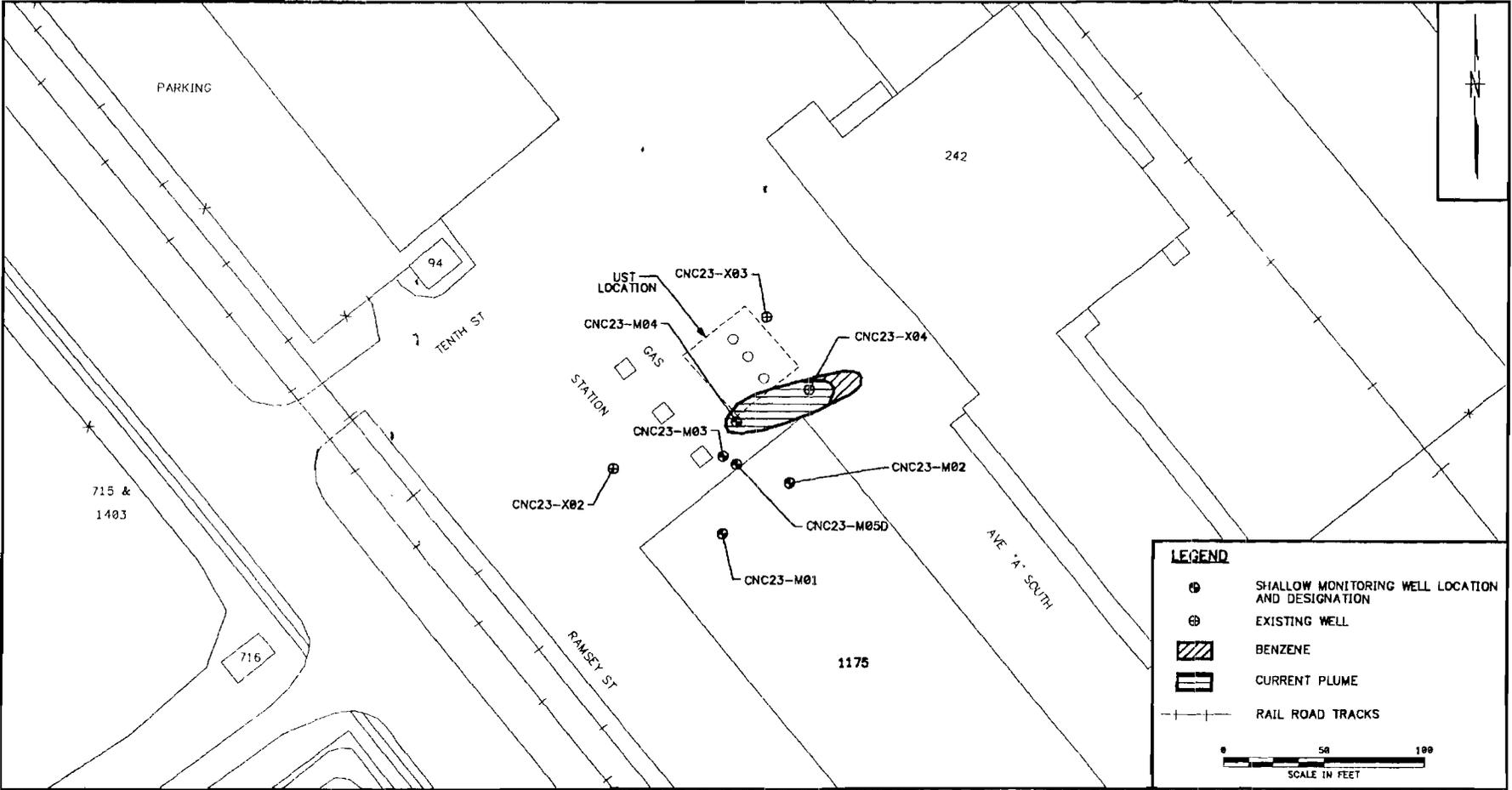
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DRAWN BY: HJP
 DATE: 11/3/99
 CHECKED BY: _____
 DATE: _____
 COST/SCHED-AREA: _____
 SCALE: AS NOTED



GROUNDWATER MTBE CONCENTRATION MAP
 (SEPTEMBER 10, 1998)
 SITE 23, BUILDING 1175
 ZONE F, CHARLESTON NAVAL COMPLEX
 NORTH CHARLESTON, SOUTH CAROLINA

CONTRACT NO. 0219
 APPROVED BY: _____ DATE: _____
 APPROVED BY: _____ DATE: _____
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 REV. 0



