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FUEL DISTRIBUTION SYSTEM CONTAMINATION ASSESSMENT REPORT ZONE G
VOLUME I OF III SECTION 1 TO 7 CNC CHARLESTON SC
9/10/1998
ENSAFE

ZONE G
FUEL DISTRIBUTION SYSTEM
CONTAMINATION ASSESSMENT REPORT
NAVBASE CHARLESTON
NORTH CHARLESTON, SOUTH CAROLINA

Volume I of III
Sections 1 to 7

CTO-029
Contract Number: N62467-89-D-0318

Prepared for:

Department of the Navy
Southern Division
Naval Facilities Engineering Command
North Charleston, South Carolina

Prepared by:

EnSafe Inc.
5724 Summer Trees Drive
Memphis, Tennessee 38134
(901) 372-7962

September 10, 1998
Revision: 0

ENSAFE

ENSAFE INC ENVIRONMENTAL AND MANAGEMENT CONSULTANTS

935 Houston Northcutt Blvd., Suite 113 • Mt. Pleasant, SC 92464 • Telephone 843-884-0029 • Facsimile 843-856-0107 • www.ensafe.com

September 10, 1998

Commanding Officer
ATTN: Mr. Gabriel L. Magwood, Code 1849
Naval Facilities Engineering Command
Southern Division
2155 Eagle Drive
P.O. Box 190010
North Charleston, South Carolina 29419-9010

RE: Contamination Assessment Report for the Fuel Distribution System, NAVBASE Charleston, Charleston, South Carolina.

Dear Mr. Magwood:

EnSafe Inc. is pleased to submit the Draft-Final Contamination Assessment Report (CAR) for the Fuel Distribution System (FDS) at NAVBASE Charleston. Your comment regarding Table 1.1 has been incorporated into this version of the report.

Copies of the CAR are being forwarded to Paul Bristol of the South Carolina Department of Health and Environmental Control (SCDHEC) for review and comment. Courtesy copies are also being forwarded to the NAVBASE Charleston RCRA Project Team to keep them apprized of the status and ongoing activity at the FDS. This includes a copy which was originally intended for Daryle Fontenot who has since left the team. A complete distribution list is provided at the bottom of this letter.

Should you have any questions or concerns regarding the CAR please do not hesitate to contact me directly at 850-434-2230. Thank you for the opportunity to assist with the assessment of these areas.

Sincerely,
EnSafe Inc.

Diane M. Maddux

for Craig R. Smith
Project Manager

Distribution List

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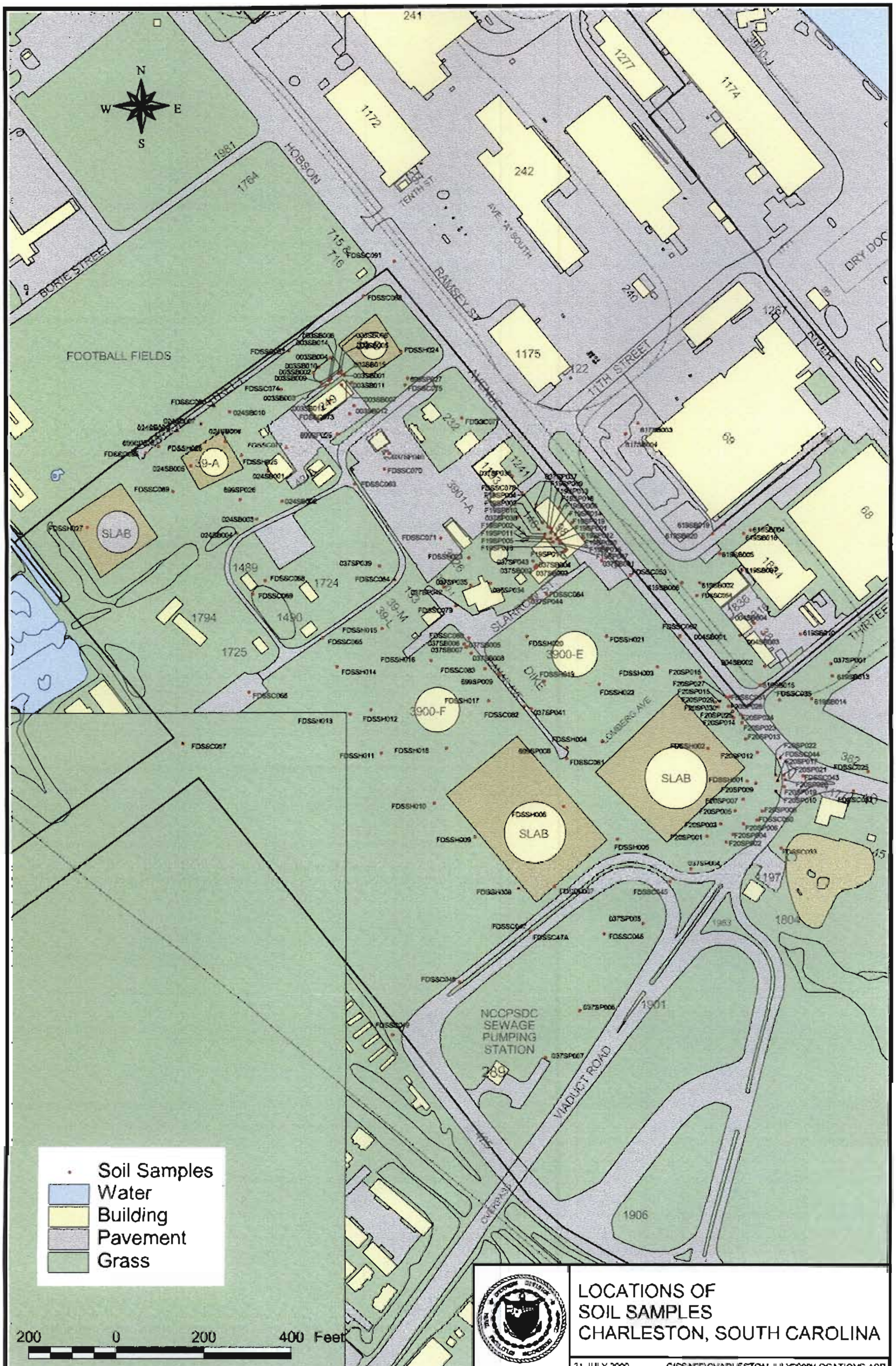

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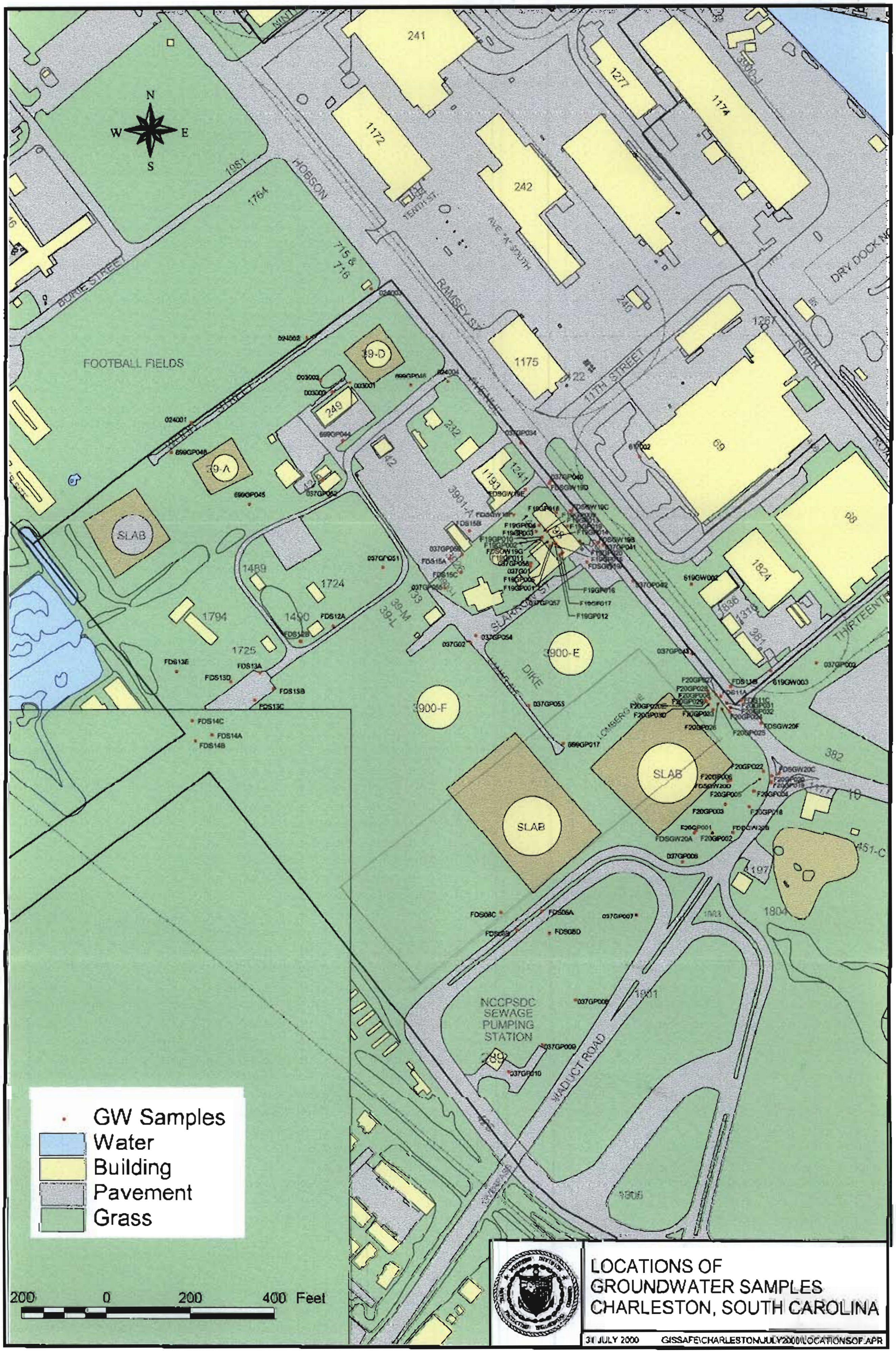

LOCATIONS OF
GROUNDWATER SAMPLES
CHARLESTON, SOUTH CAROLINA
31 JULY 2000
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ZONE G
FUEL DISTRIBUTION SYSTEM
CONTAMINATION ASSESSMENT REPORT
NAVBASE CHARLESTON
NORTH CHARLESTON, SOUTH CAROLINA

Volume I of III
Sections 1 to 7

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ABBREVIATIONS, ACRONYMS, AND SYMBOLS

The following abbreviations, acronyms, and units of measurement are used in this report.

AOC	Area of Concern
AST	Aboveground Storage Tank
ASTM	American Society for Testing and Materials
BEST	Building Economic Solutions Together
BTEX	Benzene, Toluene, Ethylbenzene, and Xylene
bgs	Below ground surface
BOS	Bottom of screen
BOW	Bottom of well
BRAC	Base Realignment and Closure Act of 1988 and Defense Base and Realignment Closure Act of 1990, collectively
°C	Degrees Centigrade
CAP	Corrective Action Plan
CAR	Contamination Assessment Report
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
cm	Centimeter
CMI	Corrective Measures Implementation
CMS	Corrective Measures Study
COC	Chemical of Concern
CPT	Cone Penetrometer Testing
CSAP	Comprehensive Sampling and Analysis Plan
DAF	Dilution Attenuation Factor
DRO	Diesel Range Organics
DQO	Data Quality Objective
E/A&H	EnSafe/Allen & Hoshall
EDB	Ethylene dibromide
EnSafe	EnSafe Inc.
ESDSOPQAM	Environmental Services Division Standard Operating Procedures and Quality Assurance Manual
FDS	Fuel Distribution System
FID	Flame Ionization Detector
FISC	Fleet and Industrial Supply Center
FSA	Full Scan Analyses
ft bgs	Feet below ground surface
ft^2/day	Square feet per day
ft msl	Feet above mean sea level

ABBREVIATIONS, ACRONYMS, AND SYMBOLS (Continued)

gpm	Gallons per minute
GPS	Global Positioning System
GRO	Gasoline Range Organics
HASP	Health and Safety Plan
HQ	Hazard Quotient
HSWA	Hazardous and Solid Waste Amendments
ICM	Interim Corrective Measure
ID	Inside Diameter
IM	Interim Measure
IRP	Installation Restoration Program
kph	Kilometers per hour
LIF	Laser Induced Fluorescence
LNAPL	Light Non-aqueous Phase Liquid
mg/kg	Milligram per kilogram
msl	Mean sea level
MTBE	Methyl-tert-butyl ether
NA	Not Available/Not Applicable
NAVBASE	Naval Base Charleston
ND	Not Detected
NFESC	Naval Facilities Engineering Service Center
NM	Not Measured
NT	Not Taken
NTU	Nephelometric turbidity unit
OP	Organophosphorous
OVA	Organic vapor analyzer
PAH	Polynuclear Aromatic Hydrocarbon
PCB	Polychlorinated biphenyl
ppm	Parts per million
PPE	Personal protective equipment
PVC	Polyvinyl Chloride
QA	Quality Assurance
QC	Quality Control

ABBREVIATIONS, ACRONYMS, AND SYMBOLS (Continued)

RAB	Restoration Advisory Board
RBC	Risk-Based Concentration
RBSL	Risk-Based Screening Level
RCRA	Resource Conservation and Recovery Act
RDA	Redevelopment Authority
RFA	RCRA Facility Assessment
RFI	RCRA Facility Investigation
SCAPS	Site Characterization and Analysis Penetrometer System
SCDHEC	South Carolina Department of Health and Environmental Control
SESE	Shipboard Electronics System Evaluation
SOUTHNAVFAC-ENGCOM	Southern Division Naval Facilities Engineering Command
SSL	Soil Screening Level
SUPSHIP	Supervisor of Shipbuilding
SVOC	Semivolatile Organic Compound
SWMU	Solid Waste Management Unit
Ta	Ashley Formation
TCDD	Tetrachlorodibenzo-p-dioxin
TEQ	TCDD equivalency quotient
THQ	Target Hazard Quotient
Tmh	Marks Head Formation
TOC	Top of Casing/Total Organic Carbon
TOS	Top of Screen
TPH	Total Petroleum Hydrocarbons
USEPA	United States Environmental Protection Agency
USFWS	United States Fish and Wildlife Service
UST	Underground Storage Tank
VOC	Volatile Organic Compound
μg/kg	Microgram per kilogram
μg/L	Microgram per liter

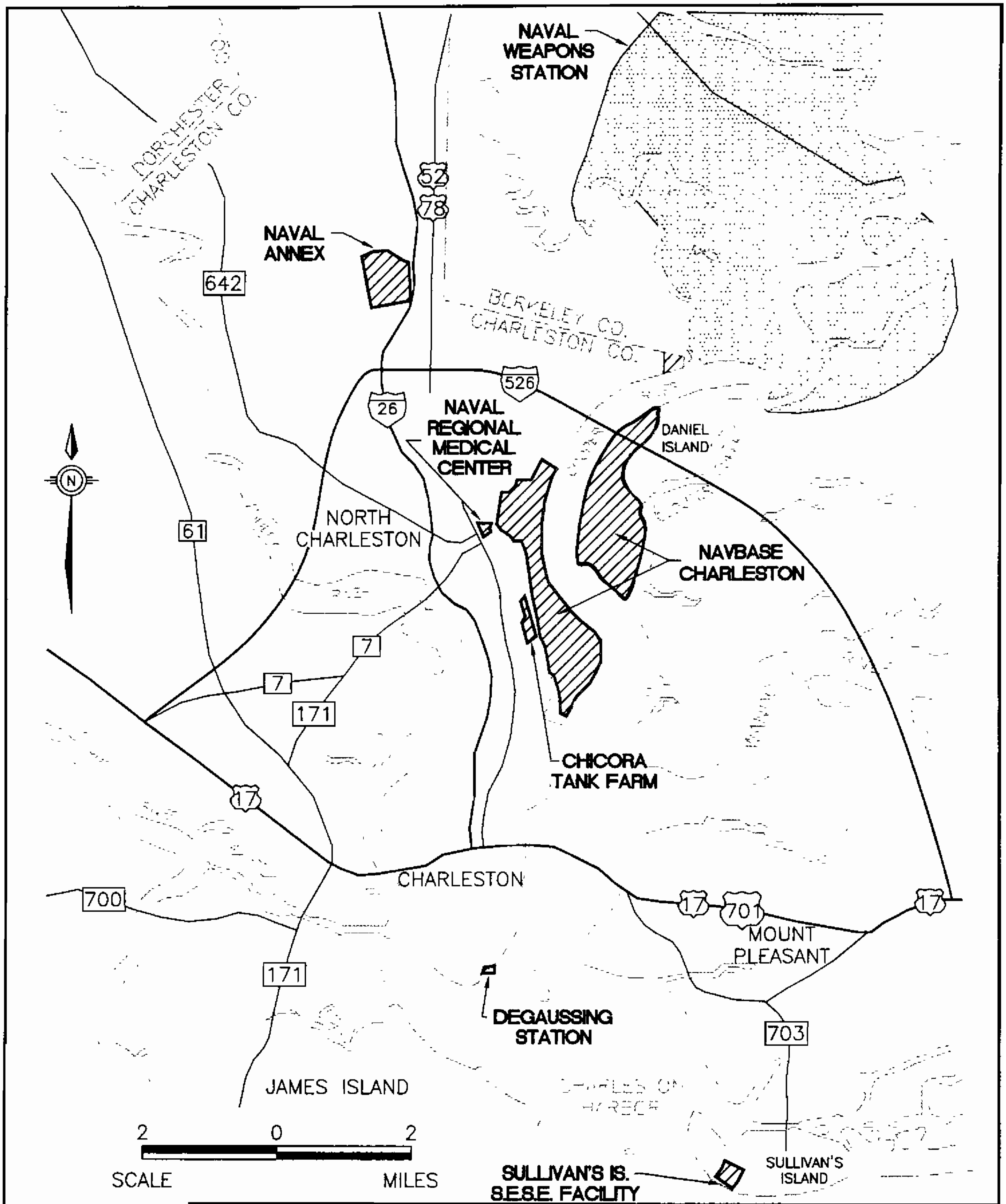
1.0 INTRODUCTION

The environmental investigation and remediation at Naval Base Charleston (NAVBASE) are required by the Hazardous and Solid Waste Amendments (HSWA) portion of the Resource Conservation and Recovery Act (RCRA) Part B permit (permit number: SCO 170 022 560) (South Carolina Department of Health and Environmental Control [SCDHEC], May 4, 1990). These conditions are consistent with the RCRA Corrective Action Program, whose objectives are to evaluate the nature and extent of any hazardous waste or constituent releases, and to identify, develop, and implement appropriate corrective measures to protect human health and the environment. The Fuel Distribution System (FDS) at NAVBASE encompasses the entire pipeline distribution system and many petroleum-related sites in Zones F and G, and traverses areas on Zones E, F, and G. The FDS was originally included in the RCRA Facility Investigation (RFI) for Zone G. However, because the initial sampling results indicated that contamination is primarily petroleum-related, most of the FDS was transferred to the SCDHEC Underground Storage Tank (UST) program. The decision to transfer the FDS was agreed on by representatives from the U.S. Navy Southern Division Naval Facilities Engineering Command (SOUTHNAVFACENGCOM), U.S. Environmental Protection Agency (USEPA) and SCDHEC. This FDS Contamination Assessment Report (CAR), prepared by EnSafe Inc. (EnSafe), addresses the field investigation and contamination assessment results of the FDS at NAVBASE.

1.1 NAVBASE Description and Background

Location

NAVBASE is in the city of North Charleston, on the banks of the Cooper River in Charleston County, South Carolina (Figure 1-1). This installation consists of two major areas: a developed area on the west bank of the Cooper River and an undeveloped dredged materials area on the east bank of the Cooper River on Daniel Island in Berkeley County.



FUEL DISTRIBUTION SYSTEM CONTAMINATION ASSESSMENT REPORT
NAVAL BASE CHARLESTON
CHARLESTON, S.C.

FIGURE 1-1
LOCATION MAP
NAVAL BASE CHARLESTON
CHARLESTON, SOUTH CAROLINA

DWG DATE: 07/07/98 | DWG NAME: 2907N012

The developed portion of the base is on a peninsula bounded on the west by the Ashley River and on the east by the Cooper River. Major commands that once occupied areas of the base include Charleston Naval Shipyard, Fleet Ballistic Missile Submarine Training Center, Fleet and Industrial Supply Center (FISC), Fleet and Mine Warfare Training Center, Naval Regional Medical Center Charleston, and Naval Station Charleston. NAVBASE also included the degaussing station in downtown Charleston, the Shipboard Electronics System Evaluation Facility (SESE) on Sullivan's Island, and the Naval Station Annex next to the Charleston Air Force Base.

The areas surrounding NAVBASE are *mature urban*, having long been developed for commercial, industrial, and residential land usage. Commercial areas are primarily west of NAVBASE; industrial areas lie primarily north of NAVBASE and along the west bank of Shipyard Creek.

The area west of Shipyard Creek is primarily industrial and has been for many years. Railways have served the area since the early 1900s. The presence of railways, when combined with nearby waterways, has made the area ideal for industry. While ownership has changed over time, the land adjacent to NAVBASE remains dedicated to chemical, fertilizer, oil refining, metallurgy, and lumber operations.

In contrast, the east bank of the Cooper River is undeveloped and contains extensive wetlands, particularly along Clouter Creek and Thomas Island. Active dredge material disposal areas are located on Navy property between the Cooper River and Clouter Creek.

History

In 1901, the U.S. Navy acquired 2,250 acres near Charleston to build a naval shipyard, and the first naval officer was assigned duty in early 1902. A work force was organized, the Navy yard surveyed, and construction of buildings and a drydock began. The drydock was finished in 1909, along with several other brick buildings and the main power plant. With a work force of approximately 300 civilians, the first ship was placed in drydock and work began on fleet vessels in 1910. World War I brought about an expansion of the yard, land area, and work force, but employment levels dropped after the war. Work increased again at the yard beginning in 1933 when a larger workload, principally construction of several Coast Guard tugs, a Coast Guard cutter, and a Navy gunboat, created the need for more facilities and a much larger work force.

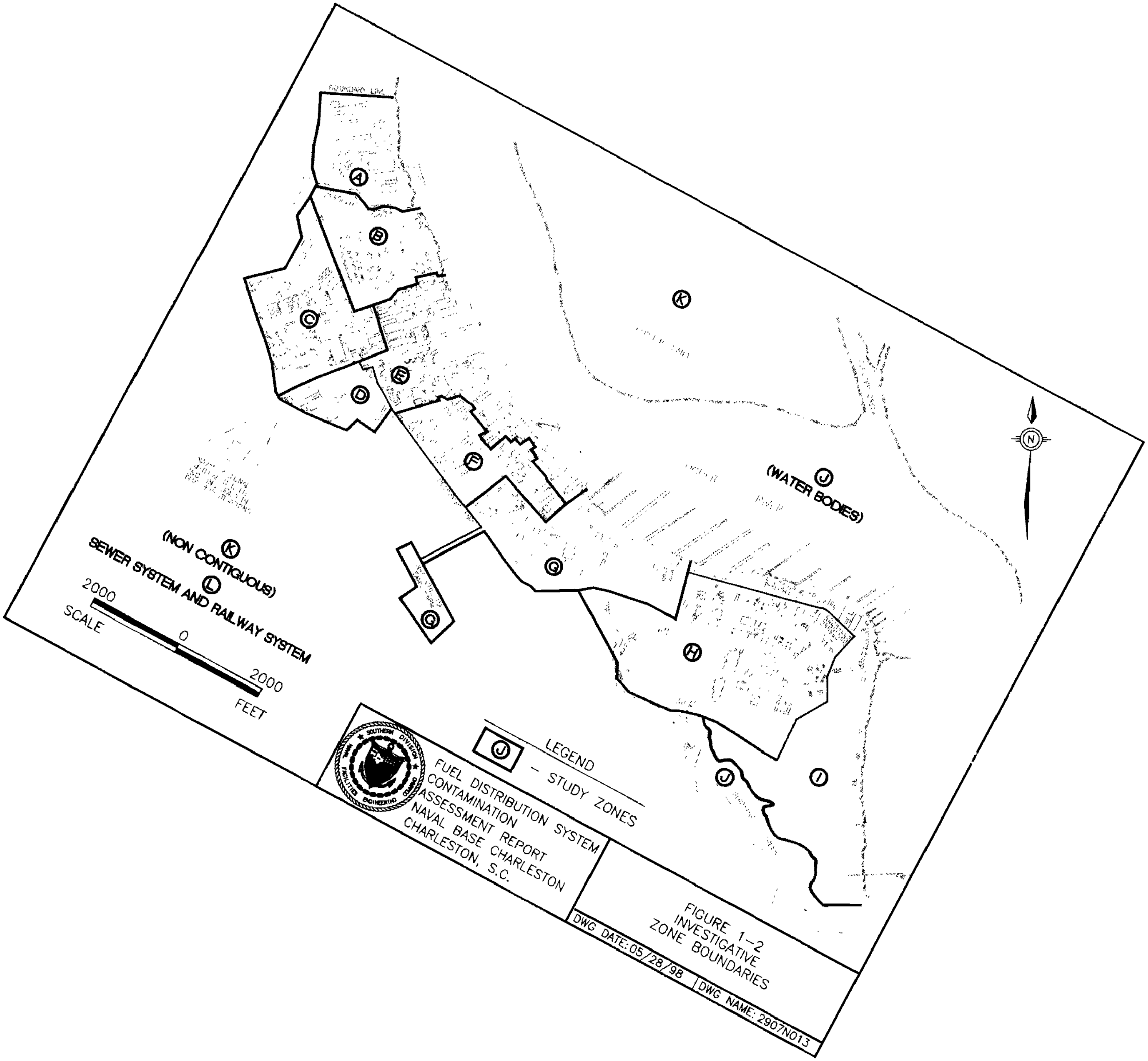
Civilian employment peaked in 1943 with almost 26,000 employees divided among three daily shifts. In 1956, construction began on new piers, barracks, and buildings for mine warfare ships and personnel. Later in the decade, Charleston became a major home port for combat ships and submarines of the U.S. Atlantic Fleet.

Base Closure

In 1993, NAVBASE Charleston was added to the list of bases scheduled for closure under the Base Realignment and Closure Act (BRAC), which regulates the base closures and transition of property to the community. Since the April 1, 1993 closure, operations have been curtailed and environmental cleanup has begun to make the property available for redevelopment.

1.2 Investigative Zone Delineation

Due to the size of the base and the level of detail required for investigations, NAVBASE has been divided into 12 investigative zones, identified as Zones A through L (Figure 1-2). The Restoration Advisory Board (RAB) and the Building Economic Solutions Together (BEST) committees ranked the investigation and cleanup priority of the zones. In 1994, BEST was replaced by the Charleston Naval Complex Redevelopment Authority (RDA), which has authority to establish leases for the transferred property. The FDS includes all pipelines, tanks and structures used to store and distribute fuel from the FISC fuel system within NAVBASE. This includes tanks, pumping systems, and abandoned pipelines. Portions of the FDS are located in Zones E, F, and G.


A
B
C
D
E
F
G
G
H
I
J
J
(WATER BODIES)
K
K
(NON CONTIGUOUS)
L
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SCALE
FEET
LEGEND
J - STUDY ZONES
FUEL DISTRIBUTION SYSTEM
CONTAMINATION
ASSESSMENT REPORT
NAVAL BASE CHARLESTON
CHARLESTON, S.C.
FIGURE 1-2
INVESTIGATIVE
ZONE BOUNDARIES
DWG DATE: 05/28/98
DWG NAME: 2907N013

1.3 Current Investigation

Objective

The objective of this CAR is to present the site background and history, investigative methodology, and contamination assessment results of the field investigation in order to prepare a Corrective Action Plan (CAP) for petroleum contamination related to the FDS.

Field Investigation Scope

Ten Solid Waste Management Units (SWMUs) or Areas of Concern (AOCs) associated with the FDS were identified through the RCRA Facility Assessment (RFA) process, as discussed in the *Final RCRA Facility Assessment for Naval Base Charleston* (EnSafe/Allen and Hoshall [E/A&H], June 6, 1995). Identification of potential SWMUs and AOCs was based on the best information available at that time and is subject to change should more information become available. Originally intended to be included in the *Draft Zone G RFI Report* (EnSafe, February 1998), the FDS was separated from the RFI process for evaluation under the South Carolina petroleum program. This CAR presents the results of this evaluation. Newly identified AOC 709 (Area 16) a portion of AOC 613 (Area 17) and SWMU 24, which were originally associated with the FDS, were retained in the RFI due to RCRA constituents detected during the FDS. The remaining nine SWMUs and AOCs associated with the FDS are described in Table 1.1. Figure 1-3 identifies the layout of the FDS. The *Final Zones D, F and G RFI Work Plan* (E/A&H, June 13, 1996) outlined an investigative strategy for the FDS. Included in this report is a discussion of the analytical results from the FDS field investigation. Two additional areas requiring investigation were identified subsequent to the RFI. Area 19 was identified adjacent to the south of Building 98 during closure activities of UST 148, which is part of AOC 623. Area 20, located at the northeast corner of AOC 626 was identified during cleaning and closure of the FDS pipelines.

Table 1.1
AOC Descriptions
Fuel Distribution System

Number	Description	Materials Released, Stored, or Disposed	Potential Pathways
AOC 622 Ballast Water Treatment Facility, Facility 3926	Facility 3926 is an oil-water separator that separates ballast water for discharge to the sanitary sewer. Oil was collected in Tank 3901A and disposed of as used oil.[a]	Petroleum Products, Metals	Soil Groundwater Sanitary sewer Surface water Utility ways
AOC 623 Concrete Tank, Building 98	Tank 148 is a concrete stripper tank used to hold the contents of pipelines while being emptied for maintenance or alteration.[a]	Residual Petroleum Products (Bunker C, Navy Special Fuel Oil)	Soil Groundwater Utility ways
AOC 624 Fuel Oil Booster Pumphouse, Building 98	Building 98 served as a pumphouse to boost the flow of fuel products (used and unused) through the FDS.[a]	Petroleum Products, Benzene, Toluene, Ethylbenzene and Xylene (BTEX), Metals, Volatile Organic Compounds (VOCs)	Soil Groundwater Surface water Utility ways
AOC 625 Sludge Pumphouse, Building 3901B	Building 3901B served as a pumphouse to transfer used oil to and from Tank 3901A.[a]	Petroleum Products, BTEX, VOCs, Metals	Soil Groundwater Surface water Utility ways
AOC 626 Charleston Naval Supply Center Fuel Farm	Fuel Farm contains four large fuel tanks, several smaller tanks, various pumps and piping systems, used oil, and wastewater processing systems.[b]	Petroleum Products, BTEX, VOCs, Polychlorinated Biphenyls (PCBs), Metals	Soil Groundwater Surface water Utility ways Subsurface gas
AOC 627 Oil Spill Area at Hobson Avenue and Viaduct Road	Location is scene of various fuel spills throughout the history of the FDS. Soil and utilities have been impacted.[a]	Petroleum Products, BTEX, VOCs, PCBs, Metals	Soil Groundwater Surface water Utility ways
AOC 629 Tank Truck/Car Loading/Unloading Facility	Facility supports transfer of petroleum products and used oil to and from tank cars, tank trucks and the FDS.[a]	Petroleum Products (including lube oils), BTEX, VOCs, PCBs, Metals	Soil Groundwater Surface water Utility ways Subsurface gas
AOC 631 Fueling Pier Kilo (K)	Facility supports transfer of petroleum products and used oil to and from barges and vessels along Pier Kilo.[a]	Petroleum Products, BTEX, VOCs, PCBs, Metals, Creosote	Soil Groundwater Surface water Utility ways Subsurface gas
AOC 641 Stripper Pumphouse, Former Building 39-K	Facility was used to remove fuel from the pipelines on pier, previously located near site of present Pier M. This facility was misidentified during the RFA process.[a]	Residual Petroleum Products (Bunker C, Navy Special Fuel Oil)	Soil Groundwater Surface water Utility ways

Notes:
a = Described in the *Final RCRA Facility Assessment, Volume II, June 6, 1995.*
b = Described in the *Final RCRA Facility Assessment, Volume I, June 6, 1995.*
SWMU 24 was retained in the RFI due to RCRA waste oil constituents detected.

1.4 Previous Activities

Various investigations of limited scope have been conducted, concentrating efforts on individual components of the FDS. In 1992, S&ME, Inc., assessed the level of Total Petroleum Hydrocarbon (TPH) contamination associated with the 18-inch pipeline along Hobson Avenue and Viaduct Road. The investigation identified three areas of elevated TPH concentration along the pipeline route at the approximate depth of groundwater (6 feet below ground surface [bgs]). The areas are delineated as: the northwest corner of Building 98 and the intersection of Viaduct and Hobson roads (S&ME, 1992). A summary of the findings is presented in the results section for Areas 19 and 20.

Following a release of diesel fuel from the FDS in 1994, an interim measures remedial action was performed on a portion of the FDS located near the intersection of Hobson Avenue and Viaduct Road, the northeast corner of AOC 626. The action was designed to remove petroleum contaminated soil and install a product recovery system (Supervisor of Shipbuilding (SUPSHIP), May 1997).

In July 1995, a Site Characterization and Analysis Penetrometer System (SCAPS) investigation of AOC 626, at the Naval Supply Center Fuel Farm was conducted by the Naval Facilities Engineering Service Center (NFESC) using laser induced fluorescence (LIF) technology. Thirty-three SCAPS pushes were completed and eight soil samples were collected for analysis to define the extent of polynuclear aromatic hydrocarbon (PAH) contamination surrounding the Fuel Farm. The investigation identified low concentrations of fuel (by EPA Method 8015 Modified) in the SCAPS push locations (NFESC April 1996). The findings relevant to Area 20 are presented in Section 4.

The NAVBASE Environmental Detachment completed closure of UST 148 in July 1997. UST 148 was a stripper tank which serviced Building 98, a pumphouse for the FDS. During

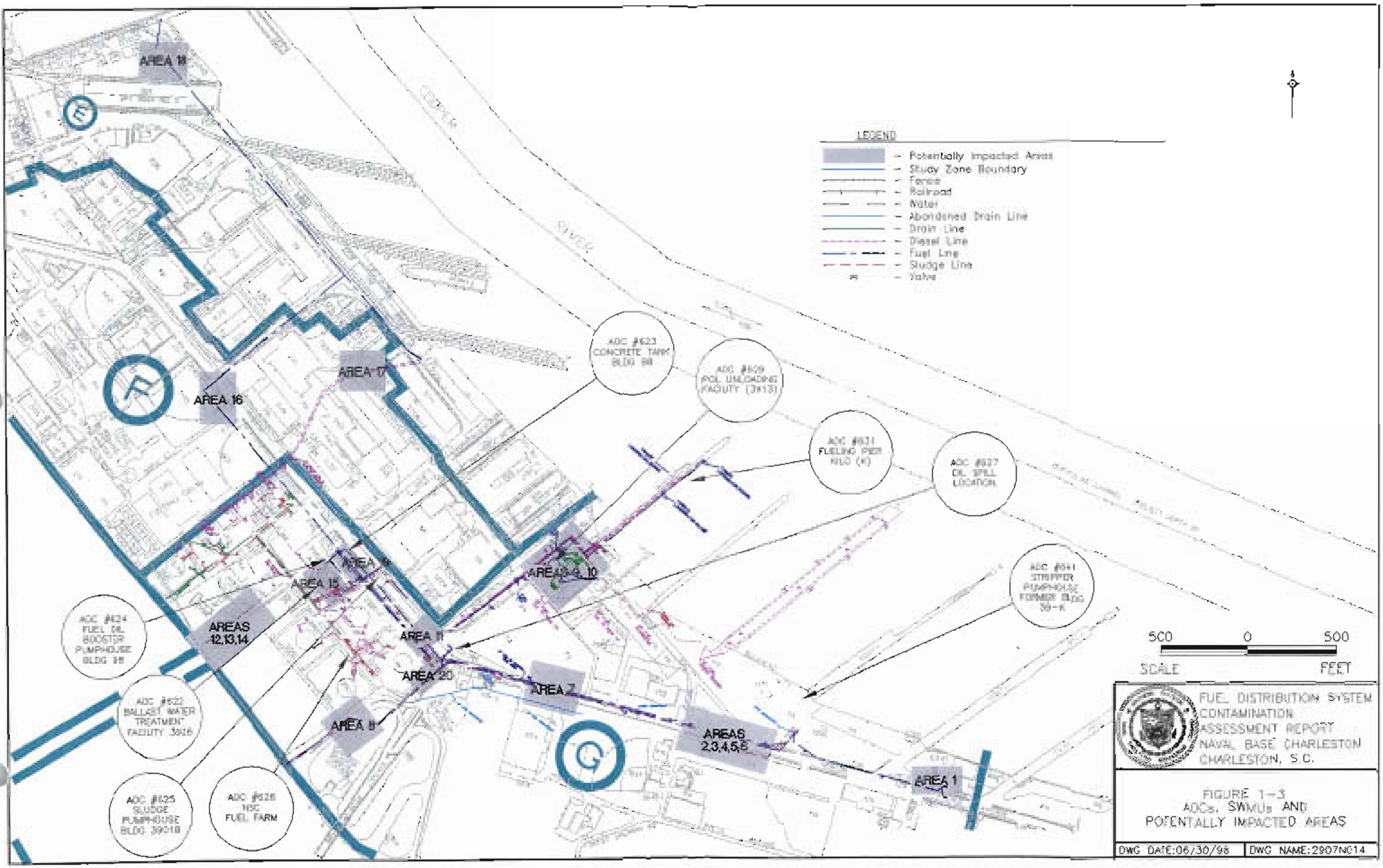


FIGURE 1-3
AOCs, SWMUs AND POTENTIALLY IMPACTED AREAS

closure and removal of the concrete UST, free product and oily soil were observed throughout the excavation. The excavation was backfilled with clean soil (SUPSHIP, July 1997). A summary of the findings is contained in the discussion of Area 19 in Section 4. Section 5 presents recommendations for additional assessment.

1.5 CAR Organization

To facilitate review, this CAR has been formatted to discuss overall technical approach, physical setting, evaluation methodologies, investigation results, and conclusions and recommendations. The report outline is sequenced as follows:

- 1.0 Introduction
- 2.0 NAVBASE Physical Setting
- 3.0 Field Investigation Methodology
- 4.0 Investigation Results
- 5.0 Conclusions and Preliminary Recommendations
- 6.0 References
- 7.0 Signatory Requirement

2.0 NAVBASE PHYSICAL SETTING

2.1 Regional Setting

2.1.1 Regional Physiographic and Geologic Description

NAVBASE is in the Lower South Carolina Coastal Plain Physiographic Province, on the Cooper River side of the Charleston Peninsula, which is formed by the confluence of the Cooper and Ashley rivers. Topography in the area is typical of the South Carolina lower coastal plain, with low-relief plains broken only by the meandering courses of sluggish streams and rivers flowing seaward past occasional marine terrace escarpments. NAVBASE is essentially flat. Elevations range from just over 20 feet above mean sea level (msl) in the northwest part of the base to sea level at the Cooper River. Most of the original topography at NAVBASE has been modified by activities such as dredge spoil deposition. The southern end of the base was originally tidal marsh drained by Shipyard Creek and its tributaries. The original elevations in other portions of the base were only slightly higher. The land surface at NAVBASE has been elevated with increments of both solid wastes and dredged materials (primarily the latter) over the last 93 years. The majority of NAVBASE remains within the 100-year flood zone of less than 10 feet above msl.

Charleston area geology is typical of the southern Atlantic Coastal Plain. Cretaceous and younger sediments thicken seaward and are underlain by older igneous and metamorphic basement rock. Surface exposures at NAVBASE, in the limited areas that remain undisturbed, consist of Quaternary-age sands, silts, and clays of high organic content (Weems and Lemon, 1993). Tertiary-age sediments immediately underlie the younger Quaternary-age deposits. Erosional remnants of late Tertiary (Pliocene to Miocene) formations may be encountered at various locations. However, the mid-Tertiary-age (Oligocene to Eocene) Cooper Group is pervasive beneath NAVBASE. The Cooper Group consists of the following in increasing age: the Ashley, Parker's Ferry, and Harleyville formations. Of particular importance in this group is the Ashley Formation, which was previously referred to as the Cooper Marl in most NAVBASE reports and regional geologic literature. The Ashley Formation is a pale green to olive-brown, sandy, phosphatic limestone or marl, locally muddy and/or sandy. In the Charleston vicinity, the Ashley Formation is encountered at a depth of approximately 30 to 70 feet bgs. The relief of the top of the Ashley Formation is associated with an erosional basin (Park, 1985). Park identifies the entire Cooper Group, of which the Ashley Formation is a member and hydrologically similar, as being approximately 300 feet thick.

Surface soil at NAVBASE has been extensively disturbed. Much of NAVBASE, particularly the southern portion, has been filled with dredged materials from the Cooper River and Shipyard Creek. The dredged materials are an unsorted mixture of sands, silts, and clays. Most of the remainder of the base has been either filled or reworked. Native soil is the fine-grained silt, silty sand, and clay typical of terrigenous tidal marsh environments. Sand lenses are present in localized areas, but are generally only a few feet thick in the upper 5 to 10 feet of the subsurface.

2.1.2 Regional Hydrologic and Hydrogeologic Description

Parts of the southern portion of NAVBASE are drained by Shipyard Creek, while northern areas are drained by Noisette Creek. The drainage basins of both waterways are tributaries of the Cooper River, which include areas other than NAVBASE. Surface drainage over the remainder of NAVBASE flows directly into the Cooper River, which discharges into Charleston Harbor.

Shipyard Creek, a small tidal tributary approximately 2 miles long, flows southeast along the southwestern boundary of NAVBASE to its confluence with the Cooper River opposite the southern tip of Daniel Island. Piers line the western shore of the Cooper River's lower mile, while the entire length of the eastern shore is bounded by tidal marshland.

Noisette Creek, which transects the northern portion of NAVBASE and separates Zones A and B, is a tidal tributary approximately 2.5 miles long. The creek flows nearly due east from its headwaters in the city of North Charleston and empties into the Cooper River. Surface water elevations in the creek, recorded during February and August 1996 groundwater-level measurement events, showed a 5-foot average change in elevation from low to high tide.

Groundwater occurs under water table or poorly confined conditions within the Quaternary deposits overlying the Tertiary-age Cooper Group. Aquifer transmissivities are generally less than 1,000 square feet per day (ft^2/day), and well yields range from zero to 200 gallons per minute (gpm). This groundwater contains high concentrations of iron and is commonly acidic at shallow depths (Park, 1985).

The Cooper Group is hydrologically significant mainly because of its low permeability. In most locales, its sandy, finely granular limestone produces little or no water and acts as a confining unit causing artesian conditions in the underlying Santee Limestone (Park, 1985).

The Santee Limestone aquifer is typically artesian, except in outcrop areas. Yields from wells in the Santee are typically less than 300 gpm (Park, 1985).

2.1.3 Regional Climate

Data in this section, including temperature and wind data in Tables 2.1 and 2.2, were obtained from the S.C. SEA Grant Consortium, 1992. Charleston Harbor area climate is typically mild compared to other areas farther inland. The mountains in the northern portion of the state block cold air masses from the northwest, and the Bermuda high-pressure system limits the progress of cold fronts into the area. These conditions produce relatively mild, temperate winters. Summers are hot and humid, but relatively moderate with regard to temperature extremes. Moderate summer temperatures are largely due to the influence of the Gulf Stream.

The average monthly air temperatures for the Charleston area are presented in Table 2.1. The temperatures are generally moderated by marine influences and are often 2°C to 3°C lower in the summer and 3°C to 8°C higher in the winter than areas farther inland. Temperatures higher than 38°C and lower than -6.5°C are unusual for the area (S.C. SEA Grant Consortium, 1992).

Table 2.1
Mean Temperature and Wind Data
for Charleston Harbor (1970 through 1985)

Month	Daily Max (°C)	Daily Min (°C)	Mean Speed (kph)	Prevailing Direction
January	16.4	3.1	14.8	SW
February	16.8	4.5	16.6	NNE
March	20.0	7.3	16.7	SSW
April	24.9	11.5	16.1	SSW
May	28.8	16.6	14.3	S
June	31.6	20.6	13.7	S
July	31.6	22.2	13.0	SW
August	31.5	21.4	12.1	SW
September	29.2	18.8	13.0	NNE
October	25.1	12.7	13.2	NNE
November	19.9	6.6	13.2	N
December	16.1	3.5	14.0	NNE
Annual	24.3	12.4	14.2	NNE

Wind direction and velocity in the Charleston area are highly variable, and rather evenly distributed in all directions. The inland portions of the region are subjected to a southwest-northeast wind. Winds prevail to the north in the fall and winter, and to the south in spring and summer. The monthly average wind velocities and directions range from a low of 12.1 kilometers per hour (kph) in August to a high of 16.7 kph in March. The average monthly wind speeds and prevailing wind directions are also presented in Table 2.1.

Table 2.2
Precipitation, Relative Humidity, and Cloud Cover for Charleston Harbor (1960 through 1985)

Month	Precipitation (cm)	Relative % Humidity (by Time of Day)				Cloud Cover (Number of Days)		
		0100 hrs.	*0700 hrs.*	*1300 hrs.*	*1900 hrs.*	*Clear*	*Partly Cloudy*	*Cloudy*
January	6.45	82	84	55	73	8	8	15
February	8.36	79	82	52	68	9	6	13
March	9.98	81	83	50	67	9	9	13
April	7.32	84	84	50	67	11	8	11
May	9.17	88	84	54	72	8	12	11
June	12.65	90	86	59	75	6	12	12
July	19.58	91	88	64	79	4	13	14
August	16.79	92	91	63	80	5	14	12
September	14.81	91	91	63	82	7	11	12
October	7.21	88	89	56	80	12	8	11
November	5.31	85	87	51	77	13	6	11
December	7.24	82	84	54	74	9	8	14
Annual	124.87	86	86	56	75	101	115	149

The Charleston area averages 124.9 centimeters (cm) of precipitation annually, which is almost exclusively rainfall. Very little precipitation is recorded as snow, sleet, or hail. The greatest mean monthly precipitation is normally received in July, while the smallest amount normally occurs in November.

Relative humidity in the Charleston Harbor area is normally very high and fluctuates greatly. Generally, it is higher during the summer months than at other times of the year, and the coastal areas exhibit a lower relative humidity than inland areas. The monthly mean relative humidity for four different times of day is presented in Table 2.2. Cloud cover varies widely for Charleston, with annual averages of 101 clear days, 115 partly cloudy days, and 149 cloudy days. The mean monthly clear, partly cloudy, and cloudy days for the area are also presented in Table 2.2.

The primary concern in climate extremes is the occurrence of tropical cyclones or hurricanes. Hurricanes frequent the east coast of the United States and almost always have some effect on the weather around Charleston Harbor. Hurricanes normally occur between August and December. The last hurricane to make landfall in the Charleston area was Hurricane Hugo, a Class IV hurricane which struck Charleston in September 1989, causing severe damage. Tornados are extremely rare in the vicinity but have occurred in the inland portions of Charleston County.

2.2 FDS Geologic Investigation

2.2.1 NAVBASE Geologic Investigation

Geologic and stratigraphic information has been obtained from Cone Penetrometer Testing (CPT) and soil and monitoring well borings installed during the RFIs for Zones A, B, C, D, E, F, G, H and I. Data for the FDS investigation have been included in the geologic and hydrogeologic assessment presented in this report. A total of 54 monitoring wells were installed during the FDS groundwater investigation. Well construction information for these wells is presented in Table 2.3. Figure 2-1 depicts the FDS monitoring well locations. Lithologic samples collected during drilling were classified and logged by an EnSafe geologist as described in the approved *Final Comprehensive Sampling and Analysis Plan (CSAP) RCRA Facility Investigation (Revision No: 02)* (E/A&H, July 30, 1996a).

Table 2.3
Monitoring Well Construction Data
Fuel Distribution System

Well Identifier	Date Installed	TOC Elevation (ft msl)	Ground Surface Elevation (ft msl)	Construction Depths (ft bgs)			GW Elev. Low Tide (ft msl)	GW Elev. High Tide (ft msl)
				TOS	BOS	BOW		
FDS01A	1/7/97	9.75	7.43	5.3	9.6	10.2	oil-6.84 H_2O-2.33	oil-6.75 H_2O-2.36
FDS01B	1/7/97	7.69	7.87	5.3	9.6	10.2	4.47	4.44
FDS01C	1/7/97	9.30	6.84	5.3	9.6	10.2	4.48	4.50
FDS01D	1/8/97	9.46	7.06	5.3	9.6	10.2	4.42	4.42
FDS01E	1/22/97	6.84	7.00	5.2	9.5	10.0	3.19	4.35
FDS02A	1/7/97	7.45	7.64	7.1	11.4	12.0	3.57	3.72
FDS02B	1/8/97	7.24	7.42	7.1	11.4	12.0	4.13	3.95
FDS02C	1/7/97	7.57	7.88	7.1	11.4	12.0	3.77	4.22
FDS03A	1/8/97	7.59	7.72	7.3	11.6	12.2	3.68	3.94
FDS03B	1/10/97	7.00	7.10	7.3	11.6	12.2	3.82	3.88
FDS03C	1/10/97	6.36	6.57	7.3	11.6	12.2	3.71	3.75
FDS04A	1/8/97	10.19	7.68	7.1	11.4	12.0	4.26	4.21
FDS04B	1/9/97	9.65	7.20	7.1	11.4	12.0	4.21	4.14
FDS04C	1/8/97	9.42	6.92	7.1	11.4	12.0	4.17	4.18
FDS05A	1/8/97	6.30	6.43	7.3	11.6	12.2	3.19	3.47
FDS05B	1/10/97	5.80	5.96	7.3	11.6	12.2	0.74	0.99
FDS06A	1/10/97	6.94	7.21	6.1	10.4	11.0	3.09	4.08
FDS06B	1/10/97	9.06	7.04	6.1	10.4	11.0	4.24	4.18
FDS06C	1/10/97	9.76	7.47	6.1	10.4	11.0	3.63	3.56
FDS07A	1/22/97	5.44	5.71	6.8	16.4	17.0	-0.60	-0.35
FDS07B	1/11/97	4.57	4.62	5.1	9.4	10.0	3.95	4.29
FDS07C	1/11/97	4.50	4.65	5.1	9.4	10.0	4.04	4.14
FDS07D	1/11/97	6.06	6.21	7.1	11.4	12.0	4.72	5.16
FDS08A	1/11/97	16.68	16.86	10.6	20.0	20.5	8.26	8.51
FDS08B	1/11/97	16.30	16.24	10.4	19.8	20.4	7.88	8.24
FDS08C	1/14/97	16.05	13.81	8.2	17.6	18.2	12.81	12.70

Table 2.3
Monitoring Well Construction Data
Fuel Distribution System

Well Identifier	Date Installed	TOC Elevation (ft msl)	Ground Surface Elevation (ft msl)	Construction Depths (ft bgs)			GW Elev. Low Tide (ft msl)	GW Elev. High Tide (ft msl)
				TOS	BOS	BOW		
FDS09A	1/13/97	4.98	4.90	5.8	15.4	16.0	3.03	3.37
FDS09B	1/13/97	4.76	4.70	5.8	15.4	16.0	3.42	3.45
FDS09C	1/13/97	4.78	4.90	5.8	15.4	16.0	3.28	3.33
FDS10A	1/12/97	5.33	5.53	7.9	17.5	18.0	2.93	2.95
FDS10B	1/13/97	5.05	5.23	8.2	17.6	18.2	3.50	3.49
FDS10C	1/13/97	6.06	6.30	8.2	17.6	18.2	3.27	3.28
FDS11A	1/13/97	7.61	7.73	5.4	14.9	15.4	3.78	3.70
FDS11B	1/21/97	7.17	7.41	4.9	14.5	15.0	3.62	3.56
FDS11C	1/21/97	6.77	6.98	4.9	14.5	15.0	2.85	2.73
FDS12A	1/21/97	12.26	9.86	4.8	14.4	15.0	6.38	6.40
FDS12B	1/21/97	11.47	8.96	4.8	14.4	15.0	5.52	5.62
FDS13A	1/14/97	9.03	9.12	6.9	16.3	16.9	7.40	7.33
FDS13B	1/20/97	9.08	9.14	5.8	15.4	16.0	6.90	6.90
FDS13C	1/20/97	9.47	9.60	5.8	15.4	16.0	8.37	8.42
FDS13D	1/20/97	11.83	9.34	5.8	15.4	16.0	7.90	7.78
FDS13E	1/20/97	10.97	8.65	5.8	15.4	16.0	6.75	6.80
FDS14A	1/14/97	8.87	8.95	5.8	15.4	16.0	6.09	6.11
FDS14B	1/20/97	8.38	8.40	5.8	15.4	16.0	5.21	5.21
FDS14C	1/14/97	8.34	8.38	5.8	15.4	16.0	6.63	6.71
FDS15A	1/21/97	12.01	12.03	6.8	16.4	17.0	5.33	5.32
FDS15B	1/21/97	10.10	10.21	6.8	16.4	17.0	5.14	4.87
FDS15C	1/22/97	10.90	10.98	6.8	16.4	17.0	5.61	5.88
FDS16A	1/23/97	10.50	8.02	5.8	15.4	16.0	5.41	5.53
FDS16B	1/23/97	8.19	8.43	6.9	16.5	17.0	5.68	5.68
FDS16C	1/23/97	9.01	9.19	6.9	16.5	17.0	3.16	3.19
FDS17A	1/22/97	9.32	9.56	4.8	14.4	15.0	4.99	5.05

Table 2.3
Monitoring Well Construction Data
Fuel Distribution System

Well Identifier	Date Installed	TOC Elevation (ft msl)	Ground Surface Elevation (ft msl)	Construction Depths (ft bgs)			GW Elev. Low Tide (ft msl)	GW Elev. High Tide (ft msl)
				TOS	BOS	BOW		
FDS17B	1/22/97	9.10	9.24	4.8	14.4	15.0	5.11	5.13
FDS18A	1/23/97	8.38	8.55	7.3	11.6	12.0	2.26	2.26

Notes:
TOC = Top of well casing
TOS = Top of screened interval
msl = mean sea level
bgs = below ground surface
BOS = Bottom of screened interval
BOW = Bottom of well (end cap)

2.2.2 FDS Geology

2.2.2.1 Tertiary-Age Sediments

Ashley Formation

The Ashley Formation, the youngest member of the Oligocene-age Cooper Group, was not encountered during the FDS investigation. The Ashley Formation (Ta) was deposited in an open-marine shelf environment during a rise in sea level in the late Oligocene (Weems and Lemon, 1993). The Ta is an olive-yellow to olive-brown, tight, slightly calcareous, clayey silt with varying amounts of very fine to fine-grained sand that decreases rapidly with depth.