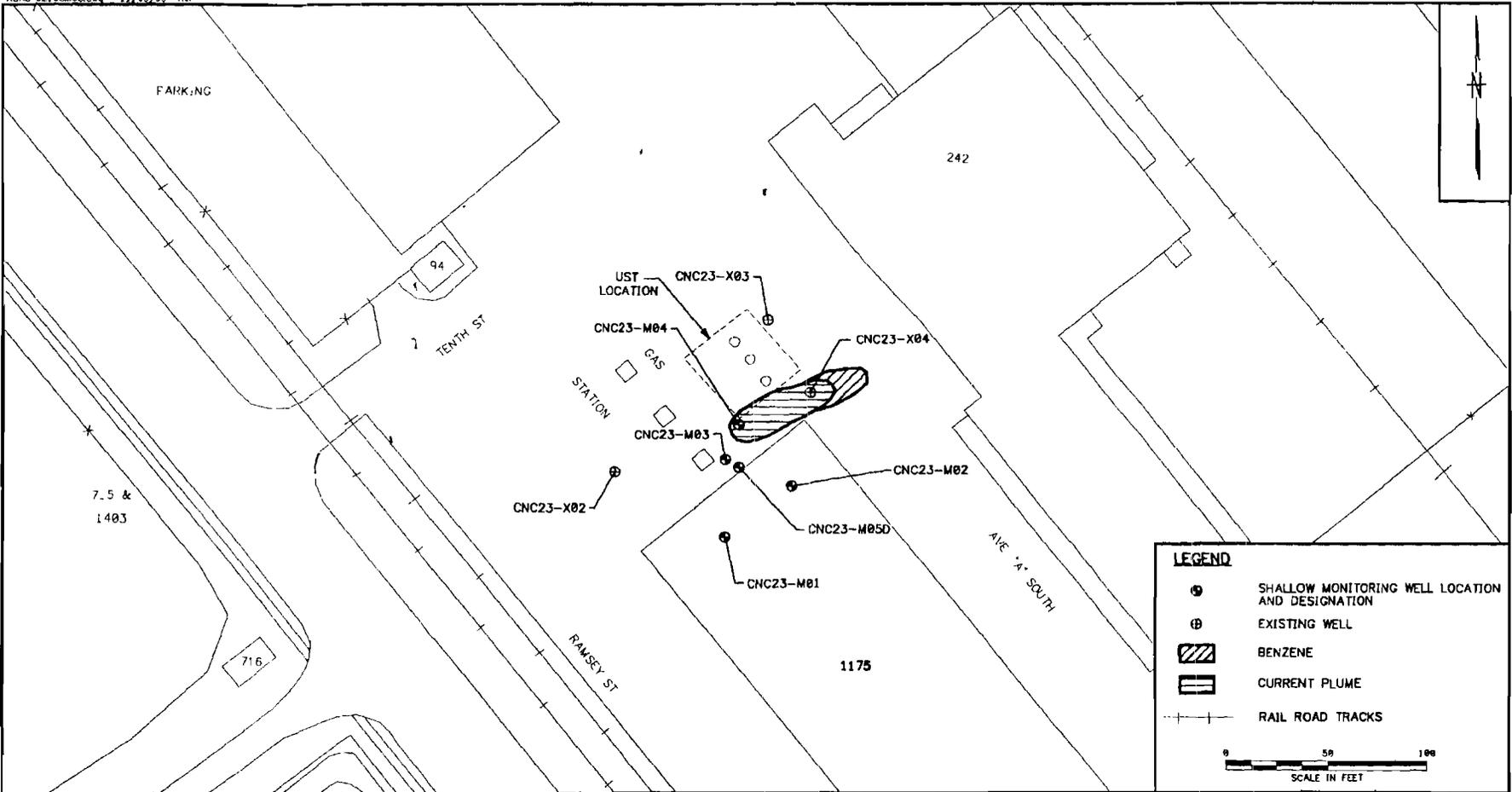
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DRAWN BY: HJP DATE: 11/4/99
 CHECKED BY: DATE: _____
 COST/SCHED-AREA: _____
 SCALE: AS NOTED



PREDICTED 10 YEAR MIGRATION
 SITE 23, BUILDING 1175
 ZONE F, CHARLESTON NAVAL COMPLEX
 NORTH CHARLESTON, SOUTH CAROLINA

CONTRACT NO. 0219	
APPROVED BY	DATE
APPROVED BY	DATE
DRAWING NO. FIGURE 9	REV. 0



LEGEND

- ⊙ SHALLOW MONITORING WELL LOCATION AND DESIGNATION
- ⊕ EXISTING WELL
- ▨ BENZENE
- ▬ CURRENT PLUME
- +—+—+ RAIL ROAD TRACKS