Due to successive sea level transgression-regression (rise and fall) sequences during late Tertiary and early Quaternary time, extensive erosion has removed many of the marine and terrigenous deposits overlying the Ta (Weems and Lemon, 1993).

Marks Head Formation

The Marks Head Formation (Tmh) is a Miocene-age marginal-marine lagoon deposit that stratigraphically overlies two other units (Edisto and Chandlers Bridge Formation) that were deposited on top of the Ta during Tertiary time. The Tmh is thought to have filled an erosional valley in early Miocene time during a sea stand lower than that of today (Weems and Lemon, 1993). However, successive erosive events removed much of the Chandlers Bridge, Edisto, and Tmh formations at NAVBASE.

2.2.2.2 Quaternary-Age Sediments

The Quaternary Period began 1.6 million years ago with the Pleistocene Epoch and continues with the Holocene (Recent) Epoch, from 65,000 years ago to the present. During Quaternary time, several sea transgressions-regressions resulted in a jumbled network of terrace complexes composed of varied depositional environments such as barrier islands, backbarrier lagoons, tidal inlets, and shallow-ocean-marine shelf systems. Due to regional crustal uplift in the Charleston region during the Quaternary, many barrier to backbarrier deposits from high sea-level stands are preserved as terraces; however, succeeding transgressions reworked the shallow-marine shelf deposits on the seaward side of each older barrier ridge or island (Weems and Lemon, 1993). The result of this erosional and redepositional process of older sediments is a subsequently younger sequence of deposits on the seaward side of the previous coastal deposit (Weems and Lemon, 1993). Therefore, it can be difficult to determine discrete formational units within the Quaternary system.

Throughout the FDS investigation area, Quaternary-age sediments extend from the top of Tertiary-age sediments (Tmh, where present, or Ta) to just below ground surface. These sediments primarily comprise the Pleistocene-age Wando Formation (deposited 70,000 to 130,000 years ago), which are overlain by Holocene-age sand and clay deposits. In general, the Wando deposition encompasses three distinct high sea-level stands in the late Pleistocene (Weems and Lemon, 1993). As a result, Wando composition consists of repeating sequences of clayey sand and clay deposits overlying barrier sand deposits which, in turn, overlie fossiliferous shelf-sand deposits. In Holocene time, rivers and streams downcut these sediment sequences, leaving scours that have become filled with clay and silty sand deposits typical of low energy environments. These younger deposits may resemble Wando-age deposits and further complicate the interpretation of local geology.

2.2.3 Soil

Due to extensive surface soil disturbance at NAVBASE during its operational history, approximately the upper 5 feet of the subsurface are typically a mixture of artificial fill and native sediments.

2.2.4 Groundwater Flow Direction

Water levels in the FDS wells were measured during low- and high-tides on April 29, 1997. Groundwater elevation data are presented on Table 2.3. Since the Zone G RFI included the majority of the FDS in its groundwater flow analyses, groundwater flow for the FDS is discussed relative to Zone G. Figures 2-2 and 2-3 depict the overall shallow groundwater potentiometric surface during low- and high-tide along that portion of the FDS in Zone G. Both maps indicate that shallow groundwater flow in the surficial aquifer is highly variable in gradient and direction. Groundwater flow at the specific areas of interest is presented in Section 4.

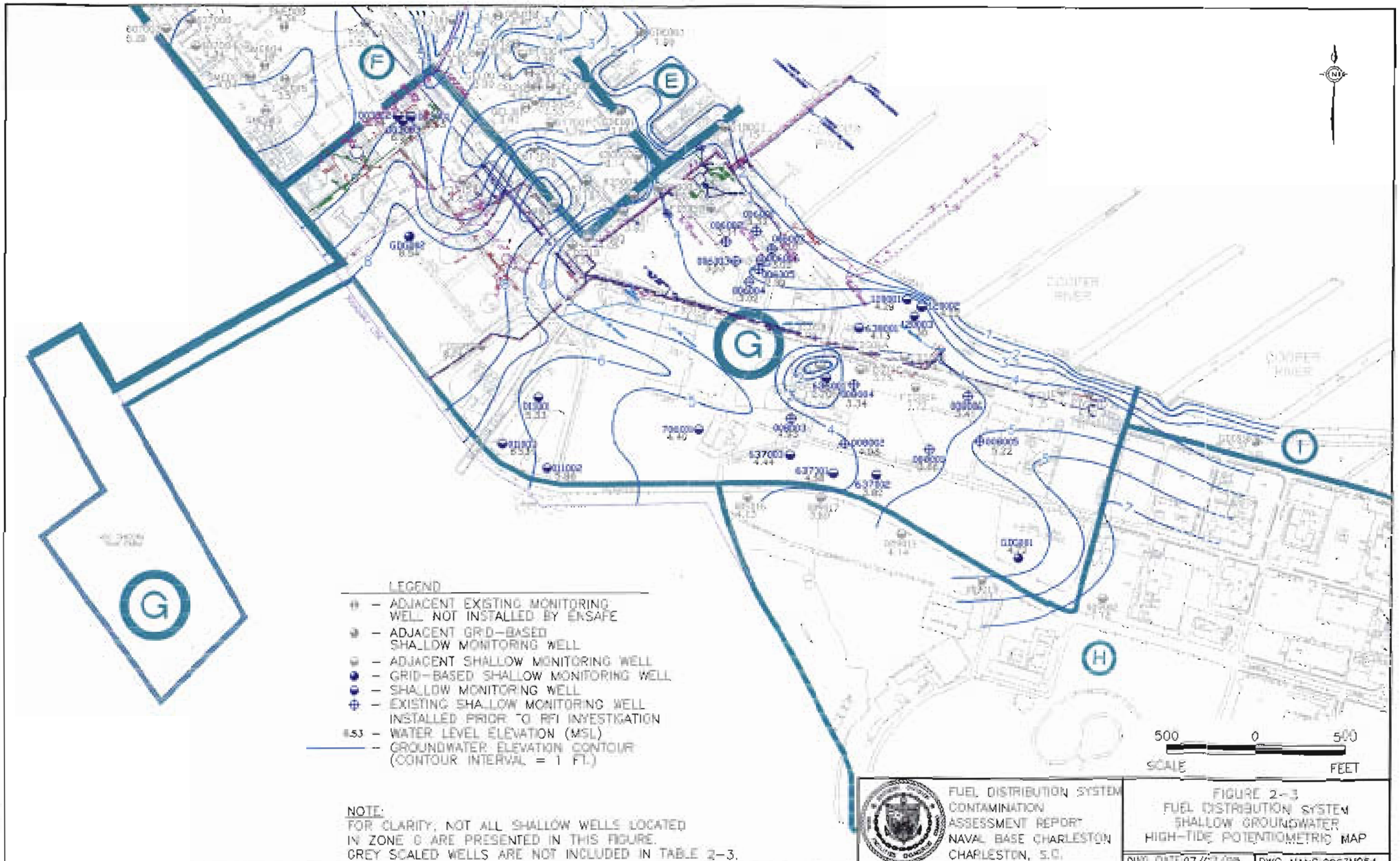
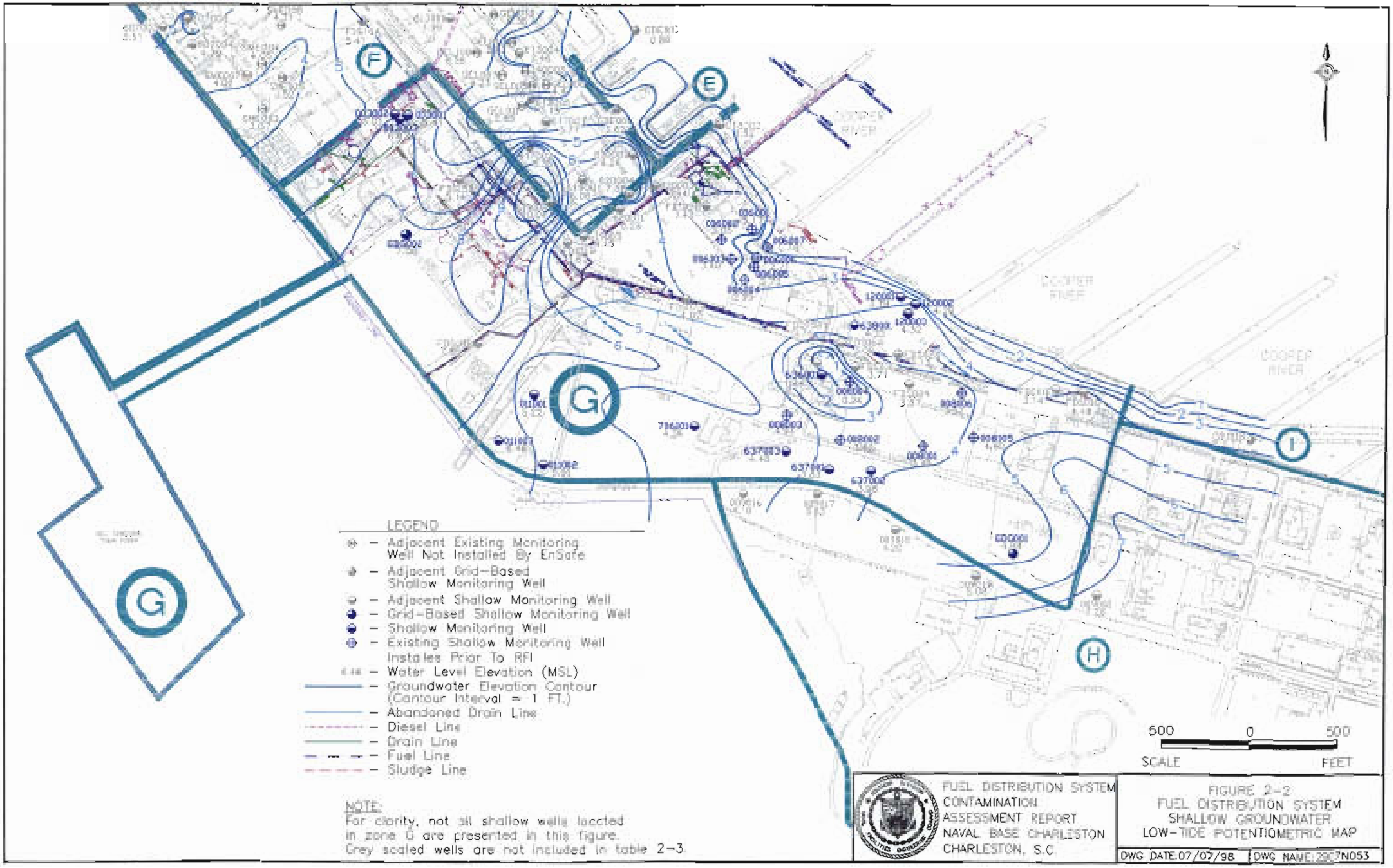


FIGURE 2-3
FUEL DISTRIBUTION SYSTEM
SHALLOW GROUNDWATER
HIGH-TIDE POTENTIOMETRIC MAP



F
E
G
G
H
I
COOPER RIVER
LEGEND
Adjacent Existing Monitoring Well Not Installed By EnSafe
Adjacent Grid-Based Shallow Monitoring Well
Adjacent Shallow Monitoring Well
Grid-Based Shallow Monitoring Well
Shallow Monitoring Well
Existing Shallow Monitoring Well Installed Prior To RFI
Water Level Elevation (MSL)
Groundwater Elevation Contour (Contour Interval = 1 FT.)
Abandoned Drain Line
Diesel Line
Drain Line
Fuel Line
Sludge Line
NOTE:
For clarity, not all shallow wells located in zone G are presented in this figure.
Grey scaled wells are not included in table 2-3.
500 0 500
SCALE FEET
FUEL DISTRIBUTION SYSTEM CONTAMINATION ASSESSMENT REPORT
NAVAL BASE CHARLESTON
CHARLESTON, S.C.
FIGURE 2-2
FUEL DISTRIBUTION SYSTEM SHALLOW GROUNDWATER LOW-TIDE POTENTIOMETRIC MAP
DWG DATE 07/07/98
DWG NAME: 29C7N053

3.0 FIELD INVESTIGATION METHODOLOGY

This section lists the field investigation objectives and describes the technical sampling methods, procedures, and protocols used in FDS data collection. Fieldwork was conducted in accordance with the approved final RFI work plan for Zones D, F and G, final CSAP and the USEPA Region IV Environmental Services Division, *Standard Operating Procedures and Quality Assurance Manual* (ESDSOPQAM) (USEPA, May, 1996a).

3.1 Investigation Objectives

The FDS sampling strategy, as detailed in the work plan, was designed and implemented in a phased approach to thoroughly screen the surface and subsurface extent of the FDS. The data was sufficient to:

- Characterize the facilities
- Define contaminant pathways and potential receptors (on and offsite, where applicable)
- Define the nature and extent of any contamination
- Assess the need for further environmental effort

Initially, the sampling and analysis objective was to provide sufficient data to meet the stated RFI requirements. The subsequent transfer to the SCDHEC petroleum program resulted in two data gaps, and extra non-petroleum regulated parameters being collected. The data gaps were the analytes ethylene dibromide (EDB) (only analyzed with duplicate samples), and methyl-tert-butyl ether (MTBE), (not analyzed for). The lack of EDB and MTBE analyses are not considered significant since the FDS was not used to transfer either leaded or unleaded automotive fuel. The extra parameters collected were included in the RFI analytical suite, but not listed in the SCDHEC Risk Based Screening Level (RBSL) tables for petroleum sites.

3.2 Soil Sampling

Soil samples were collected in two phases. One hundred fifty samples were collected during Phase I screening and analyzed for TPH (Table 3.1). The Phase I sampling strategy was to sample surface soil around the tank farm and backfill material along the pipeline trench, at a horizontal interval of approximately 200 feet to screen for subsurface releases from the FDS. Samples were generally collected between a depth of 3 and 16 feet bgs corresponding to the depth of the pipelines. In areas exhibiting elevated TPH, Phase II samples were collected and analyzed for Full Scan Analyses (FSA) metals, cyanide, pesticides/polychlorinated biphenyls (PCBs), semivolatile organic compounds (SVOCs), and volatile organic compounds (VOCs).

The objective of the Phase II sampling effort was to characterize the nature of subsurface soil contamination. Because releases were from subsurface pipelines installed in fill material of greater porosity than the native silt and clay, samples from this area would be more likely to exhibit the highest concentrations. The majority of the 23 Phase II samples were collected from this saturated backfill material (Table 3.2). Eight of the 23 samples were collected concurrently with the Phase I samples based on visual evidence of petroleum contamination, and analyzed for TPH and FSA.

3.2.1 Soil Sample Locations

Phase I soil samples were generally collected from locations proposed in the RFI work plan, which were based on the investigation strategy outlined in Section 1.2 of that document. Locations were modified when necessary based on obvious contamination and interfering utilities. Phase II samples were collected where elevated TPH was encountered. Samples were generally collected within a 4-foot radius of the buried pipeline.

Table 3.1
Phase I Soil Samples
Fuel Distribution System

Boring Location	Sample ID	Date	Depth (ft bgs)	Remarks
FDSSC001	FDSSC00101	9/12/96	4-5.5	Fuel staining on soil, fuel odor
FDSSC002	FDSSC00201	9/12/96	4-5.5	Fuel sheen and odor
FDSSC003	FDSSC00301	9/12/96	4-5.5	Slight fuel odor noted
FDSSC004	FDSSC00401	9/12/96	4-5.5	No fuel odor noted
FDSSC005	FDSSC00501	9/12/96	4-5.5	Slight fuel odor noted
FDSSC006	FDSSC00601	9/12/96	4-5.5	No fuel odor noted
FDSSC007	FDSSC00701	9/12/96	4-5	No fuel odor noted
FDSSC008	FDSSC00801	9/13/96	2.8-5.6	Slight fuel odor noted
FDSSC009	FDSSC00901	9/13/96	4-5.5	No fuel odor noted
FDSSC010	FDSSC01001	9/16/96	5.7-72	No unusual observations logged
FDSSC011	FDSSC01101 FDSCC01101*	9/16/96 9/16/96	4-6 4-6	Slight fuel odor noted
FDSSC012	FDSSC01201	9/17/96	6.8	Free product on sample
FDSSC013	FDSSC01301	9/16/96	4.3-5.8	Fuel odor present
FDSSC014	FDSSC01401	9/16/96	6-7.5	Slight fuel odor noted
FDSSC015	FDSSC01501	9/17/96	4-6.6	No fuel odor noted
FDSSC016	FDSSC01601	9/16/96	6-7.5	Fuel odor present
FDSSC017	FDSSC01701	9/17/96	2.9-7.3	Fuel odor present
FDSSC018	FDSSC01801	9/18/96	5-7	No fuel odor noted
FDSSC019	FDSSC01901 FDSCC01901*	9/17/96 9/17/96	4.5-6.5 4.5-6.5	No unusual observations logged
FDSSC020	FDSSC02001	9/17/96	6-8	No unusual observations logged
FDSSC021	FDSSC02101	9/17/96	4-6	Slight fuel odor noted
FDSSC022	FDSSC02201	9/18/96	5-7	No fuel odor noted
FDSSC023	FDSSC02301	9/18/96	4.5-6.5	No fuel odor noted
FDSSC024	FDSSC02401	9/17/96	6-8	No unusual observations logged
FDSSC025	FDSSC02501	9/18/96	3.7-5.3	Slight fuel odor noted
FDSSC026	FDSSC02601	9/18/96	5.8-8.8	No fuel odor noted

Table 3.1
Phase I Soil Samples
Fuel Distribution System

Boring Location	Sample ID	Date	Depth (ft bgs)	Remarks
FDSSC027	FDSSC02701	9/18/96	5-7	Slight fuel odor noted
FDSSC028	FDSSC02801	9/18/96	4.3-6.3	Strong fuel odor in entire interval
	FDSCC02801*	9/18/96	4.3-6.3	
FDSSC029	FDSSC02901	9/18/96	4.5-6.5	No fuel odor noted
FDSSC030	FDSSC03001	9/19/96	4.5-6.5	Fuel odor present
FDSSC031	FDSSC03101	9/19/96	4.2-6.2	No fuel odor noted
FDSSC032	FDSSC03201	9/19/96	4.5-6.5	Slight fuel odor noted
FDSSC033	FDSSC03301	9/19/96	5-7	Slight fuel odor noted
FDSSC034	FDSSC03401	9/19/96	4.5-7.5	No unusual observations logged
FDSSC035	FDSSC03501	9/19/96	7-9	No fuel odor noted
FDSSC036	FDSSC03601	9/19/96	9-11	No fuel odor noted
	FDSSC03602	9/19/96	13-15	
FDSSC037	FDSSC03701	9/20/96	7-8.5	Smelled like petroleum
	FDSSC03702	9/20/96	12-14	
FDSSC038	FDSSC03801	9/20/96	7-9	No unusual observations logged
	FDSSC03802	9/20/96	12-14	
FDSSC039	FDSSC03901	9/20/96	8-10	No unusual observations logged
	FDSSC03902	9/20/96	10.5-12.5	
FDSSC040	FDSSC04001	9/20/96	5-7	No unusual observations logged
	FDSSC04002	9/20/96	12-14	
	FDSCC04002*			
FDSSC041	FDSSC04101	9/20/96	5-7	Sulfur odor noted
	FDSSC04102	9/20/96	12-14	
FDSSC042	FDSSC04201	9/22/96	5.7-8	No fuel odor noted
	FDSSC04202	9/22/96	11.7-14.1	
FDSSC043	FDSSC04301	9/22/96	5.8-7.6	No fuel odor noted
FDSSC044	FDSSC04401	9/22/96	5.7-7.7	No unusual observations logged
FDSSC045	FDSSC04501	9/22/96	13-15	No unusual observations logged
FDSSC046	FDSSC04601	9/22/96	14-16	No fuel order noted
FDSSC047	FDSSC04701	9/22/96	14-16	Petroleum odor with sheen
FDSSC048	FDSSC04801	9/22/96	14-16	No unusual observations logged
FDSSC049	FDSSC04901	9/22/96	14-16	No unusual observations logged

Table 3.1
Phase I Soil Samples
Fuel Distribution System

Boring Location	Sample ID	Date	Depth (ft bgs)	Remarks
FDSSC050	FDSSC05001	9/23/96	7.7-9.7	No unusual observations logged
FDSSC051	FDSSC05101	9/23/96	5.7-7.4	Petroleum odor noted
FDSCC051	FDSCC05101*	9/23/96	5.7-7.4	
FDSSC052	FDSSC05201	9/23/96	6-8	No unusual observations logged
FDSSC053	FDSSC05301	9/23/96	unlogged	No fuel odor noted
FDSSC054	FDSSC05401	9/23/96	11-13	No unusual observations logged
FDSSC055	FDSSC05501	9/23/96	5-9	No unusual observations logged
FDSSC056	FDSSC05601	9/23/96	unlogged	No unusual observations logged
FDSSC057	FDSSC05701	9/24/96	3.7-5.5	No fuel odor noted
FDSSC058	FDSSC05801	9/24/96	4-10	Slight fuel odor noted
FDSSC059	FDSSC05901	9/24/96	unlogged	No fuel odor noted
FDSSC060	FDSSC06001	9/24/96	4-6	No unusual observations logged
FDSSC061	FDSSC06101	9/24/96	5-6	No unusual observations logged
	FDSCC06101*	9/24/96		
FDSSC062	FDSSC06201		No Phase I sample taken at this location	
FDSSC063	FDSSC06301	9/25/96	6.5-8.5	No fuel contamination noted
FDSSC064	FDSSC06401	9/25/96	6.5-8.5	No unusual observations logged
FDSSC065	FDSSC06501	9/25/96	6.3-10.6	Strong fuel odor noted
FDSSC066	FDSSC06601	9/25/96	8.5-10.5	Strong fuel odor noted
FDSSC067	FDSSC06701	9/25/96	8.2-11	No unusual observations logged
FDSSC068	FDSSC06801	9/30/96	8-10	No unusual observations logged
FDSSC069	FDSSC06901	9/30/96	6.5-8.5	No unusual observations logged
FDSSC070	FDSSC07001	9/30/96	7.3-9.2	No unusual observations logged
FDSSC071	FDSSC07101	9/30/96	7.2-9.2	No unusual observations logged
FDSSC072	FDSSC07201	10/01/96	unlogged	No unusual observations logged
FDSSC073	FDSSC07301	10/01/96	unlogged	No unusual observations logged
FDSSC074	FDSSC07401	10/01/96	9-11	No unusual observations logged
FDSSC075	FDSSC07501	10/01/96	8-10	No unusual observations logged

Table 3.1
Phase I Soil Samples
Fuel Distribution System

Boring Location	Sample ID	Date	Depth (ft bgs)	Remarks
FDSSC076	FDSSC07601	10/01/96	6.6-8.4	No fuel odor noted
FDSSC077	FDSSC07701	10/01/96	7-9	H_2S odor noted
	FDSCC07701*	10/01/96	7-9	
FDSSC078	FDSSC07801	10/01/96	7-9	Unrecognizable organic odor noted
FDSSC079	FDSSC07901	10/01/96	5-7	No fuel odor noted
FDSSC080	FDSSC08001	10/01/96	6-8	Fuel odor present
	FDSCC08001*	10/01/96	6-8	
FDSSC081	FDSSC08101	10/02/96	7.5-9.5	No unusual observations logged
FDSSC082	FDSSC08201	10/02/96	5.7-7.3	No fuel odor noted
FDSSC083	FDSSC08301	10/02/96	6-8	No unusual observations logged
FDSSC084	FDSSC08401	10/02/96	7-11	Slight fuel odor noted
FDSSC085	FDSSC08501	10/02/96	5-7	No fuel odor noted
FDSSC086	FDSSC08601	10/02/96	5-7	No fuel odor noted
	FDSCC08601*		5-7	
FDSSC087	FDSSC08701	10/02/96	4-6	No fuel odor noted
FDSSC088	FDSSC08801	10/02/96	9-11	No fuel odor noted
FDSSC089	FDSSC08901	10/02/96	7-9	No fuel odor noted
FDSSC090	FDSSC09001	10/03/96	3-5	No unusual observations logged
FDSSC091	FDSSC09101	10/03/96	9-11	No unusual observations logged
	FDSCC09101*	10/03/96	9-11	
FDSSC092	FDSSC09201	10/03/96	6-8	No fuel odor noted
FDSSC093	FDSSC09301	10/03/96	6-8	No unusual observations logged
FDSSC094	FDSSC09401	10/03/96	5-7	Strong fuel odor noted
FDSSC095	FDSSC09501	10/03/96	5-7	Fuel odor throughout interval
	FDSCC09501*	10/03/96	5-7	
FDSSC096	FDSSC09601	10/03/96	5-7	No unusual observations logged
FDSSC097	FDSSC09701	10/03/96	7-9	Fuel oder noted
	FDSSC09702	10/03/96	9-11	
FDSSC098	FDSSC09801	10/03/96	9-11	No fuel odor noted
FDSSC099	FDSSC09901	10/03/96	9-11	No fuel odor noted

Table 3.1
Phase I Soil Samples
Fuel Distribution System

Boring Location	Sample ID	Date	Depth (ft bgs)	Remarks
FDSSC100	FDSSC10001	10/04/96	13-15	No fuel odor noted
	FDSCC10001*	10/04/96	13-15	
FDSSC101	FDSSC10101	10/04/96	9-11	No fuel odor noted
FDSSC102	FDSSC10201	10/04/96	9-11	No fuel odor noted
FDSSC103	FDSSC10301	10/04/96	9-11	No fuel odor noted
FDSSC104	FDSSC10401	10/04/96	4-6	No fuel odor noted
	FDSSC10402	10/04/96	9-11	
FDSSC105	FDSSC10501	10/04/96	4-5	No fuel odor noted
FDSSC106	FDSSC10601	10/04/96	7-9	Slight fuel odor noted
FDSSC107	FDSSC10701	10/04/96	6-8	No fuel odor noted
	FDSCC10701*	10/04/96	6-8	
FDSSC108	FDSSC10801	10/04/96	6-8	No fuel odor noted
FDSSC109	FDSSC10901	10/05/96	7-9	No fuel odor noted
FDSSC110	FDSSC11001	10/05/96	7-9	No fuel odor noted
FDSSC111	FDSSC11101	10/05/96	6-8	No fuel odor noted
FDSSC112	FDSSC11201	10/05/96	5-7	No fuel odor noted
FDSSC113	FDSSC11301	10/05/96	5-7	No fuel odor noted
FDSSC114	FDSSC11401	10/05/96	3-5	No fuel odor noted
	FDSCC11401*	10/05/96	3-5	
FDSSC115	FDSSC11501	10/05/96	3-5	No fuel odor noted
FDSSH001	FDSSH00101	10/18/96	0-1	NA
FDSSH002	FDSSH00201	10/17/96	0-1	NA
FDSSH003	FDSSH00301	10/17/96	0-1	NA
FDSSH004	FDSSH00401	10/17/96	0-1	NA
FDSSH005	FDSSH00501	10/17/96	0-1	NA
FDSSH006	FDSSH00601	10/21/96	0-1	NA
FDSSH007	FDSSH00701	10/17/96	0-1	NA
FDSSH008	FDSSH00801	10/21/96	0-1	NA
FDSSH009	FDSSH00901	10/21/96	0-1	NA

Table 3.1
Phase I Soil Samples
Fuel Distribution System

Boring Location	Sample ID	Date	Depth (ft bgs)	Remarks
FDSSH010	FDSSH01001	10/21/96	0-1	NA
FDSSH011	FDSSH01101	10/17/96	0-1	NA
FDSSH012	FDSSH01201	10/18/96	0-1	NA
FDSSH013	FDSSH01301	10/17/96	0-1	NA
FDSSH014	FDSSH01401	10/17/96	0-1	NA
FDSSH015	FDSSH01501	10/17/96	0-1	NA
FDSSH016	FDSSH01601	10/18/96	0-1	NA
FDSSH017	FDSSH01701	10/18/96	0-1	NA
FDSSH018	FDSSH01801	10/18/96	0-1	NA
FDSSH019	FDSSH01901	10/18/96	0-1	NA
FDSSH020	FDSSH02001	10/18/96	0-1	NA
	FDSCH02001*	10/18/96	0-1	
FDSSH021	FDSSH02101	10/18/96	0-1	NA
FDSSH022	FDSSH02201	10/18/96	0-1	NA
FDSSH023	FDSSH02301	10/17/96	0-1	Strong fuel odor noted
FDSSH024	FDSSH02401	10/21/96	0-1	Strong fuel odor noted
	FDSCH02401*	10/21/96	0-1	
FDSSH025	FDSSH02501	10/21/96	0-1	NA
FDSSH026	FDSSH02601	10/21/96	0-1	Strong fuel odor noted
FDSSH027	FDSSH02701	10/21/96	0-1	NA

Note
* = Indicates a duplicate sample.
H_2S = hydrogen sulfide
All Phase I samples were analyzed for total petroleum hydrocarbons-gasoline range organics (TPH-GRO) and TPH-diesel range organics (DRO) unless noted.

Table 3.2
Phase II Soil Samples
Fuel Distribution System

Boring Location	Sample Identifier	Date	Sample Interval (ft bgs)	Remarks
FDSSC002	FDSSC00201	12/4/96	4-6	Fuel odor noted
FDSSC011	FDSSC01101	12/4/96	4-6	No unusual observations logged
FDSSC012	FDSSC01201	12/4/96	6-8	Free product present
FDSSC013	FDSSC01301	12/4/96	4-6	Oily sheen present
FDSSC014	FDSSC01401	12/5/96	6-8	Strong fuel odor noted, 117 ppm FID
FDSSC016	FDSSC01601	12/4/96	6-8	Fuel odor noted
FDSSC030	FDSSC03001	12/4/96	4.5-6.5	No odor noted, 83 ppm FID
FDSSC47A	FDSSC47A01	9/24/96	13.5-15.5	No unusual observations logged
FDSSC051	FDSSC05101	1/13/97	5-7	
FDSSC055	FDSSC05501	12/5/96	6-8	No unusual observations logged, 17 ppm FID
FDSSC058	FDSSC05801	9/24/96	4-6	Fuel odor
FDSSC062	FDSSC06201	12/10/96	0-1	Strong fuel odor noted
FDSSC065	FDSSC06501	9/25/96	6.3-10.6	Strong fuel odor noted
FDSSC066	FDSSC06601	12/4/96	8.5-10.5	Strong fuel odor
FDSSC067	FDSSC06701 FDSCC06701*	12/4/96 12/4/96	8.5-10.5 8.5-10.5	Strong fuel odor noted, 173 ppm FID
FDSSC084	FDSSC08401	10/2/96	7-11	Slight fuel odor noted
FDSSC094	FDSSC09401	10/3/96	5-7	Strong fuel odor noted
FDSSC095	FDSSC09501	12/5/96	5-7	Strong fuel odor noted
FDSSC097	FDSSC09701 FDSCC09701*	12/5/96 12/5/96	8-10 8-10	Strong fuel odor noted
FDSSC114	FDSSC11401	12/5/96	3-5	No unusual observations logged, 54 ppm FID
FDSSH023	FDSSH02301	10/17/96	0-1	Strong fuel odor noted
FDSSH024	FDSSH02401	10/21/96	0-1	Strong fuel odor noted
FDSSH026	FDSSH02601	10/21/96	0-1	Strong fuel odor noted

Notes:
* = Duplicates were analyzed for Appendix IX parameters (metals, pesticides/PCBs, herbicides, organophosphorous (OP) pesticides, dioxins, SVOCs, VOCs); cyanide, and hex-chrome, Level IV.
FID = Flame ionization detector
ppm = parts per million
Samples were analyzed using SW-846 methods (metals, pesticides/PCBs, SVOCs, VOCs) at data quality objective (DQO) Level III.

3.2.2 Soil Sample Collection

Samples were collected from the 0- to 1- foot bgs interval where potential surface releases may have occurred, using a hand auger as detailed in Section 4.5 of the CSAP.

Subsurface sampling was conducted using CPT to provide a continuous soil-type analysis, which allows the operator and field geologist to detect and distinguish between the native silt and clay sediment and backfill material surrounding the pipeline. Sections 4.3.3 and 6.1.3 of the approved final CSAP describe the CPT soil sampling procedures used in the FDS investigation. This information, combined with the utility survey, which identified the approximate depth of the pipeline, was used to determine the exact subsurface sample depth. The CPT logs are contained in Appendix A. The subsurface samples were collected across a 2- foot depth interval intended to bracket the depth of the pipe. Where the depth of the pipe was uncertain, or where multiple pipes were stacked (necessitating a greater depth interval), samples were collected at more than one interval.

3.3 Groundwater Sampling

Shallow monitoring wells were installed at each location where elevated TPH was encountered during Phase I. A total of 18 areas of potential groundwater contamination were identified for investigation, based on the Phase I/II soil investigation. Wells were typically installed within a 25 to 30-foot radius of the soil sample of concern. Additional wells were installed at a greater distance depending on the need for further delineation based on field observations. Monitoring wells were installed so that groundwater samples could be collected from the saturated backfill material surrounding the pipeline or at a comparable depth. All monitoring wells were installed in accordance with South Carolina Well Standards and Regulations (R.61-71.11) after permits were acquired from SCDHEC.

3.3.1 Monitoring Well Installation

A total of 54 shallow monitoring wells were installed and sampled during the FDS groundwater investigation (Table 3.3). These wells were installed using the hollow-stem auger drilling method, in accordance with Section 5.4 of the CSAP, using 4.25-inch inside-diameter (ID) hollow-stem augers. The total well depths depended primarily on depth of the pipeline or, in areas where surface releases may have occurred, the depth to groundwater. The pipeline depth along the FDS ranged from approximately 4 to 15 feet bgs. Typically, monitoring wells were installed to a depth of 10 to 15 feet bgs, with the deepest well set at 20 feet bgs.

A split-barrel sampler was driven ahead of the hollow-stem augers. This procedure determined borehole lithology and helped find the depth of the FDS pipeline.

Monitoring wells were constructed of an appropriate length of 2-inch ID polyvinyl chloride (PVC) riser pipe attached to a 5 or 10-foot section of 0.010-inch slotted PVC well screen. After drilling to the desired depth, the riser pipe and well screen were inserted down the inside of the hollow-stem auger. Filter pack sand was added to the annular space of the borehole to approximately 2 feet above the top of the screened section. As the sand was added, the level in the annulus was measured with a weighted tape. The hollow-stem auger sections were gradually withdrawn while the sand was being added, to allow uniform placement of the filter pack and avoid bridging and inadvertently raising the well screen and riser with the augers. To prevent the formation from collapsing on the well screen care was taken not to raise the hollow-stem auger sections higher than the filter pack level in the borehole. Bentonite pellets were placed from the top of the filter pack to just below ground surface, then hydrated with potable water. After allowing the bentonite to hydrate for approximately 24 hours, the surface well protector was installed. An expansion-locking well cap provided temporary protection before the surface mount was completed. Appendix B contains boring logs and monitoring well construction diagrams.

Table 3.3
FDS Groundwater Samples

Well Number	Sample Identifier	Date sampled	Remarks
Area 1			
FDS01A	FDS01A01	1/14/97	Area 1 associated with FDSSC002; elevated
	FDS01A02	6/05/97	TPH-GRO/SVOCs
FDS01B	FDS01B01	1/14/97	
	FDS01B02	6/02/97	
FDS01C	FDS01C01	1/14/97	
	FDS01C02	6/02/97	
FDS01D	FDS01D01*	1/15/97	* duplicate sample also collected
	FDS01D02*	6/04/97	
FDS01E	FDS01E01	1/29/97	
	FDS01E02	6/02/97	
Area 2			
FDS02A	FDS02A01*	1/16/97	Area 2 associated with FDSSC012; elevated
	FDS02A02*	5/30/97	TPH-GRO/VOCs/SVOCs/inorganics
			* duplicate sample also collected
FDS02B	FDS02B01	1/19/97	
	FDS02B02	5/20/97	
FDS02C	FDS02C01	1/16/97	
	FDS02C02	5/30/97	
Area 3			
FDS03A	FDS03A01	1/19/97	Area 3 associated with FDSSC014; elevated
	FDS03A02	6/04/97	TPH-GRO/inorganics
FDS03B	FDS03B01	1/15/97	
	FDS03B02	6/02/97	
FDS03C	FDS03C01	1/15/97	
	FDS03C02	6/04/97	
Area 4			
FDS04A	FDS04A01	1/20/97	Area 4 associated with FDSSC011; elevated
	FDS04A02	5/23/97	TPH-GRO
FDS04B	FDS04B01	1/20/97	
	FDS04B02	5/28/97	
FDS04C	FDS04C01	1/20/97	
	FDS04C02	5/28/97	
Area 5			
FDS05A	FDS05A01	1/19/97	Area 5 associated with FDSSC016; elevated
	FDS05A02	6/05/97	TPH-GRO/inorganics

Table 3.3
FDS Groundwater Samples

Well Number	Sample Identifier	Date sampled	Remarks
FDS05B	FDS05B01	1/17/97	
	FDS05B02	6/05/97	
Area 6			
FDS06A	FDS06A01	1/18/97	Area 6 associated with FDSSC013; elevated
	FDS06A02	5/20/97	TPH-GRO/SVOCs/inorganics
FDS06B	FDS06B01	1/20/97	
	FDS06B02	5/20/97	
FDS06C	FDS06C01	1/20/97	
	FDS06C02	5/30/97	
Area 7			
FDS07A	FDS07A01	1/29/97	Area 7 associated with FDSSC030; elevated
	FDS07A02	6/05/97	inorganics
FDS07B	FDS07B01	1/17/97	
	FDS07B02	6/09/97	
FDS07C	FDS07C01	1/17/97	
	FDS07C02	6/09/97	
FDS07D	FDS07D01	1/24/97	
	FDS07D02	6/19/97	
Area 8			
FDS08A	FDS08A01	1/24/97	Area 8 associated with FDSSC047 and
	FDS08A02	6/05/97	FDSSC47A; elevated TPH-GRO/SVOCs
FDS08B	FDS08B01	1/25/97	
	FDS08B02	6/09/97	
FDS08C	FDS08C01*	1/24/97	*duplicate sample also collected
	FDS08C02*	6/09/97	
Area 9			
FDS09A	FDS09A01	1/21/97	Area 9 associated with FDSSC058; elevated
	FDS09A02	6/10/97	SVOCs
FDS09B	FDS09B01*	1/21/97	* duplicate sample also collected
	FDS09B02*	6/10/97	
FDS09C	FDS09C01	1/21/97	
	FDS09C02	6/10/97	
Area 10			
FDS10A	FDS10A01	1/21/97	Area 10 associated with FDSSC055;
	FDS10A02	6/10/97	elevated TPH-GRO

Table 3.3
FDS Groundwater Samples

Well Number	Sample Identifier	Date sampled	Remarks
FDS10B	FDS10B01	1/21/97	
	FDS10B02	6/10/97	
FDS10C	FDS10C01	1/21/97	
	FDS10C02	6/10/97	
Area 11			
FDS11A	FDS11A01	1/28/97	Area 11 associated with FDSSC051;
	FDS11A02	6/11/97	elevated TPH-GRO
FDS11B	FDS11B01	1/28/97	
	FDS11B02	6/11/97	
FDS11C	FDS11C01*	1/28/97	* duplicate sample also collected
	FDS11C02*	6/11/97	
Area 12			
FDS12A	FDS12A01*	1/27/97	Area 12 associated with FDSSC065;
	FDS12A02*	6/11/97	elevated TPH-GRO/inorganics
			* duplicate sample also collected
FDS12B	FDS12B01	1/27/97	
	FDS12B02	6/11/97	
Area 13			
FDS13A	FDS13A01	1/27/97	Area 13 associated with FDSSC066;
	FDS13A02	6/11/97	elevated TPH-GRO/SVOCs
FDS13B	FDS13B01	1/27/97	
	FDS13B02	6/13/97	
FDS13C	FDS13C01	1/27/97	
	FDS13C02	6/12/97	
FDS13D	FDS13D01	1/27/97	
	FDS13D02	6/12/97	
FDS13E	FDS13E01	1/28/97	
	FDS13E02	6/13/97	
Area 14			
FDS14A	FDS14A01	1/27/97	Area 14 associated with FDSSC067;
	FDS14A02	6/12/97	elevated TPH-GRO/SVOCs/inorganics
FDS14B	FDS14B01	1/27/97	
	FDS14B02	6/12/97	
FDS14C	FDS14C01	1/21/97	
	FDS14C02	6/13/97	

Table 3.3
FDS Groundwater Samples

Well Number	Sample Identifier	Date sampled	Remarks
Area 15			
FDS15A	FDS15A01	1/28/97	Area 15 associated with FDSSH023;
	FDS15A02	6/13/97	elevated TPH-GRO/inorganics
FDS15B	FDS15B01	1/28/97	
	FDS15B02	6/16/97	
FDS15C	FDS15C01	1/28/97	
	FDS15C02	6/16/97	
Area 16			
FDS16A	FDS16A01	1/29/97	Area 16 associated with FDSSC097;
	FDS16A02	6/18/97	elevated TPH-GRO/SVOCs
FDS16B	FDS16B01	1/29/97	
	FDS16B02	6/16/97	
FDS16C	FDS16C01	1/29/97	
	FDS16C02	6/16/97	
Area 17			
FDS17A	FDS17A01	1/28/97	Area 17 associated with FDSSC095;
	FDS17A02	6/17/97	elevated TPH-GRO/SVOCs
FDS17B	FDS17B01	1/28/97	
	FDS17B02	6/17/97	
Area 18			
FDS18A	FDS18A01	1/29/97	Area 18 associated with FDSSC114;
	FDS18A02	6/27/97	elevated TPH-GRO/inorganics

Notes:
* = Duplicates; analyzed for Appendix IX parameters (metals, pesticides/PCBs, herbicides, OP pesticides, dioxins, SVOCs, VOCs); cyanide, and hex-chrome, at DQO Level IV
Samples were analyzed using SW-846 methods (metals, pesticides/PCBs, SVOCs, VOCs) at DQO Level III. First-round samples were also analyzed for cyanide.

3.3.2 Monitoring Well Protector Construction

The well protectors installed were either the flush-mount (manhole) type, or above-grade protective casing type, depending on the well location. Well protectors were installed in accordance with Section 5.4 of the CSAP.

Flush-mount well protectors were installed in vehicle traffic areas such as roadways or parking lots. Above-grade steel protective casings were installed at all other areas. In the case of flush mounts, a 2- by 2-foot section of surface material, typically concrete or asphalt, was removed from around the borehole to approximately 6 inches deep. An 8-inch ID by 8-inch deep flush-mount protector with a bolt-down access cover was then placed over the capped well. The top of the completed well cover was generally constructed 2 inches above the adjacent ground surface. Concrete was added to the 2- by 2-foot excavated area and mounded to provide a sloped surface away from the cover. A monitoring well identification tag listing the well number, date installed, drilling subcontractor, total well depth, and depth to groundwater was mounted onto the sloped concrete surface of each flush-mount pad. Expansion caps and keyed-alike locks were placed on each of these monitoring wells.

Above-grade well protectors were prepared by installing a 3.5- foot long section of 4-inch ID steel protective surface casing over the PVC riser pipe. Care was taken not to compromise the integrity of the bentonite seal overlying the filter pack. The protective casings were hinged approximately 6 inches from the top to allow access to the top of the PVC riser pipe. The hinged covers for each above-grade protective casing were designed to allow for security locking. A 4- by 4-foot concrete pad approximately 6 to 8 inches thick was then constructed around each protective casing. Weep holes were drilled through the well protector at a height that would not allow water to rise above the top of the well. A 3-inch diameter steel bumper post filled with concrete was set at each corner of the pad. A monitoring well identification tag, listing the well number, date installed, drilling subcontractor, total well depth, and depth to groundwater was mounted onto the hinged cover of each above-grade well protector pad. Each hinged cover was secured with a keyed-alike lock.

3.3.3 Monitoring Well Development

Monitoring well development consisted of initially stressing the filter pack by surging and pumping until turbidity was reduced as much as practical and specific conductance, pH, and temperature were stabilized as described below. Monitoring wells were developed according to Section 5.5 of the CSAP.

Surging Procedures:

1. Decontaminated PVC rods were attached to a 2-inch diameter surge block.

2. The surge block was lowered into the monitoring well screen section.

3. The surge block was then raised and lowered repeatedly so groundwater would be surged in and out of the monitoring well screen.

4. Surging was conducted for approximately 10 minutes per well.

5. The surge block was removed from the well for decontamination.

Shallow Well Pumping Procedures:

1. Decontaminated Teflon tubing was lowered into the well.

2. The tubing was attached to a peristaltic pump at the surface and pumping was begun.

3. If the productivity of the monitoring well was low, it was alternately pumped then left idle to recover.

4. Monitoring wells were developed until the water column was as free of turbidity as possible given the subsurface conditions, and until the following parameters were stabilized to satisfy the following criteria.

Temperature:	within ± 1.0°C
pH:	within ± 0.5 standard unit
Conductivity:	within ± 10% from the duplicate
Turbidity:	generally between 10 and 30 nephelometric turbidity units (NTUs) or relatively stable (± 15 NTU)

At least three well volumes of groundwater were removed from each well during development.

3.3.4 Groundwater Sample Collection

Groundwater samples were collected from well locations and analyzed for the parameters listed in the work plan. Each well was sampled twice. Groundwater was sampled in accordance with Section 6 of the CSAP. The following discussion briefly summarizes the site-specific methods applied for the FDS.

Groundwater sample collection followed these steps:

1. Wells were allowed to recover for at least three days after development.

2. Decontaminated sampling equipment and supplies were transported to the monitoring well.

3. A temporary work area was established by placing plastic sheeting around each well. Personal protective equipment (PPE) was donned in accordance with the approved Health and Safety Plan (HASP).

4. The condition and security of the monitoring well were recorded in the field logbook. The security casing was unlocked and the well cap removed. Headspace was immediately measured for VOCs using a flame ionization detector (FID), which was also used to monitor the breathing zone before and during sampling.

5. Depth to water and total well depth were measured with an oil/water interface probe if organic vapor analyzer (OVA) readings exceeding background, odor, or other indicators suggested a light nonaqueous phase liquid (LNAPL) on the water surface. Otherwise, a water-level meter was used. All measurements were recorded to the nearest 0.01 foot. Static water level was measured from the top of casing at a permanent datum point notched in the well casing. Well volumes were calculated, and all measurements and observations recorded in the field logbook. All equipment was decontaminated before reuse.

6. New decontaminated Teflon tubing was installed in the well. The tubing extended into the well and, if water level was sufficient, positioned above the screened interval. A peristaltic pump was positioned at the surface, and the tubing mounted through the pump. Groundwater was purged into graduated buckets or containers to measure volume removed, which was recorded in the field logbook.

7. Each well was purged of at least three well casing volumes of water. Temperature, pH, specific conductance, and turbidity were measured after each volume of water was removed. A well was considered stabilized for sampling when three consecutive temperature, specific conductance, and pH readings met the criteria outlined for well development in Section 5 of the CSAP. Turbidity was monitored until the reading was less than 10 NTUs or lowered as much as practical, and no less than five well casing volumes of water were removed. Wells that were purged dry due to slow recovery were sampled after 12 hours of recovery. Lithologic variabilities prevented purging some wells to less

than 10 NTUs. For example, in wells installed in areas with increased silt content, it was typically more difficult to achieve a turbidity of less than 10 NTUs.

8. After purging, groundwater samples were collected according to the analytical parameters proposed for each monitoring well. Samples for VOC analyses were collected first by capping the tubing and raising it from the well, and then allowing the contents to drain into the sample containers. A precleaned transfer bottle, equipped with an airtight cap containing an inlet and outlet, was then assembled to collect all other sample containers. Once this system was established, the vacuum created allowed collection of groundwater, which was directly poured into the appropriate sample container. Where additional volumes were needed, the transfer bottle was filled repeatedly.

3.4 Sample Management

3.4.1 Sample Identification

All samples collected during the FDS investigation were identified using the 10-character scheme outlined in Section 11.4 of the approved final CSAP. This scheme identifies the samples by site, sample matrix, location, and sample depth. The first three characters identify the site where the sample was collected. The fourth and fifth characters identify the sample medium or quality control (QC) code. Characters six through eight designate sampling location: boring or well number, sampling station, trench number, existing well identification, and others. The ninth and tenth characters represent sample-specific identification such as depth to the nearest foot, depth interval, sampling event (for water samples), and others.

The following characters were used to identify specific media for sample identification during the FDS investigation: CPT soil samples — SC, and groundwater samples — GW (GW is not used as a well location identifier on maps and tables in this report).

3.4.2 Sample Analytical Protocols

All site samples were analyzed per USEPA SW-846 methods at data quality objective (DQO) Level III by Southwest Laboratories, Inc., of Broken Arrow, Oklahoma, unless otherwise noted. Analytical methods for soil and groundwater samples included:

Phase I soil samples:

- TPH-Gasoline Range Organics (GRO) — USEPA Method 8015
- TPH-Diesel Range Organics (DRO) — USEPA Method 8015

Phase II soil samples, and groundwater samples:

- VOCs — USEPA Method 8260
- SVOCs — USEPA Method 8270
- PCBs — USEPA Method 8080
- Cyanide — USEPA Method 9010
- Metals — USEPA Method 6010

Approximately 10% of the samples collected for each medium were duplicated and submitted for Appendix IX analytical parameters at DQO Level IV. These additional samples were collected to fulfill quality assurance (QA)/QC standards while cost-effectively analyzing additional parameters. In addition to analyses for VOC, SVOC, pesticide, PCB, metal, and cyanide constituents, Appendix IX samples included:

- Hexavalent chromium — USEPA Method 7196
- Dioxins/Dibenzofurans — USEPA Method 8290
- Herbicides — USEPA Method 8150
- Organophosphorous (OP) pesticides — USEPA Method 8140
- Ethylene dibromide (EDB) — USEPA Method 8260

3.4.3 Sample Preparation, Packaging, and Shipment

Section 11 of the CSAP details procedures for sample preparation, packaging, and shipment. The following is a brief overview of these procedures.

For soil, sample material was transferred from the sampler to a stainless-steel bowl with a stainless-steel spoon. VOC samples were transferred directly to the container and filled with zero headspace to reduce volatilization. Soil for all other analyses was homogenized with a stainless-steel spoon and placed into appropriate containers. Any remaining soil was returned to the borehole. Bentonite pellets, hydrated in place with American Society for Testing and Materials (ASTM) Type III water, were used to backfill any remaining space.

Groundwater samples were preserved according to laboratory criteria for parameters being analyzed. Appropriate labels and custody seals were completed and affixed to each sample bottle. Immediately after sample collection and identification, sample containers were placed on ice in coolers. Records of sampling were entered in a dedicated field logbook, and a master logbook placed in a fireproof safe in the site trailer.

Soil and groundwater sample containers were individually custody-sealed, encased in protective bubble wrap, double-bagged in waterproof resealable plastic bags, and placed on ice in a cooler to ensure proper preservation at 4°C during shipment. All sample information was recorded on a preprinted chain-of-custody form, which was then affixed to the top inside surface of the cooler. Temperature blanks were included with each shipment to monitor sample temperature upon arrival.

After recording sample numbers, analyses, times, date, and an air-bill shipping number on an official shipping log, the coolers were shipped priority overnight via FedEx to the contracted laboratory.