0 50 100
SCALE IN FEET

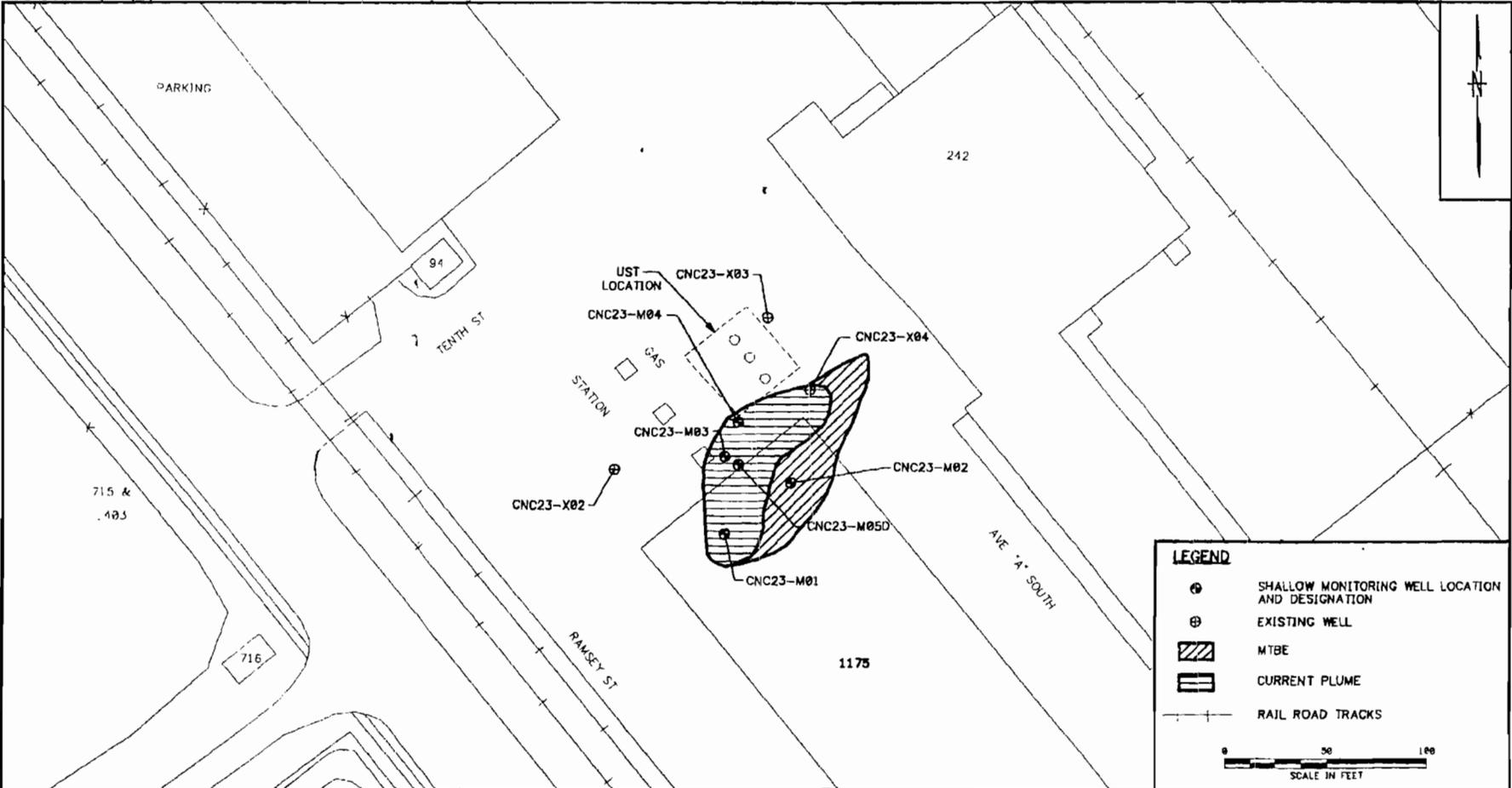
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 CHECKED BY: DATE: _____
 COST/SCHED-AREA: _____
 SCALE: AS NOTED



PREDICTED 20 YEAR MIGRATION
 SITE 23, BUILDING 1175
 ZONE F, CHARLESTON NAVAL COMPLEX
 NORTH CHARLESTON, SOUTH CAROLINA

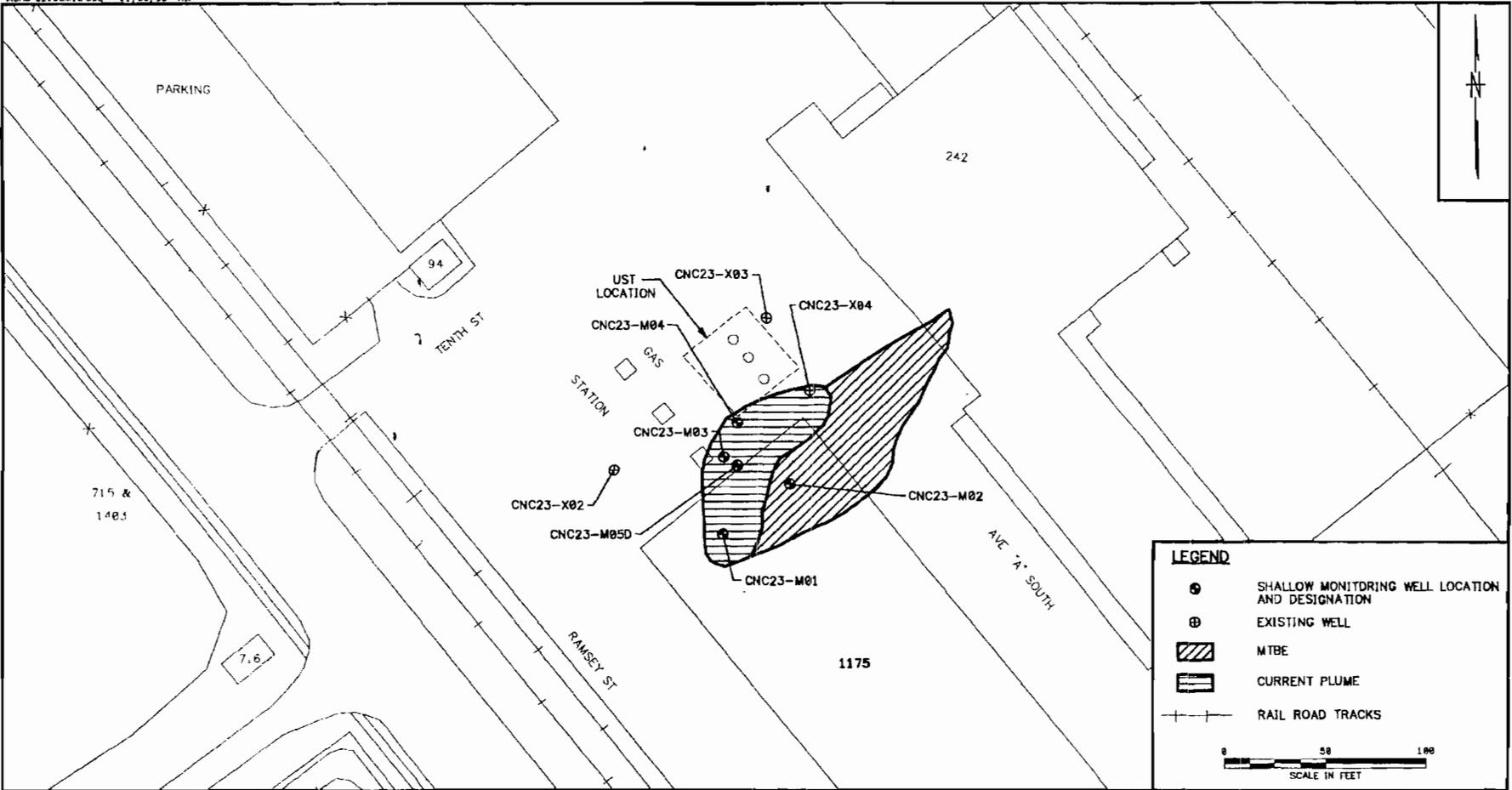
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NO.	DATE	REVISIONS	BY	CHKD	APPO	REFERENCES	SCALE	AS NOTED	CONTRACT NO.	APPROVED BY	DATE	DRAWING NO.	REV.
									0219			FIGURE 11	0



PREDICTED 10 YEAR MIGRATION
 SITE 23, BUILDING 1175
 ZONE F, CHARLESTON NAVAL COMPLEX
 NORTH CHARLESTON, SOUTH CAROLINA



NO.	DATE	REVISIONS	BY	CHKD	APPD	REFERENCES

DRAWN BY: HJP 11/4/99
 DATE: 11/4/99
 CHECKED BY: DATE:
 COST/SCHED-AREA:
 SCALE: AS NOTED



PREDICTED 20 YEAR MIGRATION
 SITE 23, BUILDING 1175
 ZONE F, CHARLESTON NAVAL COMPLEX
 NORTH CHARLESTON, SOUTH CAROLINA

CONTRACT NO. 0219
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 APPROVED BY: DATE:
 DRAWING NO. FIGURE 12
 REV. 0