3.5 Vertical and Horizontal Surveying

Soil CPT locations were surveyed by the Global Positioning System (GPS). Monitoring well locations and elevations were determined by conventional plane surveying techniques. The horizontal and vertical control were established from existing monumentation on NAVBASE, with horizontal datum from North American Datum 1983 and vertical datum from National Geodetic Vertical Datum 1929. All traverse closures exceeded 1/20,000. No data corrections were required as part of the monitoring well survey.

3.6 Aquifer Characterization

High and low-tide water level runs were conducted for all FDS wells and adjacent AOC and SWMU site wells. This was done to characterize groundwater elevation and flow direction in the surficial aquifer beneath the individual areas of investigation.

3.7 Decontamination Procedures

Decontamination was conducted in accordance with Section 15 of the CSAP. A brief discussion of the FDS decontamination procedures is listed below.

3.7.1 Decontamination Area Setup

The decontamination area contains a concrete pad sloped to direct wash runoff into a catch basin, from which liquids were pumped regularly into the tanker. Equipment was cleaned on sawhorses or auger racks above the concrete surface. When field cleaning of equipment was necessary, plastic sheeting was placed on the ground to contain any spills.

3.7.2 Cross-Contamination Prevention

The following procedures were implemented during sampling activities to reduce cross-contamination risk.

- Fresh disposable outer gloves were donned before handling sampling equipment.

- Only Teflon, glass, or stainless-steel spray bottles/pressurized containers were used to apply decontamination fluids. Each solution was kept in a separate container.

- All necessary decontaminated field equipment was transported to the sampling location to minimize the need for field cleaning.

3.7.3 Nonsampling Equipment

Nonsampling equipment used during the FDS investigation included only CPT and drill rigs. The rigs were decontaminated using the following procedures:

1. A high-pressure hot water and/or steam wash was used first.

2. Equipment components that contact sample material were scrubbed with a laboratory-grade detergent and clean water wash solution.

3. Equipment was rinsed with clean water.

3.7.4 Sampling Equipment

Sampling equipment includes any downhole equipment and sampling tools not dedicated to the sample location. Hollow downhole equipment or equipment with holes that could transmit water or drilling fluids were cleaned on the inside and outside. The decontamination procedure is as follows:

1. Protective gloves were donned before decontaminating the equipment.

2. Items were washed and scrubbed with a laboratory-grade detergent and clean water wash solution or sprayed with high-pressure steam.

3. Equipment was rinsed with ASTM Type III water.

4. Equipment was rinsed twice with pesticide-grade isopropyl alcohol.

5. Equipment was rinsed with ASTM Type III water.

6. Equipment was air dried. If weather prohibited air drying, the isopropyl alcohol rinse was repeated and the item was rinsed twice with ASTM Type III water.

7. Items were wrapped in aluminum foil or plastic sheeting if the equipment was to be stored or transported.

8. Augers and drill rods were covered in clean plastic following decontamination.

4.0 INVESTIGATION RESULTS

The contamination assessment results for the FDS include 150 Phase I subsurface soil samples, 23 Phase II subsurface soil, and 54 shallow groundwater samples. Phase I soil samples were analyzed for TPH-GRO and DRO to screen for petroleum contamination. These results were compared to a conservative concentration of 50 micrograms per kilogram (μg/kg) GRO or 50 milligrams per kilogram (mg/kg) DRO to identify impacted areas.

Phase II soil samples, collected from areas identified during Phase I, were analyzed for FSA parameters to characterize the nature of the contaminants. The monitoring well samples were also analyzed for FSA parameters. Each well was sampled twice. For purposes of this CAR, applicable chemicals of concern (COCs) were compared to the RBSLs for soil and groundwater, as specified in *South Carolina Risk-Based Corrective Action for Petroleum Releases* (SCDHEC, January 5, 1998). This document details South Carolina's petroleum program relative to determining the need for corrective action. The RBSLs for sandy soil, less than 5 feet to groundwater, were used for comparison to subsurface soil results. Two groundwater sampling events were included in this assessment. The second, most recent sampling event was compared to the RBSLs. Parameters without a designated RBSL were compared as follows:

- For soil, non-RBSL parameters were compared to the soil-to-groundwater screening levels (SSLs), used in the draft Zone G RFI Report. These levels were determined using *Soil Screening Guidance, Technical Background Document* (USEPA, 1996b). Inorganics in soil were also compared to the Zone G soil background concentrations, found in the draft Zone G RFI Report.

- For groundwater, non-RBSL parameters were compared to the tap water risk-based concentrations (RBCs) with a target hazard quotient (THQ) of 0.1 as presented in the USEPA Region III Risk Based Concentration Table (USEPA, October 22, 1997).

Inorganics in groundwater were compared to the Zone G groundwater background concentrations, found in the draft Zone G RFI Report.

4.1 Phase I

A total of 150 Phase I soil screening samples were collected and analyzed for TPH, as described in Section 3 of this CAR. Figure 2-1 presents the locations of the soil samples. Table 4.1 presents the Phase I sample analytical results; complete analytical results are contained in Appendix C. Ninety-nine samples exhibited detectable TPH concentrations. Ninety-six exhibited TPH-GRO, while only three showed TPH-DRO. Of these, 18 exhibited concentrations which either exceeded the conservative arbitrary screening value of 50 mg/kg DRO/50 μg/kg GRO, or appeared to be grossly contaminated based on visual observation. These 18 locations, (indicated in bold type in the table), were advanced to Phase II for specific constituent soil analysis and monitoring well installation and sampling. Where duplicate samples were collected the results were averaged with the original. Sample FDSSC05101 exhibited a TPH-GRO of 77.6 μg/kg, while the duplicate reported 7.9 μg/kg. To ensure a conservative approach, this area was included in Phase II based on the original result. The area identified by sample FDSSC05801 was advanced to Phase II based on odor and visual petroleum contamination. Phase I sampling identified 18 areas of potential impact from the FDS which advanced to Phase II soil and groundwater sampling. Table 4.1 correlates the Phase I sample results with the area designation. Subsequent to Phase II sampling, two other areas, 19 and 20, were identified for inclusion in this CAR.

Table 4.1
Phase I
Detected Soil TPH Concentrations
Fuel Distribution System

Sample ID	Result	Area
	TPH-DRO Diesel (mg/kg)	
FDSSC02701	30.20	
FDSSC03001	**102.00**	Area 7
FDSSC11401	**336.00**	Area 18
	TPH-GRO Gasoline (μg/kg)	
FDSSC00101	14.00	
FDSSC00201	**16300.00**	Area 1
FDSSC00301	24.00	
FDSSC00401	13.00	
FDSSC00501	11.00	
FDSSC00601	9.00	
FDSSC00701	35.00	
FDSSC00801	24.80	
FDSSC00901	13.50	
FDSSC01001	22.60	
FDSSC01101	**61.80**	Area 4
FDSSC01201	**124000.00**	Area 2
FDSSC01301	**77.60**	Area 6
FDSSC01401	**67.50**	Area 3
FDSSC01501	25.50	
FDSSC01601	**65.00**	Area 5
FDSSC01701	32.70	
FDSSC01901	37.95	
FDSSC02001	23.60	
FDSSC02101	12.40	
FDSSC02201	10.00	
FDSSC02301	14.00	

Table 4.1
Phase I
Detected Soil TPH Concentrations
Fuel Distribution System

Sample ID	Result	Area
FDSSC02501	10.00	
FDSSC02601	29.00	
FDSSC02801	25.50	
FDSSC02901	13.00	
FDSSC03001	9.00	
FDSSC03101	8.00	
FDSSC03201	27.00	
FDSSC03301	18.00	
FDSSC03602	15.00	
FDSSC03701	23.80	
FDSSC03702	20.30	
FDSSC03901	17.20	
FDSSC03902	24.00	
FDSSC04001	16.40	
FDSSC04002	15.40	
FDSSC04101	14.60	
FDSSC04102	14.00	
FDSSC04201	8.51	
FDSSC04202	21.50	
FDSSC04301	23.70	
FDSSC04401	35.80	
FDSSC04601	11.10	
FDSSC04701	**19000.00**	Area 8
FDSSC04801	8.88	
FDSSC04901	7.12	
FDSSC05001	15.30	
FDSSC05101	**42.75**[a]	Area 11

Table 4.1
Phase I
Detected Soil TPH Concentrations
Fuel Distribution System

Sample ID	Result	Area
FDSSC05201	8.56	
FDSSC05301	24.60	
FDSSC05401	16.80	
FDSSC05501	**63.70**	Area 10
FDSSC05601	37.60	
FDSSC05701	17.00	
FDSSC05801	**10.00**[b]	Area 9
FDSSC05901	10.00	
FDSSC06001	21.00	
FDSSC06101	8.00	
FDSSC06401	8.00	
FDSSC06501	**147.00**	Area 12
FDSSC06601	**67.00**	Area 13
FDSSC06701	**106.00**	Area 14
FDSSC06801	18.00	
FDSSC06901	8.00	
FDSSC07001	15.00	
FDSSC07201	8.00	
FDSSC07301	15.00	
FDSSC07401	8.00	
FDSSC07701	11.50	
FDSSC08101	9.00	
FDSSC08201	8.00	
FDSSC08301	8.00	
FDSSC08401	7.00	
FDSSC08801	9.00	
FDSSC08901	35.00	

Table 4.1
Phase I
Detected Soil TPH Concentrations
Fuel Distribution System

Sample ID	Result	Area
FDSSC09501	**33078.50**	Area 17
FDSSC09701	25.00	
FDSSC09702	**87.00**	Area 16
FDSSC10001	17.00	
FDSSC10501	42.00	
FDSSC10601	7.00	
FDSSC10701	9.50	
FDSSC11201	9.00	
FDSSC11301	15.00	
FDSSC11501	7.00	
FDSSH00101	10.00	
FDSSH00601	9.00	
FDSSH01201	9.00	
FDSSH01601	32.00	
FDSSH01801	10.00	
FDSSH02101	10.00	
FDSSH02201	10.00	
FDSSH02301	**501.00**	Area 15
FDSSH02601	20.00	

Notes:
a = Average of original duplicate concentrations. Original sample concentration was 77.6 μg/kg.
b = Based on visual observation of gross contamination.
Bolded concentrations exceed 50 μg/kg (GRO) or 50 mg/kg (DRO).

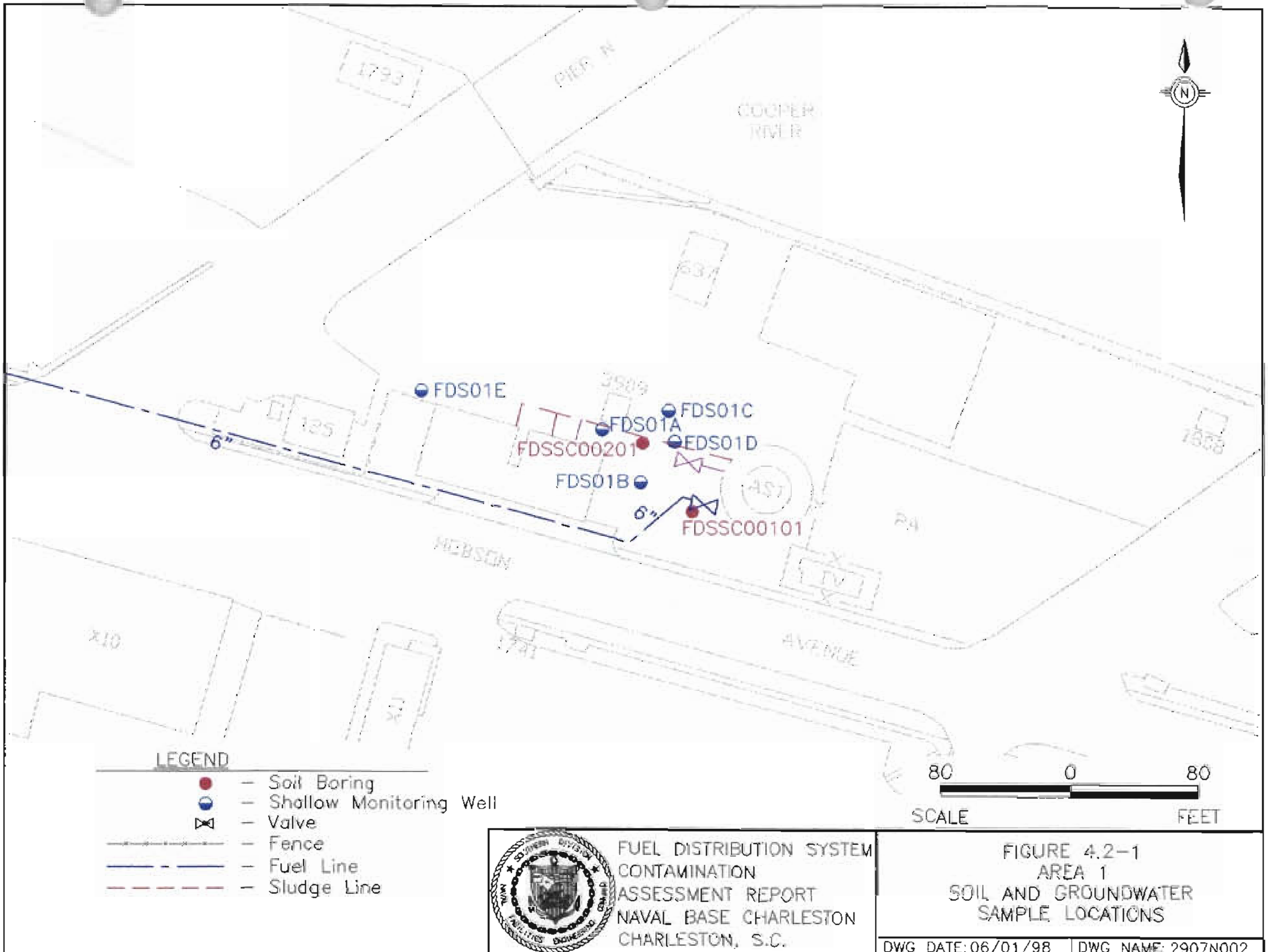
4.2 Area 1

Area 1 was identified by Phase I soil sample FDSSC00201 (collected from the 4.5 to 5.5 feet bgs depth interval). This area of potential impact is near the northeast corner of Building 123, which faces Hobson Avenue as shown on Figure 1-3. An aboveground storage tank (AST) sits approximately 70 feet east of the building. Soil sample FDSSC00101 was collected near the AST to evaluate its potential impact, but no significant impact was indicated. The Cooper River lies approximately 110 feet to the north. The soil boring associated with this area, FDSSC00201, is about 20 feet east of the northeast corner of Building 123. Four shallow monitoring wells (FDS01A, FDS01B, FDS01C, and FDS01D) were initially installed around this location to detect possible petroleum constituents that may have migrated to groundwater. Upon discovering free product in FDS01A, a fifth well (FDS01E) was installed near the northwest corner of Building 123 to further delineate downgradient groundwater petroleum contamination. Figure 4.2-1 presents the soil and groundwater sampling locations for Area 1.

4.2.1 Site Geology and Hydrogeology

Based on borings advanced at this site, the general stratigraphy at Area 1 is comprised of silty sand and gravel fill from land surface to 2 feet bgs, overlying alternating intervals of dark gray to black silty organic clay, and silty clayey sand, to a depth of 10 feet bgs. Petroleum odors were noted on soil samples collected from 0 to 6 feet bgs at monitoring well boring FDS01A. Appendix B contains boring logs and monitoring well construction diagrams for Area 1.

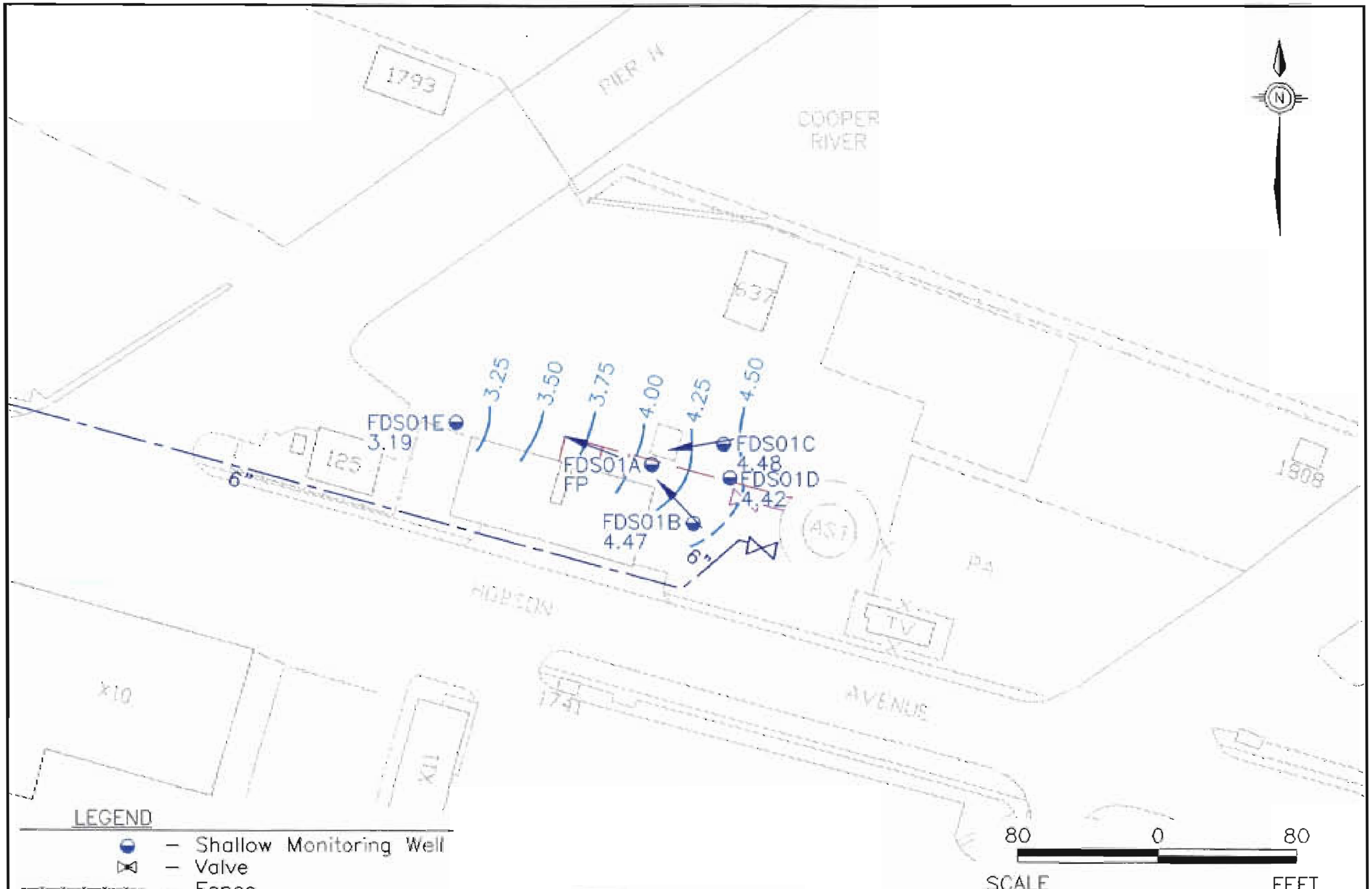
Shallow groundwater at Area 1 generally occurs from 2.3 to 3.8 feet bgs. Figures 4.2-2 and 4.2-3 depict the shallow groundwater potentiometric surface and inferred flow direction for the site during low- and high-tide, respectively. Shallow groundwater flow direction changes only slightly between tidal stages. Well FDS01E provides downgradient coverage during low-tide. But during high-tide, flow changes to a more southwesterly direction. Consequently, it appears as though no



FUEL DISTRIBUTION SYSTEM
CONTAMINATION
ASSESSMENT REPORT
NAVAL BASE CHARLESTON
CHARLESTON, S.C.

FIGURE 4.2-1
AREA 1
SOIL AND GROUNDWATER
SAMPLE LOCATIONS

DWG DATE: 06/01/98 | DWG NAME: 2907N002



LEGEND

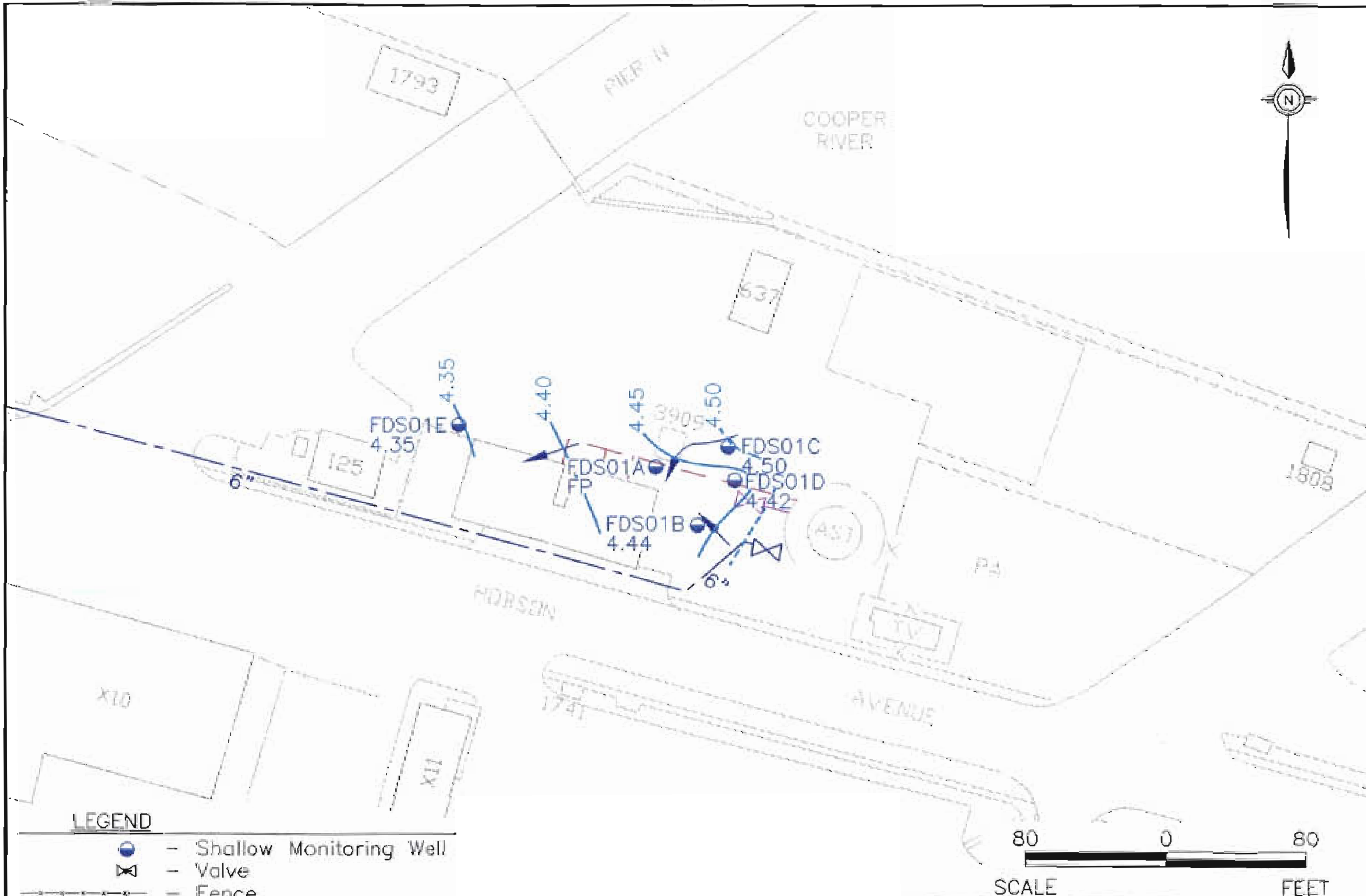
- Shallow Monitoring Well
- Valve
- Fence
- Fuel Line
- Sludge Line
- Contour Interval = 0.25 Feet
- Arrow Indicates Flow Direction

FP – Free Product

FUEL DISTRIBUTION SYSTEM CONTAMINATION ASSESSMENT REPORT
NAVAL BASE CHARLESTON
CHARLESTON, S.C.

FIGURE 4.2-2
AREA 1
SHALLOW GROUNDWATER
LOW-TIDE POTENTIOMETRIC MAP

DWG DATE: 06/29/98 | DWG NAME: 2907N026



LEGEND

- Shallow Monitoring Well
- Valve
- Fence
- Fuel Line
- Sludge Line
- Contour Interval = 0.05 Feet
- Arrow Indicates Flow Direction

FP - Free Product

FUEL DISTRIBUTION SYSTEM CONTAMINATION ASSESSMENT REPORT
NAVAL BASE CHARLESTON
CHARLESTON, S.C.

FIGURE 4.2-3
AREA 1
SHALLOW GROUNDWATER
HIGH-TIDE POTENTIOMETRIC MAP

DWG DATE: 06/30/98 | DWG NAME: 2907N027

clear downgradient well exists for the high-tide flow regime. Water level elevations at Area 1 vary greatly with the tide from 0.0 to 1.16 feet. Maximum average calculated groundwater velocity (utilizing the steepest gradient at the site) was 0.193 feet per day (feet/day) based on an average porosity (0.359) and representative hydraulic conductivity (7.7 feet/day) determined during the Zone G RFI (EnSafe, February 1998).

4.2.2 Nature of Contamination in Subsurface Soil

Area 1 subsurface soil analytical results are summarized in Table 4.2.1. No surface soil samples were collected in Area 1. Appendix C contains a complete analytical data report for all FDS samples.

TPH-GRO in Subsurface Soil

The Phase I soil sample FDSSC00201 exhibited 16,300 μg/kg of TPH-GRO, prompting subsequent Phase II soil and groundwater sampling at Area 1. Soil samples FDSSC00101 and FDSSC00301 adjacent to Area 1 identified no significant TPH contamination.

Volatile Organic Compounds in Subsurface Soil

Four VOCs were detected in subsurface soil at Area 1. All compounds detected were present at concentrations far below their soil RBSLs or SSLs, if no RBSL is available.

Semivolatile Organic Compounds in Subsurface Soil

Eight SVOCs were detected in Area 1 subsurface soil. A total naphthalene concentration of 1,360 μg/kg exceeded its RBSL of 210 μg/kg. This sum is comprised of 2-methylnaphthalene (940 μg/kg) and naphthalene (420 μg/kg). Both of these concentrations are far below their SSLs. No other SVOC RBSL or SSL was exceeded.

Table 4.2.1
Analytes Detected in Subsurface Soil
Area 1
Fuel Distribution System

Parameters	Location	Subsurface Conc.	RBSL/SSL	Subsurface Background
TPH - GRO (μg/kg)				
Gasoline	FDSSC00201	16300	NL/NL	NA
Volatile Organic Compounds (μg/kg)				
Carbon Disulfide	FDSSC00201	4	NL/32000	NA
Ethylbenzene	FDSSC00201	4	1260/13000	NA
Toluene	FDSSC00201	7	1622/12000	NA
Xylene (Total)	FDSSC00201	36	42471/148000	NA
Semivolatile Organic Compounds (μg/kg)				
Total Naphthalenes	FDSSC00201	**1360**	210/84000	NA
2-Methylnaphthalene	FDSSC00201	940	NL/126000	NA
Naphthalene	FDSSC00201	420	NL/84000	NA
Chrysene	FDSSC00201	50	12998/160000	NA
Dibenzofuran	FDSSC00201	460	NL/50000	NA
Fluoranthene	FDSSC00201	310	NL/4300000	NA
Fluorene	FDSSC00201	1200	NL/560000	NA
Phenanthrene	FDSSC00201	980	NL/1380000	NA
Pyrene	FDSSC00201	360	NL/4200000	NA
Inorganics (mg/kg)				
Aluminum (Al)	FDSSC00201	9080	NL/1000000	23600
Arsenic (As)	FDSSC00201	10.8	NL/29	15.5[a]
Barium (Ba)	FDSSC00201	17.2	NL/1600	64.5
Beryllium (Be)	FDSSC00201	0.78	NL/63	1.63
Calcium (Ca)	FDSSC00201	10300	NL/NL	NL
Chromium (Cr)	FDSSC00201	17.7	NL/1000000	43.4[a]
Cobalt (Co)	FDSSC00201	2.8	NL/2000	8.14
Copper (Cu)	FDSSC00201	3.7	NL/920	32.6
Iron (Fe)	FDSSC00201	13100	NL/NL	NL

Table 4.2.1
Analytes Detected in Subsurface Soil
Area 1
Fuel Distribution System

Parameters	Location	Subsurface Conc.	RBSL/SSL	Subsurface Background
Lead (Pb)	FDSSC00201	6.8	NL/400	66.3
Magnesium (Mg)	FDSSC00201	1880	NL/NL	NL
Manganese (Mn)	FDSSC00201	124	NL/1100	291
Nickel (Ni)	FDSSC00201	5.5	NL/130	18.3
Potassium (K)	FDSSC00201	952	NL/NL	NL
Sodium (Na)	FDSSC00201	391	NL/NL	NL
Vanadium (V)	FDSSC00201	32.2	NL/6000	72.5
Zinc (Zn)	FDSSC00201	19	NL/12000	145

Notes:
a = Background value for non-clay samples
NL = Not listed
NA = Not applicable
μg/kg = Micrograms per kilogram
mg/kg = Milligrams per kilogram
RBSLs from the *South Carolina Risk-Based Corrective Action for Petroleum Releases* (SCDHEC, January 5, 1998) and soil-to-groundwater SSLs (DAF=20) from the *Soil Screening Guidance: Technical Background Document* (USEPA, 1996b) were used as reference concentrations.
Bolded concentrations exceed RBSL or the SSL (if no RBSL is available).
All background values for Zone G are based on twice the mean of grid sample concentrations.

Inorganics in Subsurface Soil

Seventeen metals were detected in Area 1 subsurface soil. No RBSLs are available for the metals detected in Area 1 in soil. All detected metal concentrations were below their SSLs.

4.2.3 Nature of Contamination in Shallow Groundwater

During the water level run performed on April 29, 1997, free product (approximately 4.5 feet thick) was observed in well FDS01A. Currently, the free product is less than 0.5 feet thick. Area 1 groundwater analytical results are summarized in Table 4.2.2. Appendix C contains a complete analytical data report for all FDS samples.

Volatile Organic Compounds in Shallow Groundwater

Four VOCs were detected in samples from well FDS01A during both sampling events, but concentrations were slightly lower in the second event. Benzene was detected at a concentration equal to the RBSL during the first event. Benzene was below the RBSL, but still exceeded the tap water RBC during the second sampling event. None of the VOCs detected during the second and most recent sampling event exceeded their groundwater RBSLs.

Semivolatile Organic Compounds in Shallow Groundwater

Fifteen PAHs and two other SVOCs, benzoic acid and dibenzofuran, were detected in Area 1 groundwater samples. Anthracene, acenaphthene, fluoranthene, fluorene, 2-methylnaphthalene, phenanthrene, and pyrene exceeded their respective RBSLs in monitoring well FDS01A during the second sampling event. Concentrations of acenaphthene and naphthalene also exceeded their respective RBSLs in well FDS01B during the second sampling event. Consequently, the RBSL for total PAHs was also exceeded in samples from FDS01A and FDS01B. The tap water RBC for dibenzofuran was also exceeded during both sampling events in well FDS01A. No RBSL exists for dibenzofuran. Figure 4.2-4 presents the distribution of PAHs detected in groundwater during the second most recent sampling event at Area 1.

Inorganics in Shallow Groundwater

Twenty-two metals plus cyanide were detected in Area 1 shallow groundwater samples, but no RBSLs for groundwater metals were exceeded. Concentrations of beryllium, manganese, and thallium exceeded their tap water RBCs in the second sampling event. No background was established for beryllium or thallium. Although concentrations of manganese exceeded the RBC, they were below the Zone G background value.

Table 4.2.2
Analytes Detected in Shallow Groundwater
Area 1
Fuel Distribution System

Parameters	Location	First Sampling Event	Second Sampling Event	RBSL/Tap Water RBC (μg/L)	Shallow Background
Volatile Organic Compounds (μg/L)					
Benzene	FDS01A	5	4	5/0.36	NA
Ethylbenzene	FDS01A	45	42	700/130	NA
Toluene	FDS01A	6	4	1000/75	NA
Xylene (Total)	FDS01A	280	230	10000/1200	NA
Semivolatile Organic Compounds (μg/L)					
Total PAHs	FDS01A	**495**	**333**	25/NL	NA
	FDS01B	20	**48**		
	FDS01C	0	2		
	FDS01D	3	4		
Anthracene	FDS01A	**16**	**13**	10/1100	NA
Acenaphthene	FDS01A	**47**	**37**	10/220	NA
	FDS01B	**19**	**25**		
	FDS01C	ND	2		
	FDS01D	3	4		
Benzo(a)anthracene	FDS01A	7	6	10/9.2E-02	NA
Benzo(b)fluoranthene	FDS01A	6	2	10/9.2E-02	NA
Benzo(k)fluoranthene	FDS01A	ND	3	10/0.92	NA
Benzo(g,h,i)perylene	FDS01A	1	1	10/150	NA
Benzo(a)pyrene	FDS01A	3	2	10/9.2E-03	NA
Chrysene	FDS01A	7	6	10/9.2	NA
Fluoranthene	FDS01A	**50**	**34**	10/150	NA
Fluorene	FDS01A	**41**	**44**	10/150	NA
Indeno(1,2,3-cd)pyrene	FDS01A	1	1	10/9.2E-02	NA
2-Methylnaphthalene	FDS01A	**130**	**71**	10/150	NA
Naphthalene	FDS01A	**39**	ND	10/150	NA
	FDS01B	ND	**23**		
Phenanthrene	FDS01A	**120**	**91**	10/150	NA
	FDS01B	1	ND		

Table 4.2.2
Analytes Detected in Shallow Groundwater
Area 1
Fuel Distribution System

Parameters	Location	First Sampling Event	Second Sampling Event	RBSL/Tap Water RBC (µg/L)	Shallow Background
Pyrene	FDS01A	**27**	**22**	10/110	NA
Benzoic Acid	FDS01D	1	ND	NL/15000	NA
Dibenzofuran	FDS01A	**32**	**25**	NL/15	NA
Inorganics (µg/L)					
Aluminum (Al)	FDS01A	315	335	NL/3700	692
	FDS01B	30.4	244		
	FDS01C	52.8	136		
	FDS01D	1165	111		
	FDS01E	358	ND		
Antimony (Sb)	FDS01E	**4.2**	ND	NL/1.5	4 85
Arsenic (As)	FDS01A	6.9	2.2	50/4.5E-02	17.8
	FDS01B	5.7	9.9		
	FDS01C	9.8	4.3		
	FDS01D	5.4	4.6		
	FDS01E	5.9	ND		
Barium (Ba)	FDS01A	21.1	10.6	2000/260	31
	FDS01B	14.8	7.3		
	FDS01C	31	36.1		
	FDS01D	27.2	19.8		
	FDS01E	11.5	3.1		
Beryllium (Be)	FDS01A	**0.34**	ND	NL/1.6E-02	ND
	FDS01B	**0.36**	**0.37**		
	FDS01C	**0.34**	**0.35**		
	FDS01E	ND	**0.35**		
Cadmium (Cd)	FDS01B	ND	0.41	5/1.8	0.53
Calcium (Ca)	FDS01A	101000	116000	NL/NL	NL
	FDS01B	166000	160000		
	FDS01C	238000	117000		
	FDS01D	95200	88550		
	FDS01E	50800	73800		
Chromium (Cr)	FDS01A	1	1.5	100/18	3.88
	FDS01B	ND	1.2		
	FDS01D	3.8	ND		
	FDS01E	1.6	ND		
Cobalt (Co)	FDS01D	ND	1	NL/220	1.45

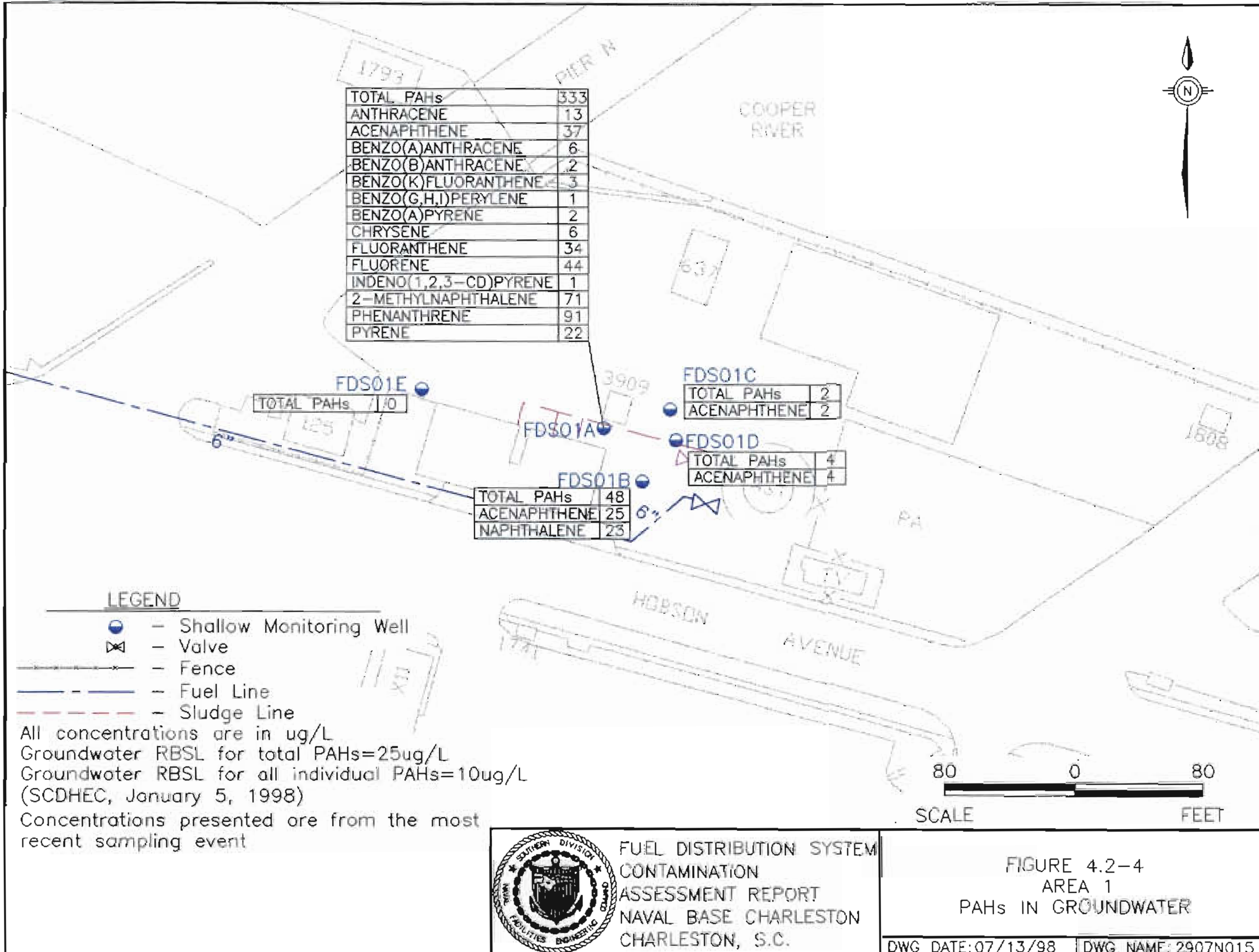
Table 4.2.2
Analytes Detected in Shallow Groundwater
Area 1
Fuel Distribution System

Parameters	Location	First Sampling Event	Second Sampling Event	RBSL/Tap Water RBC ($\mu g/L$)	Shallow Background
Copper (Cu)	FDS01A	2.8	2.7	NL/13000	8.33
	FDS01B	0.61	ND		
	FDS01D	5.6	ND		
Cyanide (CN)	FDS01A	6	NT	NL/73	3.8
	FDS01B	ND	NT		
	FDS01D	3.6	NT		
	FDS01E	3.9	NT		
Iron (Fe)	FDS01A	2670	2230	NL/NL	NL
	FDS01B	4670	6070		
	FDS01C	11900	7110		
	FDS01D	7685	6780		
	FDS01E	1410	930		
Lead (Pb)	FDS01B	ND	1.5	15/15	4.6
Magnesium (Mg)	FDS01A	22800	15800	NL/NL	NL
	FDS01B	17500	12500		
	FDS01C	34700	37500		
	FDS01D	79500	74500		
	FDS01E	9960	9080		
Manganese (Mn)	FDS01A	**229**	**193**	NL/84	2,906
	FDS01B	**323**	**213**		
	FDS01C	**626**	**258**		
	FDS01D	**792**	**660**		
	FDS01E	**123**	**129**		
Mercury (Hg)	FDS01D	0.1	ND	2/1.1	ND
Nickel (Ni)	FDS01A	1.5	2.2	NL/73	4.08
	FDS01B	1.9	1.8		
	FDS01D	4.0	1.2		
	FDS01E	3.0	ND		
Potassium (K)	FDS01A	17200	8810	NL/NL	NL
	FDS01B	29800	27200		
	FDS01C	20100	33700		
	FDS01D	48300	45450		
	FDS01E	8780	8120		
Silver (Ag)	FDS01A	ND	1.2	5/18	1.65
	FDS01D	ND	1.7		
Sodium (Na)	FDS01A	161000	63300	NL/NL	NL
	FDS01B	116000	96500		
	FDS01C	170000	325000		
	FDS01D	338000	357500		
	FDS01E	114000	79800		

Table 4.2.2
Analytes Detected in Shallow Groundwater
Area 1
Fuel Distribution System

Parameters	Location	First Sampling Event	Second Sampling Event	RBSL/Tap Water RBC (μg/L)	Shallow Background
Thallium (Tl)	FDS01D	**9.2**	**6.7**	NL/0.29	ND
Tin (Sn)	FDS01D	2.7	ND	NL/2200	ND
Vanadium (V)	FDS01A	4.7	5.4	NL/26	15.4
	FDS01B	2.7	2.5		
	FDS01C	1.3	2		
	FDS01D	5.2	2.0		
	FDS01E	6.1	ND		

Notes:
NL = Not listed
NA = Not applicable
ND = Not detected
NT = Not taken
μg/L = Micrograms per liter
RBSLs from the *South Carolina Risk-Based Corrective Action for Petroleum Releases* (SCDHEC, January 5, 1998) and tap water RBCs (THQ=0.1) from *Risk Based Concentration Table* (USEPA, October 22, 1997) were used as reference concentrations.
Bolded concentrations exceed RBSL or the tap water RBC (if no RBSL is available).
All background values for Zone G are based on twice the mean of grid sample concentrations. Background values for groundwater are based on two sampling rounds in two wells at each depth.



All concentrations are in ug/L
Groundwater RBSL for total PAHs=25ug/L
Groundwater RBSL for all individual PAHs=10ug/L
(SCDHEC, January 5, 1998)
Concentrations presented are from the most recent sampling event

FUEL DISTRIBUTION SYSTEM CONTAMINATION ASSESSMENT REPORT
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FIGURE 4.2-4
AREA 1
PAHs IN GROUNDWATER

DWG DATE: 07/13/98 DWG NAME: 2907N015

4.3 Areas 2, 3, 4, 5, and 6

Areas 2, 3, 4, 5, and 6 were identified by soil samples FDSSC01201 (collected from the 6.8 feet bgs depth interval), FDSSC01401 (6 to 7.5 feet bgs depth interval), FDSSC01101 (4 to 6 feet bgs depth interval), FDSSC01601 (6 to 7.5 feet bgs depth interval), and FDSSC01301 (4.3 to 5.8 feet bgs depth interval), respectively. These areas of potential impact, grouped together for discussion because of their proximity, are all in the vicinity of Building 132, which was investigated during the Zone G RFI as AOC 638. Building 132 is on the northeast corner of Hobson Avenue and Brumby Street. The Cooper River lies approximately 400 feet to the east. To investigate potential groundwater petroleum contamination, 14 shallow monitoring wells were installed at this combined site. Because of the proximity to AOC 638, the shallow well installed for this site's RFI (638001) was included in the groundwater investigation. Figure 4.3-1 presents the soil and groundwater sampling locations for the combined Areas 2, 3, 4, 5, and 6.

4.3.1 Site Geology and Hydrogeology

Based on well borings, the general stratigraphy at the combined site is brown silty, sandy clay, to a depth of approximately 3 feet bgs. This material overlies alternating intervals of tan, brown, and black sand, tan to olive green to gray silt, and gray to black organic clay, to a depth of approximately 12 feet bgs. Petroleum odors and/or stains were noted in stratigraphic soil samples collected from 5 to 7 feet bgs at well borings FDS02A, FDS04A, and FDS06A. Appendix B contains boring logs and monitoring well construction diagrams for wells associated with Areas 2, 3, 4, 5, and 6.

Shallow groundwater at Areas 2, 3, 4, 5, and 6 occurs from less than 2.8 to 5.2 feet bgs. Figures 4.3-2 and 4.3-3 depict the shallow groundwater potentiometric surface and inferred flow direction for the site during low- and high-tides, respectively. The overall shallow groundwater flow patterns are relatively consistent, with only minor localized variations between tidal stages.

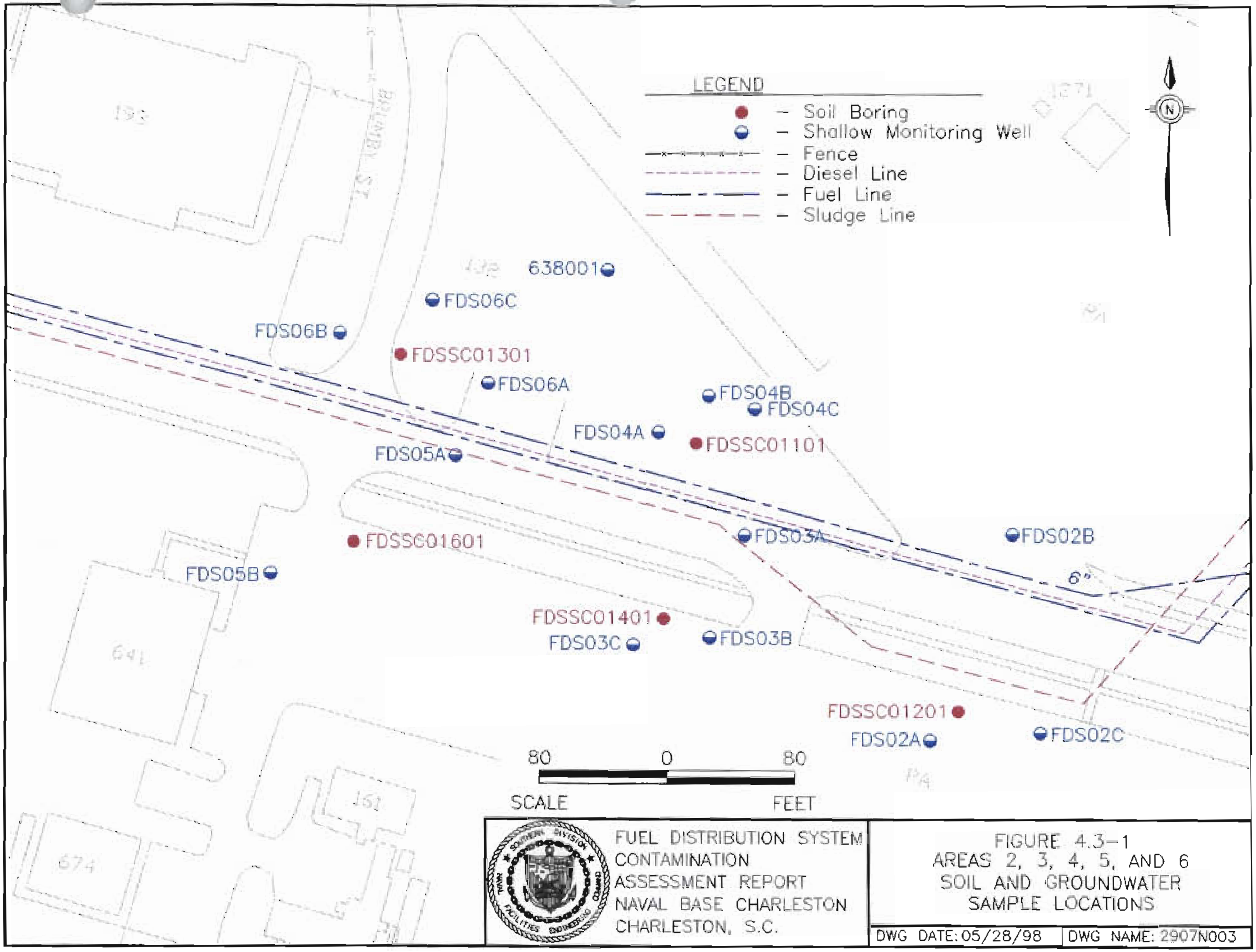

FIGURE 4.3-1
AREAS 2, 3, 4, 5, AND 6
SOIL AND GROUNDWATER
SAMPLE LOCATIONS

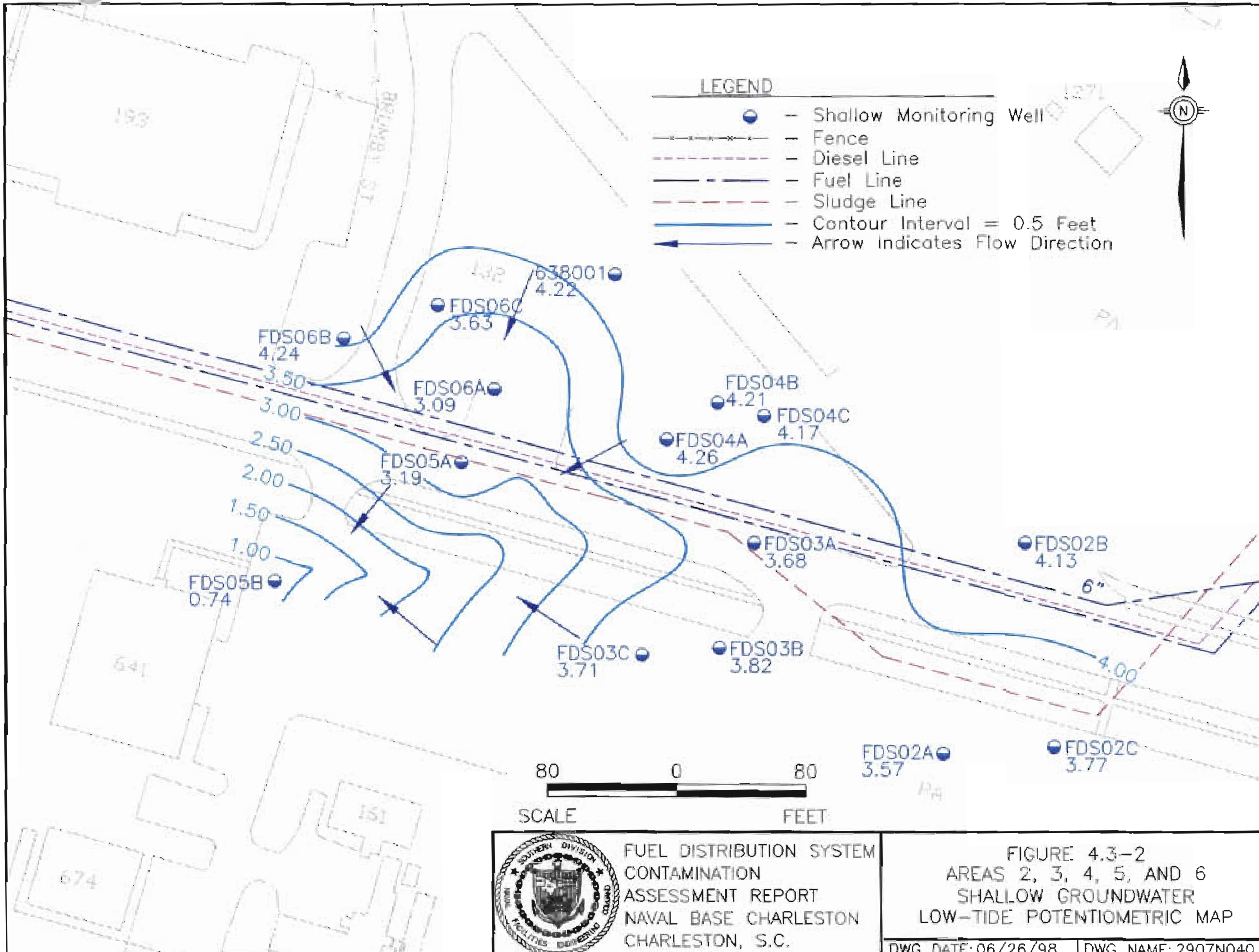

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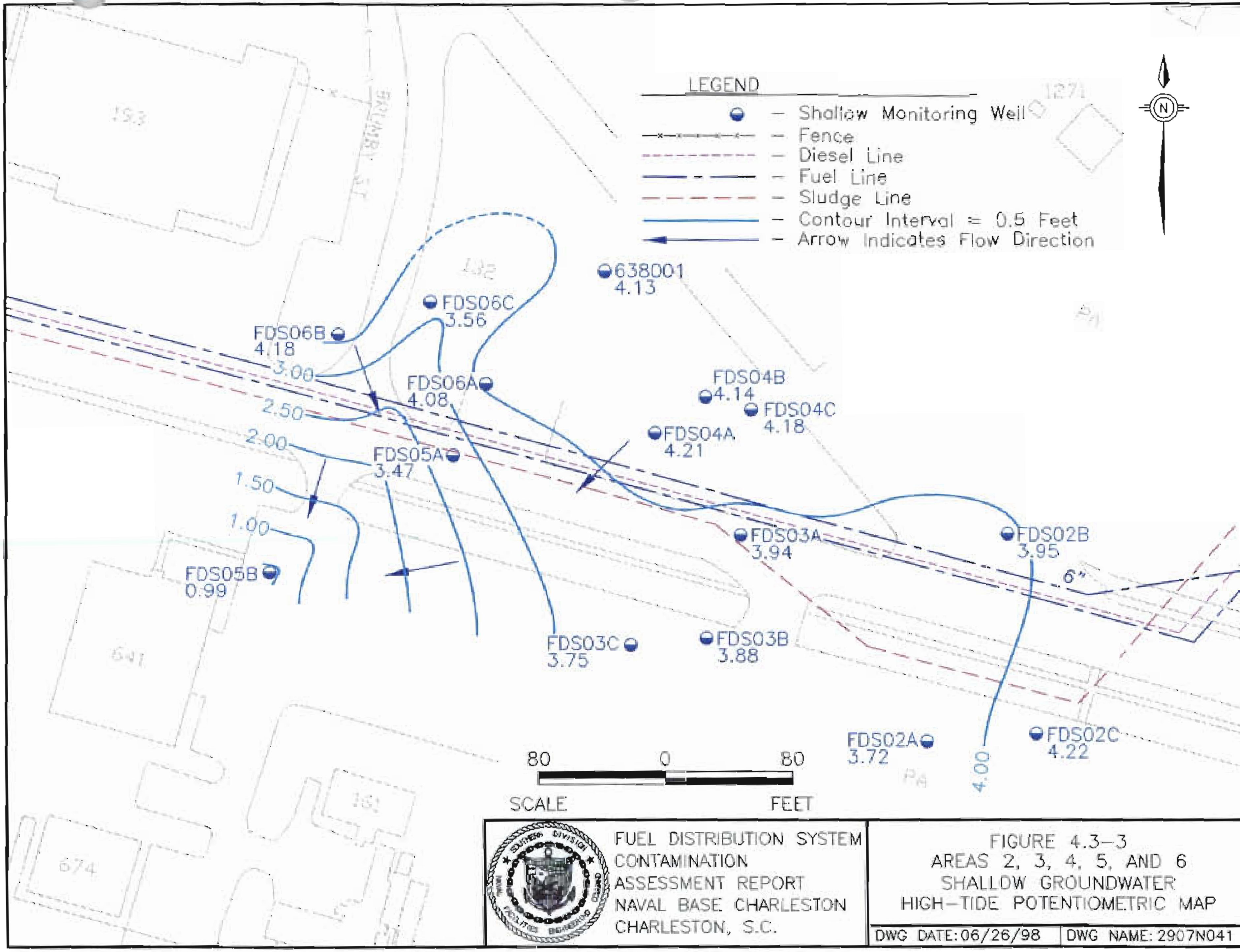
FIGURE 4.3-2
AREAS 2, 3, 4, 5, AND 6
SHALLOW GROUNDWATER
LOW-TIDE POTENTIOMETRIC MAP

DWG DATE: 06/26/98 | DWG NAME: 2907N040



FUEL DISTRIBUTION SYSTEM CONTAMINATION ASSESSMENT REPORT
NAVAL BASE CHARLESTON
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FIGURE 4.3-3
AREAS 2, 3, 4, 5, AND 6
SHALLOW GROUNDWATER
HIGH-TIDE POTENTIOMETRIC MAP

DWG DATE: 06/26/98 | DWG NAME: 2907N041

Tidal influences appear strong with groundwater elevation changes ranging from 0.01 to 0.99 feet. Maximum average calculated groundwater velocity (utilizing the steepest gradient) was 2.30 feet/day based on an average porosity (0.359) and representative hydraulic conductivity (6.1 feet/day) determined during the Zone G RFI (EnSafe, February 1998).

4.3.2 Nature of Contamination in Subsurface Soil

Analytes detected in Areas 2, 3, 4, 5, and 6 subsurface soil are summarized in Table 4.3.1. No surface soil samples were collected in these combines areas. Appendix C contains a complete analytical data report for all FDS samples.

TPH-GRO in Subsurface Soil

The Phase I sample results from the borings associated with these combined areas ranged from 61.8 μg/kg of TPH-GRO at FDSSC01101 to 124,000 μg/kg at FDSSC01301, prompting subsequent Phase II soil and groundwater sampling. Nearby samples FDSSC00901, FDSSC02701, and FDSSC02801 identified no significant TPH contamination.

Volatile Organic Compounds in Subsurface Soil

Five VOCs were detected in subsurface soil at Areas 2, 3, 4, 5, and 6. A benzene concentration of 100 μg/kg at FDSSC01201 exceeded its RBSL of 5 μg/kg, and its SSL of 30 μg/kg. All other VOC concentrations were far below their RBSLs or SSLs. Figure 4.3-4 presents the BTEX concentrations detected in soil at these combined areas.

Table 4.3.1
Analytes Detected in Subsurface Soil
Areas 2, 3, 4, 5 and 6
Fuel Distribution System

Parameters	Location	Subsurface Conc.	RBSL/SSL	Subsurface Background
TPH - GRO (μg/kg)				
Gasoline	FDSSC01101	61.8	NL/NL	NA
	FDSSC01301	124000		
	FDSSC01201	77.6		
	FDSSC01401	67.5		
	FDSSC01601	65		
Volatile Organic Compounds (μg/kg)				
Benzene	FDSSC01201	**100**	5/30	NA
Carbon Disulfide	FDSSC01301	7	NL/32000	NA
	FDSSC01401	5		
	FDSSC01601	7		
Ethylbenzene	FDSSC01201	740	1260/13000	NA
Toluene	FDSSC01201	430	1622/12000	NA
	FDSSC01301	15		
	FDSSC01401	17		
Xylene (Total)	FDSSC01201	3700	42471/148000	NA
	FDSSC01301	2		
Semivolatile Organic Compounds (μg/kg)				
Total Naphthalenes	FDSSC01201	**159000**	210/84000	NA
	FDSSC01301	**5490**		
2-Methylnaphthalene	FDSSC01201	120000	NL/126000	NA
	FDSSC01301	5200		
Naphthalene	FDSSC01201	39000	NL/84000	NA
	FDSSC01301	290		
Acenaphthene	FDSSC01301	2600	NL/570000	NA
Anthracene	FDSSC01301	950	NL/12000000	NA
Benzo(a)anthracene	FDSSC01101	74	73084/2000	NA
	FDSSC01301	730		
Benzo(b)fluoranthene	FDSSC01101	66	29097/5000	NA
	FDSSC01301	560		
	FDSSC01401	120		
	FDSSC01601	84		
Benzo(k)fluoranthene	FDSSC01101	61	231109/49000	NA
	FDSSC01301	410		
	FDSSC01401	88		
	FDSSC01601	86		
Benzo(a)pyrene	FDSSC01101	65	NL/8000	NA
	FDSSC01301	490		
	FDSSC01401	130		
Benzo(g,h,i)perylene	FDSSC01301	370	NL/4.66E+08	NA
	FDSSC01401	110		
Benzoic acid	FDSSC01101	78	NL/400000	NA
	FDSSC01401	120		
	FDSSC01601	130		
Butylbenzylphthalate	FDSSC01301	84	NL/930000	NA

Table 4.3.1
Analytes Detected in Subsurface Soil
Areas 2, 3, 4, 5 and 6
Fuel Distribution System

Parameters	Location	Subsurface Conc.	RBSL/SSL	Subsurface Background
Chrysene	FDSSC01101	98	12998/160000	NA
	FDSSC01201	1200		
	FDSSC01301	1200		
Dibenz(a,h)anthracene	FDSSC01301	110	87866/2000	NA
Dibenzofuran	FDSSC01201	6200	NL/50000	NA
	FDSSC01301	1500		
Fluoranthene	FDSSC01101	150	NL/4300000	NA
	FDSSC01301	2000		
Fluorene	FDSSC01201	12000	NL/560000	NA
	FDSSC01301	2700		
Indeno(1,2,3-cd)pyrene	FDSSC01101	72	NL/14000	NA
	FDSSC01301	320		
	FDSSC01401	130		
2-Nitrophenol	FDSSC01401	200	NL/28800	NA
Phenanthrene	FDSSC01101	22000	NL/1380000	NA
	FDSSC01301	7700		
Pyrene	FDSSC01101	230	NL/4200000	NA
	FDSSC01201	2200		
	FDSSC01301	3300		
	FDSSC01401	210		
	FDSSC01601	190		
Pesticides (μg/kg)				
Aroclor-1260	FDSSC01201	840	NL/1000	NA
Inorganics (mg/kg)				
Aluminum (Al)	FDSSC01101	12700	NL/1000000	23600
	FDSSC01201	9000		
	FDSSC01301	18800		
	FDSSC01401	16300		
	FDSSC01601	21700		
Arsenic (As)	FDSSC01101	13.4	NL/29	15.5[a]
	FDSSC01201	4.1		
	FDSSC01301	27.5		
	FDSSC01401	15.3		
	FDSSC01601	28.8		
Barium (Ba)	FDSSC01101	37.2	NL/1600	64.5
	FDSSC01201	77.1		
	FDSSC01301	31.5		
	FDSSC01401	29.4		
	FDSSC01601	34.5		
Beryllium (Be)	FDSSC01101	.91	NL/63	1.63
	FDSSC01201	.5		
	FDSSC01301	1.2		
	FDSSC01401	.97		
	FDSSC01601	1.4		
Cadmium (Cd)	FDSSC01101	0.32	NL/8	0.48
	FDSSCO1201	0.56		

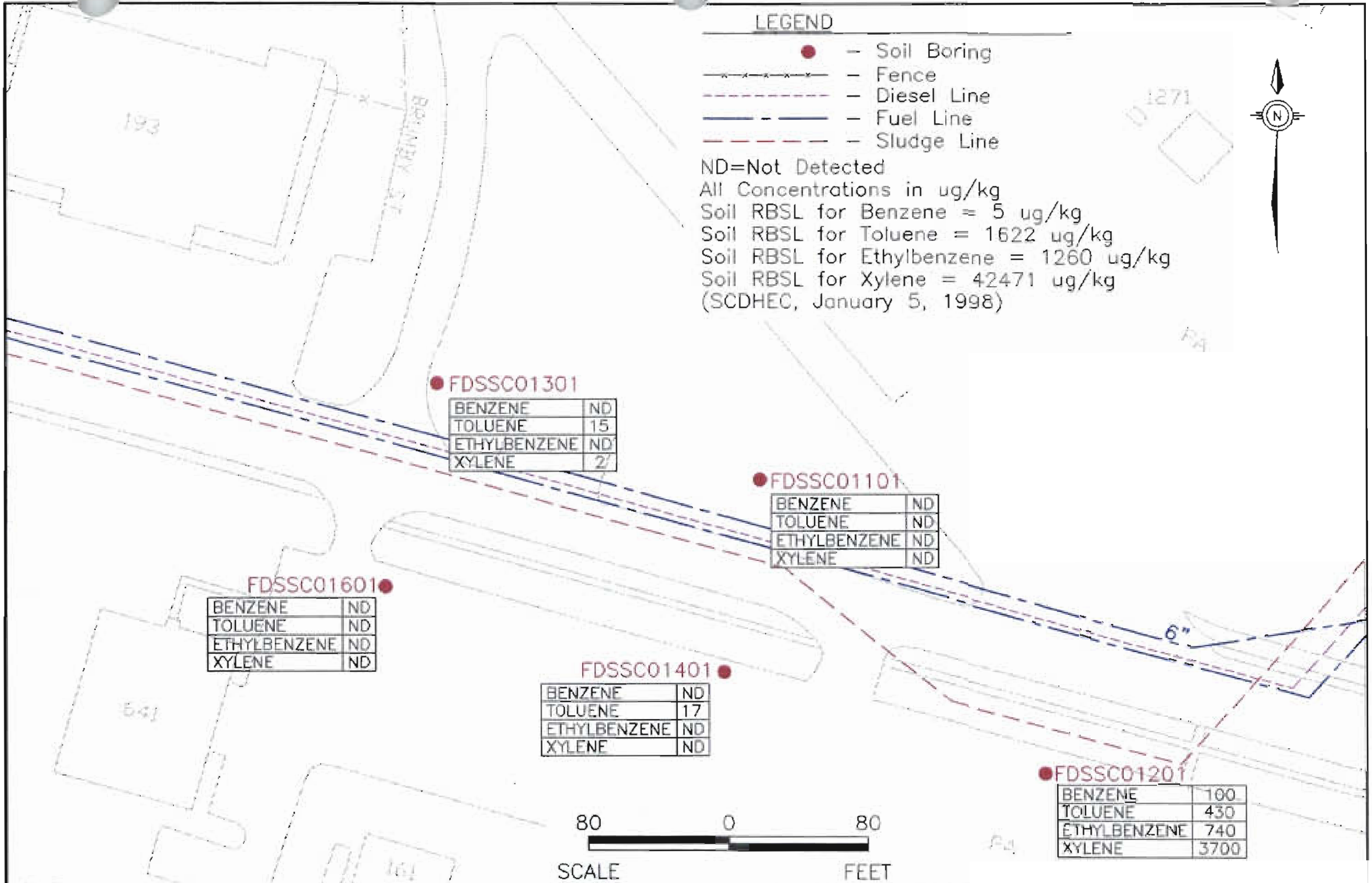
Table 4.3.1
Analytes Detected in Subsurface Soil
Areas 2, 3, 4, 5 and 6
Fuel Distribution System

Parameters	Location	Subsurface Conc.	RBSL/SSL	Subsurface Background
Calcium (Ca)	FDSSC01101	31500	NL/NL	NL
	FDSSC01201	122000		
	FDSSC01301	9130		
	FDSSC01401	14100		
	FDSSC01601	10200		
Chromium (Cr)	FDSSC01101	38.3	NL/1000000	43.4[a]
	FDSSC01201	25.5		
	FDSSC01301	34.8		
	FDSSC01401	30.8		
	FDSSC01601	40.8		
Cobalt (Co)	FDSSC01101	4.1	NL/2000	8.14
	FDSSC01201	2.4		
	FDSSC01301	6		
	FDSSC01401	5.3		
	FDSSC01601	7.6		
Copper (Cu)	FDSSC01101	12.6	NL/920	32.6
	FDSSC01201	35.2		
	FDSSC01301	32.1		
	FDSSC01401	23.4		
	FDSSC01601	37.2		
Iron (Fe)	FDSSC01101	15100	NL/NL	NL
	FDSSC01201	11700		
	FDSSC01301	29400		
	FDSSC01401	25400		
	FDSSC01601	34200		
Lead (Pb)	FDSSC01101	17.3	NL/400	66.3
	FDSSC01201	44.5		
	FDSSC01301	38.7		
	FDSSC01401	46.5		
	FDSSC01601	58		
Magnesium (Mg)	FDSSC01101	3440	NL/NL	NL
	FDSSC01201	4850		
	FDSSC01301	4570		
	FDSSC01401	4620		
	FDSSC01601	6860		
Manganese (Mn)	FDSSC01101	152	NL/1100	291
	FDSSC01201	263		
	FDSSC01301	506		
	FDSSC01401	385		
	FDSSC01601	526		
Mercury (Hg)	FDSSC01101	.19	NL/2.1	0.31
	FDSSC01201	.21		
	FDSSC01301	.17		
	FDSSC01401	.45		
	FDSSC01601	.67		

Table 4.3.1
Analytes Detected in Subsurface Soil
Areas 2, 3, 4, 5 and 6
Fuel Distribution System

Parameters	Location	Subsurface Conc.	RBSL/SSL	Subsurface Background
Nickel (Ni)	FDSSC01101	15.2	NL/130	18.3
	FDSSC01201	10		
	FDSSC01301	11.3		
	FDSSC01401	9.4		
	FDSSC01601	12.2		
Potassium (K)	FDSSC01101	1680	NL/NL	NL
	FDSSC01301	2450		
	FDSSC01401	2140		
	FDSSC01601	3370		
Selenium (Se)	FDSSC01101	1.4	NL/5	1.26
	FDSSC01401	.65		
Sodium (Na)	FDSSC01101	1380	NL/NL	NL
	FDSSC01201	1450		
	FDSSC01301	3090		
	FDSSC01401	2380		
	FDSSC01601	10600		
Vanadium (V)	FDSSC01101	36.7	NL/6000	72.5
	FDSSC01201	16.8		
	FDSSC01301	60.1		
	FDSSC01401	52.2		
	FDSSC01601	74.3		
Zinc (Zn)	FDSSC01101	69.4	NL/12000	145
	FDSSC01201	264		
	FDSSC01301	92.5		
	FDSSC01401	91.5		
	FDSSC01601	150		

Notes:
a = Background value for non-clay samples
NL = Not listed
NA = Not applicable
µg/kg = Micrograms per kilogram
mg/kg = Milligrams per kilogram
RBSLs from the *South Carolina Risk-Based Corrective Action for Petroleum Releases* (SCDHEC, January 5, 1998) and soil-to-groundwater SSLs (DAF=20) from the *Soil Screening Guidance: Technical Background Document* (USEPA, 1996b) were used as reference concentrations.
Bolded concentrations exceed RBSL or the SSL (if no RBSL is available).
All background values for Zone G are based on twice the mean of grid sample concentrations.



FUEL DISTRIBUTION SYSTEM CONTAMINATION ASSESSMENT REPORT
NAVAL BASE CHARLESTON
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FIGURE 4.3-4
AREAS 2, 3, 4, 5, AND 6
BTEX IN SOIL

DWG DATE: 06/01/98 | DWG NAME: 2907N016

Semivolatile Organic Compounds in Subsurface Soil

Twenty SVOCs, were detected in subsurface soil in these combined areas. The greatest number of SVOC concentrations (18) occurred in sample FDSSC01301, while the fewest occurrences (four) were detected in sample FDSSC01601. The RBSL for total naphthalenes (210 μg/kg) was exceeded at FDSSC01201 and FDSSC01301. The total naphthalene concentration at FDSSC01201 (159,000 μg/kg) was derived by summing the concentrations of 2-methylnaphthalene (120,000 μg/kg) and naphthalene (39,000 μg/kg) at this location. The total naphthalene concentration at FDSSC01201 also exceeded the SSL for naphthalenes, 84,000 μg/kg. Likewise, total naphthalenes at FDSSC01301 (5,490 μg/kg) were derived by the same method (summing 5,200 μg/kg and 290 μg/kg for 2-methylnaphthalene and naphthalene, respectively). All other SVOC concentrations were far below their RBSLs or SSLs. Figure 4.3-5 presents the distribution of naphthalenes in soil at Areas 2, 3, 4, 5, and 6.

PCBs in Subsurface Soil

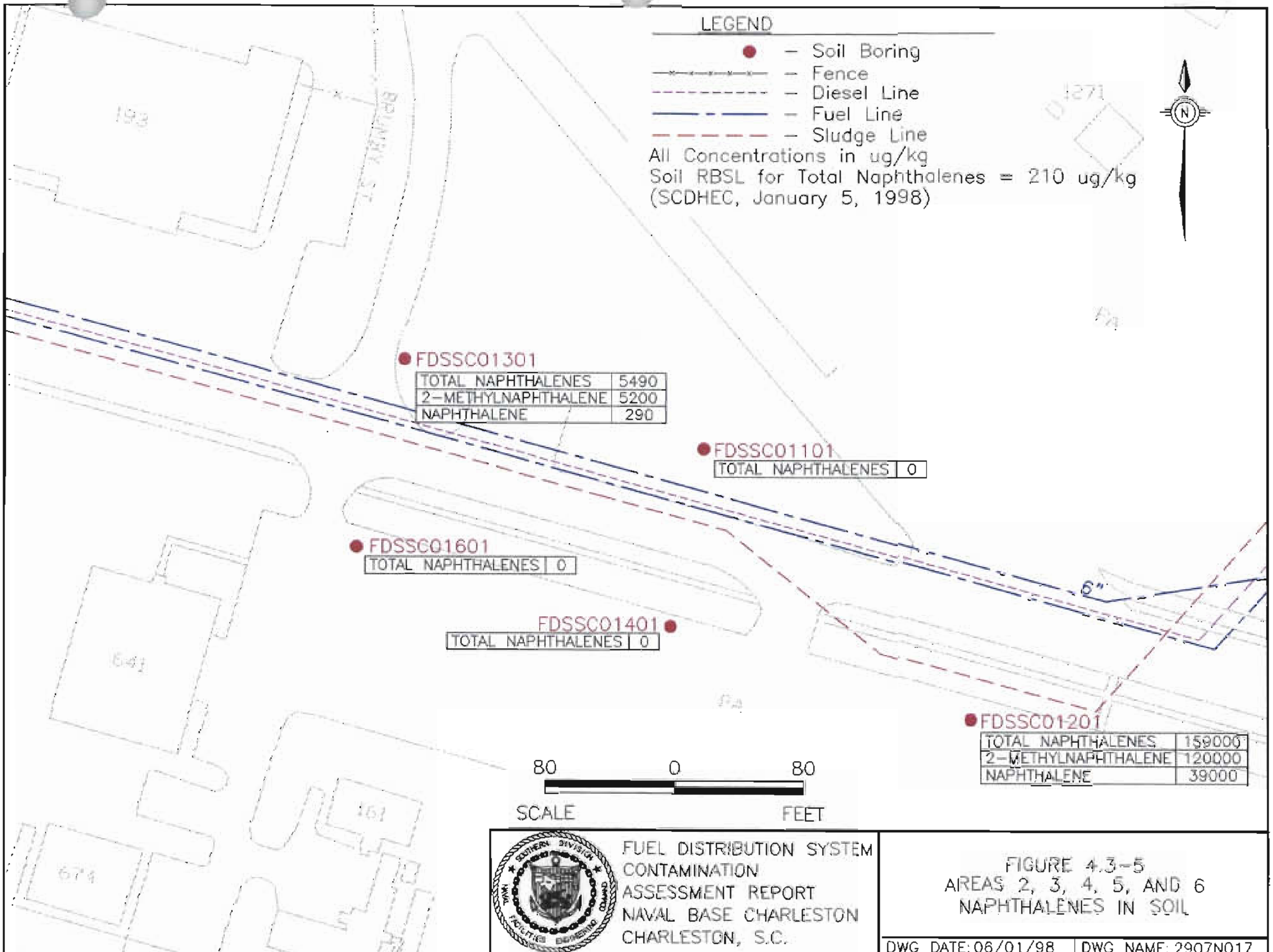
Aroclor-1260 was detected at FDSSC01201 at a concentration below its SSL. No RBSL is listed for Aroclor.

Inorganics in Subsurface Soil

Twenty metals were detected in subsurface soil at Areas 2, 3, 4, 5, and 6. No RBSLs are listed for these metals. All metal concentrations were below their SSLs.

4.3.3 Nature of Contamination in Shallow Groundwater

Analytes detected in shallow groundwater at Areas 2, 3, 4, 5, and 6 are summarized in Table 4.3.2. No free product was observed in the combined area monitoring wells. FDS well data are based on sampling events conducted in January and June of 1997. For monitoring well 638001, data are taken from sampling events in November of 1996 and May 1997. Appendix C contains a complete analytical data report for all FDS samples.



FUEL DISTRIBUTION SYSTEM CONTAMINATION ASSESSMENT REPORT
NAVAL BASE CHARLESTON
CHARLESTON, S.C.

FIGURE 4.3-5
AREAS 2, 3, 4, 5, AND 6
NAPHTHALENES IN SOIL

DWG DATE: 06/01/98 | DWG NAME: 2907N017

Table 4.3.2
Analytes Detected in Shallow Groundwater
Areas 2, 3, 4, 5, and 6
Fuel Distribution System

Parameters	Location	First Sampling Event	Second Sampling Event	RBSL/Tap Water RBC (μg/L)	Shallow Background
Volatile Organic Compounds (μg/L)					
Chlorobenzene	FDS06B	ND	**6**	NL/3.9	NA
Styrene	FDS03B	1	1	NL/160	NA
Semivolatile Organic Compounds (μg/L)					
Total PAHs	FDS03A	0	5	25/NL	NA
	FDS05A	4	18		
	FDS06B	**104**	**27**		
Acenaphthene	FDS03A	ND	2	10/220	NA
	FDS05A	ND	3		
	FDS06B	7	8		
Fluorene	FDS03A	ND	2	10/150	NA
	FDS05A	2	7		
	FDS06B	5	5		
2-Methylnaphthalene	FDS06B	**85**	10	10/150	NA
Phenanthrene	FDS03A	ND	1	10/150	NA
	FDS05A	2	8		
	FDS06B	7	4		
Benzoic Acid	FDS02A	1	1	NL/15000	NA
	FDS03A	1	ND		
	FDS04A	1	ND		
	FDS04B	1	ND		
	FDS04C	1	ND		
	FDS05A	2	ND		
	FDS06C	1	ND		
bis(2-Ethylhexyl)phthalate (BEHP)	FDS02A	1.5	ND	NL/4.8	NA
	FDS02C	1	ND		
Butylbenzylphthalate	FDS04B	ND	1	NL/730	NA
2-Chlorophenol	FDS03A	1	ND	NL/18	NA
Dibenzofuran	FDS06B	2	2	NL/15	NA
4-Nitrophenol	FDS03A	ND	2	NL/29	NA
Pentachlorophenol	FDS03A	ND	**1**	NL/0.56	NA
Phenol	FDS02A	ND	2.5	NL/2200	NA

Table 4.3.2
Analytes Detected in Shallow Groundwater
Areas 2, 3, 4, 5, and 6
Fuel Distribution System

Parameters	Location	First Sampling Event	Second Sampling Event	RBSL/Tap Water RBC (μg/L)	Shallow Background
Inorganics (μg/L)					
Aluminum (Al)	638001	26.7	ND	NL/3700	692
	FDS02A	3220	807		
	FDS02B	141	ND		
	FDS02C	521	ND		
	FDS03A	144	17.4		
	FDS03B	100	ND		
	FDS03C	722	38		
	FDS04A	50.8	ND		
	FDS04B	193	ND		
	FDS04C	69.9	ND		
	FDS05A	114	57		
	FDS05B	38.7	17.1		
	FDS06A	243	481		
	FDS06B	173	ND		
	FDS06C	2790	347		
Antimony (Sb)	FDS02B	2.4	ND	NL/1.5	4.85
	FDS02C	2.1	ND		
	FDS04A	ND	23.4		
	FDS04B	2.5	ND		
	FDS04C	2.5	ND		
	FDS05A	4.2	ND		
	FDS05B	2.7	ND		
	FDS06C	3.1	ND		
Arsenic (As)	638001	5.1	5	50/4.5E-02	17.8
	FDS02A	11.6	4 3		
	FDS02B	8.9	8.3		
	FDS02C	18.1	8.2		
	FDS03A	8	ND		
	FDS03B	9.2	ND		
	FDS03C	5.8	3.4		
	FDS04A	6.5	ND		
	FDS04B	3.1	ND		
	FDS05A	6.5	2.7		
	FDS06A	ND	16.1		
	FDS06B	2.6	ND		
	FDS06C	37.1	19		

Table 4.3.2
Analytes Detected in Shallow Groundwater
Areas 2, 3, 4, 5, and 6
Fuel Distribution System

Parameters	Location	First Sampling Event	Second Sampling Event	RBSL/Tap Water RBC (μg/L)	Shallow Background
Barium (Ba)	638001	23.8	16.4	2000/260	31
	FDS02A	94	128		
	FDS02B	83.1	33.7		
	FDS02C	38	24.8		
	FDS03A	32.3	30.3		
	FDS03B	36.3	25		
	FDS03C	38.4	23.8		
	FDS04A	32.5	14.6		
	FDS04B	23.3	21.3		
	FDS04C	28.2	17		
	FDS05A	30.9	45.3		
	FDS05B	37.7	33.1		
	FDS06A	35.1	19.7		
	FDS06B	28.9	38.2		
	FDS06C	103	30.7		
Beryllium (Be)	FDS02A	.55	.51	NL/0.016	ND
	FDS02B	ND	.34		
	FDS02C	ND	.37		
	FDS03B	ND	.33		
	FDS05B	.47	ND		
	FDS06A	ND	.28		
	FDS06B	ND	.31		
	FDS06C	ND	.33		
Cadmium (Cd)	FDS02A	ND	.38	5/1.8	0.53
	FDS02C	ND	.33		
	FDS06C	ND	.31		
Calcium (Ca)	638001	89500	69000	NL/NL	NL
	FDS02A	125400	133000		
	FDS02B	109000	91100		
	FDS02C	88200	50900		
	FDS03A	58400	86500		
	FDS03B	52500	46700		
	FDS03C	62800	63900		
	FDS04A	61400	60200		
	FDS04B	80200	118000		
	FDS04C	46900	52200		
	FDS05A	73500	82100		
	FDS05B	136000	128000		
	FDS06A	58000	63200		
	FDS06B	110000	137000		
	FDS06C	90900	68100		

Table 4.3.2
Analytes Detected in Shallow Groundwater
Areas 2, 3, 4, 5, and 6
Fuel Distribution System

Parameters	Location	First Sampling Event	Second Sampling Event	RBSL/Tap Water RBC (μg/L)	Shallow Background
Chromium (Cr)	FDS02A	13.25	4.4	100/18	3.88
	FDS02C	4.7	1.2		
	FDS03B	1.5	ND		
	FDS03C	3.1	ND		
	FDS04B	ND	1.2		
	FDS05A	ND	1.4		
	FDS05B	1.3	11		
	FDS06A	ND	4.8		
	FDS06B	ND	1.2		
	FDS06C	7	2.1		
Cobalt (Co)	FDS02B	1.8	ND	NL/220	1.45
	FDS03A	1.1	ND		
	FDS03C	ND	1.2		
	FDS04A	1.2	ND		
	FDS04C	1	ND		
	FDS05A	1.5	ND		
	FDS05B	ND	1.1		
	FDS06A	1.3	ND		
	FDS06B	1.2	ND		
	FDS06C	1.7	ND		
Copper (Cu)	FDS02A	6.3	3.3	NL/13000	8.33
	FDS02C	4.7	ND		
	FDS03B	2.6	ND		
	FDS03C	3.7	ND		
	FDS04A	4.4	ND		
	FDS05A	ND	3.3		
	FDS05B	.77	ND		
	FDS06A	3.8	3.8		
	FDS06C	8.1	2.6		
Cyanide (CN)	FDS02C	2.5	NT	NL/73	3.8
	FDS03C	2.7	NT		
	FDS04A	2.8	NT		
	FDS04B	3.3	NT		
	FDS05A	2.5	NT		
	FDS05B	3	NT		
	FDS06A	4.3	NT		
	FDS06B	4	NT		
	FDS06C	10.1	NT		

Table 4.3.2
Analytes Detected in Shallow Groundwater
Areas 2, 3, 4, 5, and 6
Fuel Distribution System

Parameters	Location	First Sampling Event	Second Sampling Event	RBSL/Tap Water RBC (μg/L)	Shallow Background
Iron (Fe)	638001	6680	5870	NL/NL	NL
	FDS02A	3110	1615		
	FDS02B	2870	5930		
	FDS02C	2130	5410		
	FDS03A	1450	11700		
	FDS03B	974	4340		
	FDS03C	2540	3600		
	FDS04A	4030	6330		
	FDS04B	3400	3880		
	FDS04C	3370	2810		
	FDS05A	13600	25600		
	FDS05B	7590	7970		
	FDS06A	189	6270		
	FDS06B	3550	1240		
	FDS06C	3940	4140		
Lead (Pb)	FDS02A	2.9	4	15/15	4.6
	FDS02C	7	1.7		
	FDS03B	ND	1.2		
	FDS04A	ND	4.4		
	FDS06C	3.8	2		
Magnesium (Mg)	638001	259000	224000	NL/NL	NL
	FDS02A	215500	192000		
	FDS02B	181000	123000		
	FDS02C	106000	160000		
	FDS03A	148000	87600		
	FDS03B	163000	161000		
	FDS03C	182000	185000		
	FDS04A	83600	70900		
	FDS04B	87200	104000		
	FDS04C	112000	106000		
	FDS05A	171000	69100		
	FDS05B	395000	382000		
	FDS06A	84900	52100		
	FDS06B	44700	38100		
	FDS06C	168000	134000		
Manganese (Mn)	638001	**196**	**116**	NL/84	2906
	FDS02A	**442.5**	**398.5**		
	FDS02B	**139**	54.8		
	FDS02C	**296**	**105**		
	FDS03A	**91.4**	**355**		
	FDS03B	**90.5**	74.5		
	FDS03C	**93.2**	57.8		
	FDS04A	**286**	**250**		
	FDS04B	**163**	**169**		
	FDS04C	**176**	**171**		
	FDS05A	**232**	**269**		
	FDS05B	**247**	**237**		
	FDS06A	77.9	**119**		
	FDS06B	**311**	**249**		
	FDS06C	**569**	**736**		

Table 4.3.2
Analytes Detected in Shallow Groundwater
Areas 2, 3, 4, 5, and 6
Fuel Distribution System

Parameters	Location	First Sampling Event	Second Sampling Event	RBSL/Tap Water RBC (μg/L)	Shallow Background
Mercury (Hg)	FDS02A	.16	1	2/1.1	ND
	FDS02C	.13	ND		
	FDS03C	.1	ND		
	FDS05B	.18	ND		
Nickel (Ni)	638001	ND	.83	NL/73	4.08
	FDS02A	10.9	6.45		
	FDS02B	5.3	ND		
	FDS02C	7.8	ND		
	FDS03A	3.5	ND		
	FDS03B	3.8	ND		
	FDS03C	2.8	1.5		
	FDS04A	3.2	1.4		
	FDS04B	2.6	3.3		
	FDS04C	8.4	1.2		
	FDS05A	1.8	1.1		
	FDS05B	1.7	5.1		
	FDS06A	6.4	6.6		
	FDS06B	1.4	ND		
	FDS06C	4.8	2.6		
Potassium (K)	638001	109000	146000	NL/NL	NL
	FDS02A	114350	146000		
	FDS02B	74100	58400		
	FDS02C	61900	82200		
	FDS03A	81800	47600		
	FDS03B	81200	80900		
	FDS03C	91200	86200		
	FDS04A	55000	51300		
	FDS04B	46200	55400		
	FDS04C	68500	73200		
	FDS05A	89700	46600		
	FDS05B	178000	149000		
	FDS06A	52300	44100		
	FDS06B	33200	35300		
	FDS06C	95800	72100		
Selenium (Se)	FDS02A	3.1	ND	50/18	4.3
Silver (Ag)	FDS05A	1.2	1.3	5/18	1.65

Table 4.3.2
Analytes Detected in Shallow Groundwater
Areas 2, 3, 4, 5, and 6
Fuel Distribution System

Parameters	Location	First Sampling Event	Second Sampling Event	RBSL/Tap Water RBC (μg/L)	Shallow Background
Sodium (Na)	638001	2520000	2620000	NL/NL	NL
	FDS02A	2730000	3345000		
	FDS02B	1480000	1050000		
	FDS02C	1140000	1780000		
	FDS03A	1430000	758000		
	FDS03B	1460000	1350000		
	FDS03C	1730000	1760000		
	FDS04A	690000	475000		
	FDS04B	416000	363000		
	FDS04C	1040000	709000		
	FDS05A	1720000	765000		
	FDS05B	4300000	4070000		
	FDS06A	773000	433000		
	FDS06B	246000	503000		
	FDS06C	1670000	1130000		
Thallium (Tl)	638001	ND	**6.4**	NL/0.29	ND
	FDS02A	**6.75**	ND		
	FDS02C	**5.1**	ND		
	FDS03B	**3**	ND		
	FDS03C	**5.7**	ND		
	FDS04A	ND	**5.3**		
	FDS04C	ND	**6.4**		
	FDS05B	**5.6**	ND		
Tin (Sn)	FDS05B	3	ND	NL/2200	ND
Vanadium (V)	FDS02A	11.35	11.05	NL/26	15.4
	FDS02B	2.2	ND		
	FDS02C	4.4	ND		
	FDS03A	1.8	ND		
	FDS03B	2.7	ND		
	FDS03C	5	2		
	FDS04A	2.4	1 4		
	FDS04B	2.1	1.1		
	FDS04C	2.3	ND		
	FDS05A	3	1.4		
	FDS05B	1.9	1.3		
	FDS06A	6.1	4.2		
	FDS06B	2	1.7		
	FDS06C	11.4	21.4		
Zinc (Zn)	FDS02B	8.8	ND	NL/1100	15.6
	FDS03A	6.3	ND		
	FDS04A	5.4	ND		
	FDS04C	6.9	ND		
	FDS06A	6.7	ND		
	FDS06B	8	ND		
	FDS06C	16	ND		

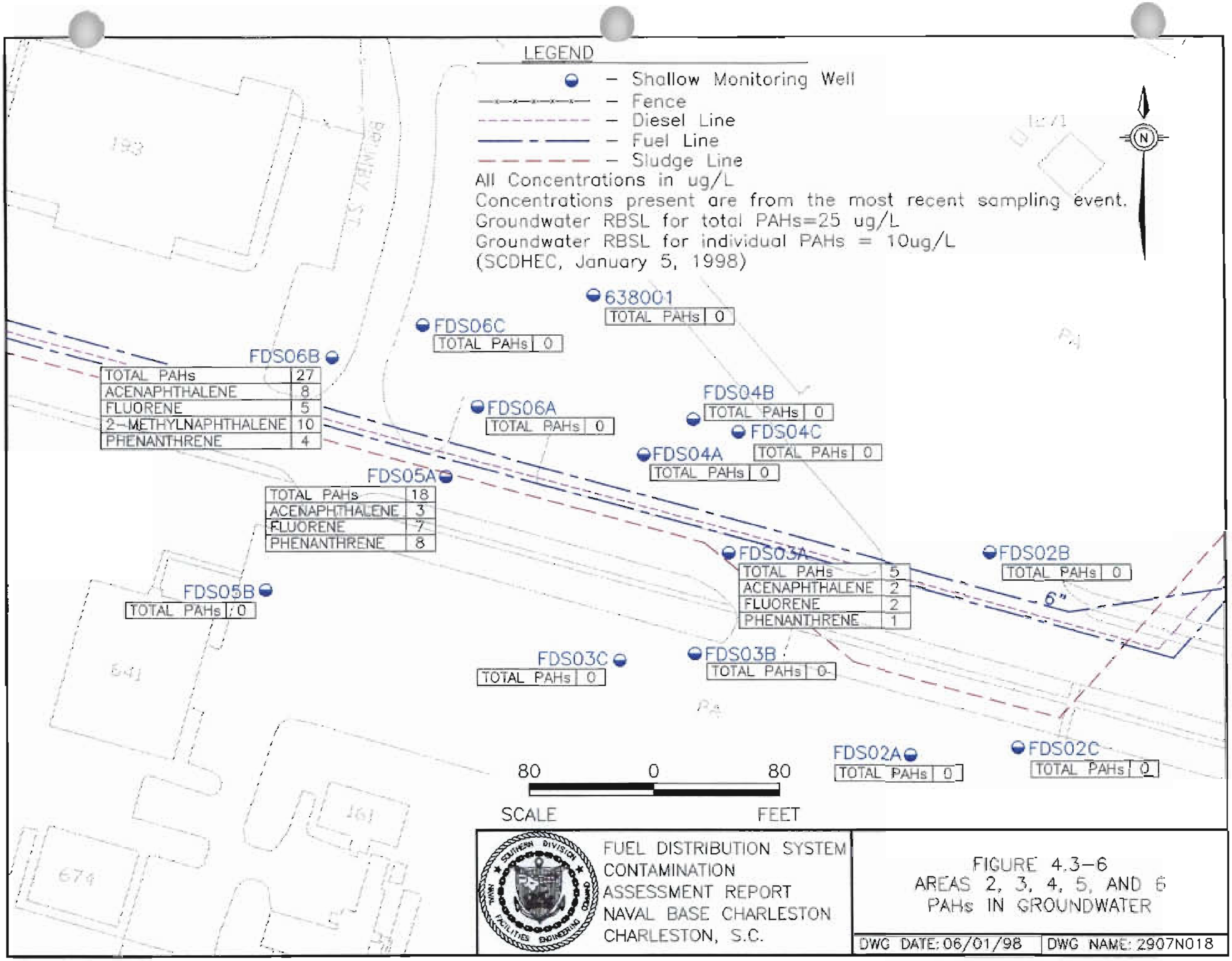
Notes:
NL = Not listed
NA = Not applicable
ND = Not detected
NT = Not taken
μg/L = Micrograms per liter
RBSLs from the *South Carolina Risk-Based Corrective Action for Petroleum Releases* (SCDHEC, January 5, 1998) and tap water RBCs (THQ=0.1) from *Risk Based Concentration Table* (USEPA, October 22, 1997) were used as reference concentrations.
Bolded concentrations exceed RBSL or the tap water RBC (if no RBSL is available).
All background values for Zone G are based on twice the mean of grid sample concentrations. Background values for groundwater are based on two sampling rounds in two wells at each depth.

Volatile Organic Compounds in Shallow Groundwater

Two VOCs were detected in groundwater samples at Areas 2, 3, 4, 5, and 6. Neither compound has an assigned RBSL. Chlorobenzene was detected at 6 μg/L in the second sampling event from well FDS06B, at a concentration exceeding the tap water RBC of 3.9 μg/L. Chlorobenzene was not detected in the first sample collected from this well. Styrene was detected in FDS03B in both the first and second sampling events at 1 μg/L, far below its tap water RBC of 160 μg/L.

Semivolatile Organic Compounds in Shallow Groundwater

Twelve SVOCs, including four PAHs, were detected in groundwater samples from Areas 2, 3, 4, 5, and 6. The RBSL for 2-methylnaphthalene (10 μg/L) was exceeded at well FDS06B (85 μg/L) during the first sampling event, and was also detected at this well in the second sampling event but at a significantly lower concentration (10 μg/L) which equaled the RBSL. The RBSL for total PAHs (25 μg/L) was exceeded during both sampling events at well FDS06B (104 μg/L and 27 μg/L, respectively). Total PAHs dropped significantly between the two sampling events. Total PAH concentrations were attained by collectively summing all PAH constituent concentrations from each well. Figure 4.3-6 presents the distribution of total and individual PAHs in groundwater at Areas 2, 3, 4, 5, and 6. Pentachlorophenol was detected in well FDDS03A. No RBSL is available for pentachlorophenol. The tap water RBC for pentachlorophenol (0.56 μg/L) was exceeded at FDS03A (1 μg/L) during the second sampling event, but was not detected in the first sampling event.


LEGEND
— Shallow Monitoring Well
— Fence
— Diesel Line
— Fuel Line
— Sludge Line
All Concentrations in ug/L
Concentrations present are from the most recent sampling event.
Groundwater RBSL for total PAHs=25 ug/L
Groundwater RBSL for individual PAHs = 10ug/L
(SCDHEC, January 5, 1998)
638001
TOTAL PAHs 0
FDS06C
TOTAL PAHs 0
FDS06B
TOTAL PAHs 27
ACENAPHTHALENE 8
FLUORENE 5
2-METHYLNAPHTHALENE 10
PHENANTHRENE 4
FDS06A
TOTAL PAHs 0
FDS04B
TOTAL PAHs 0
FDS04C
TOTAL PAHs 0
FDS04A
TOTAL PAHs 0
FDS05A
TOTAL PAHs 18
ACENAPHTHALENE 3
FLUORENE 7
PHENANTHRENE 8
FDS03A
TOTAL PAHs 5
ACENAPHTHALENE 2
FLUORENE 2
PHENANTHRENE 1
FDS02B
TOTAL PAHs 0
6"
FDS05B
TOTAL PAHs 0
FDS03C
TOTAL PAHs 0
FDS03B
TOTAL PAHs 0
FDS02A
TOTAL PAHs 0
FDS02C
TOTAL PAHs 0
80 0 80
SCALE FEET
FUEL DISTRIBUTION SYSTEM
CONTAMINATION
ASSESSMENT REPORT
NAVAL BASE CHARLESTON
CHARLESTON, S.C.
FIGURE 4.3-6
AREAS 2, 3, 4, 5, AND 6
PAHs IN GROUNDWATER
DWG DATE: 06/01/98
DWG NAME: 2907N018

Inorganics in Shallow Groundwater

Twenty-four metals plus cyanide were detected in groundwater samples from Areas 2, 3, 4, 5, and 6, but no RBSLs for metals in groundwater were exceeded. However, concentrations of antimony, beryllium, manganese, and thallium exceeded their tap water RBCs in the second sampling event. Antimony exceeded its shallow background of 4.85 μg/L in the second sampling event in well FDS04A with a detection of 23.4 μg/L. Although concentrations of manganese exceeded the RBC, they were below the Zone G background value. No background was established for beryllium or thallium.

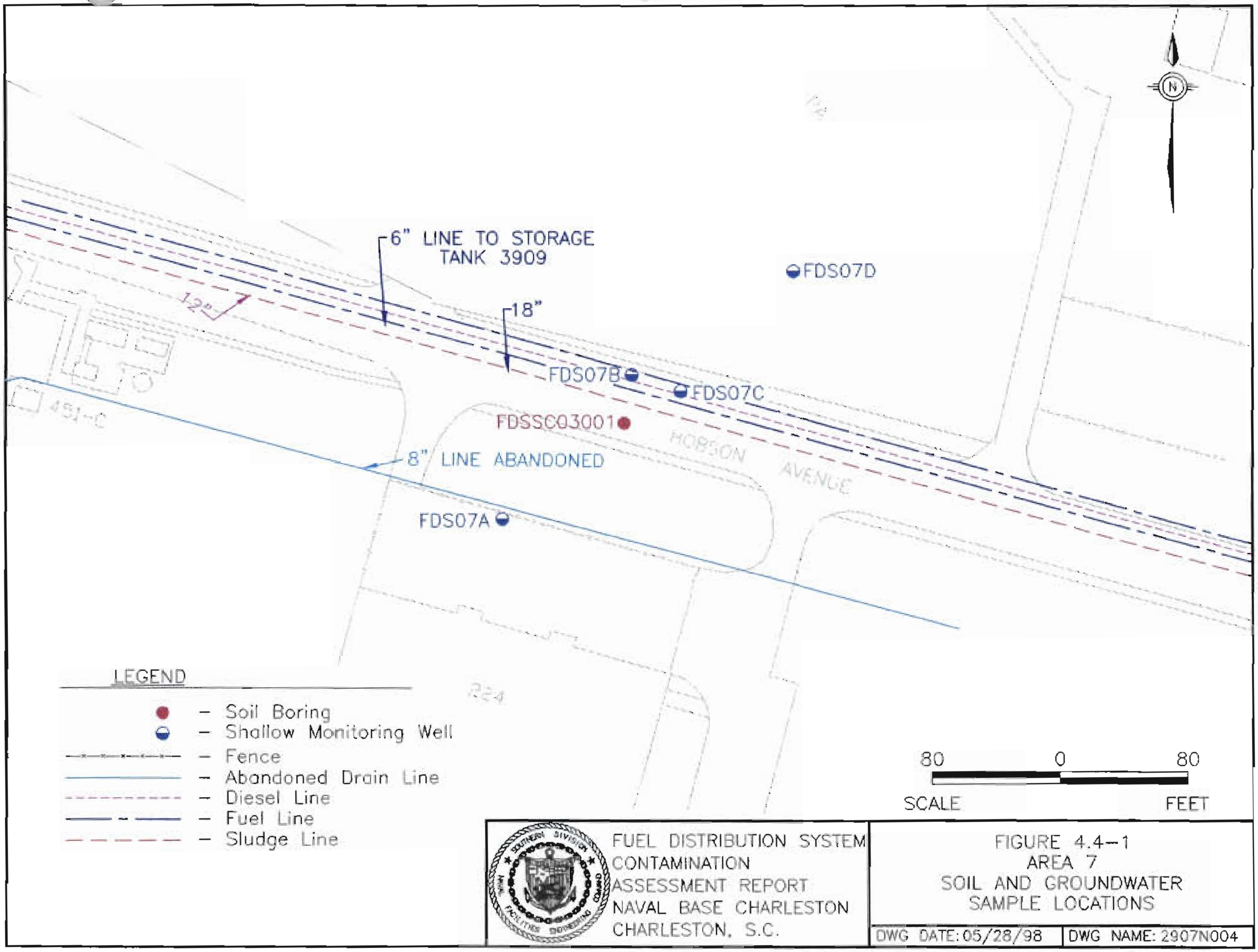
4.4 Area 7

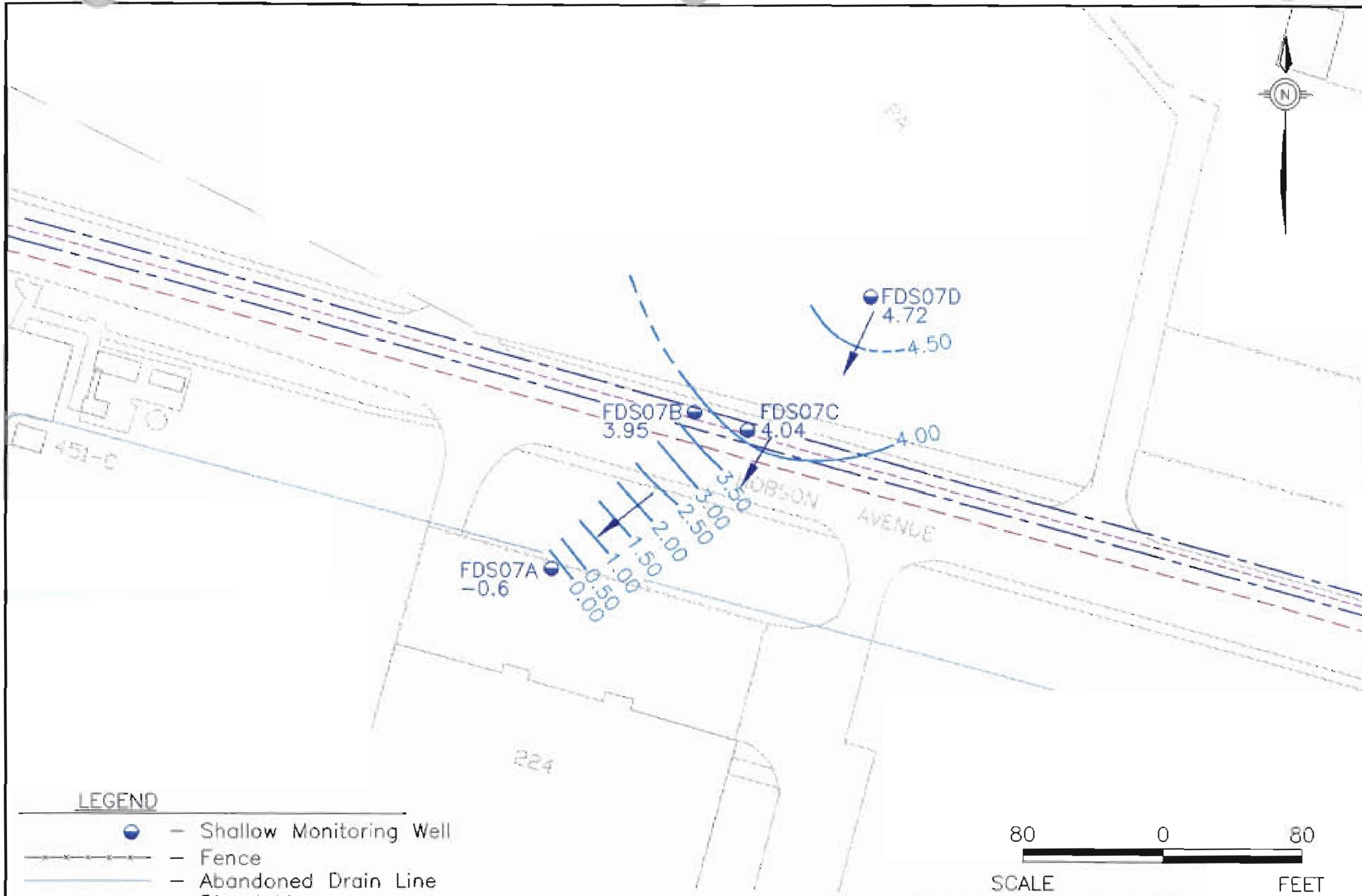
Area 7 is associated with soil sample FDSSC03001 (collected from the 4 to 5.5 feet bgs depth interval). This area of potential impact is located along Hobson Avenue, where the road passes Building 224. The Cooper River lies approximately 1,000 feet to the east. To investigate potential petroleum groundwater contamination, four shallow monitoring wells were installed: two along the east side of Hobson Avenue across from Building 224, one in a fenced parking lot on the east side of Building 224 facing Hobson Avenue, and a fourth well in a large parking lot across Hobson Avenue from Building 224. Figure 4.4-1 presents the soil boring and monitoring well locations for Area 7.

4.4.1 Site Geology and Hydrogeology

Based on well borings advanced at this site, the general stratigraphy at Area 7 is tan silty, gravely, sandy soil to a depth of approximately 4 feet bgs, which overlies alternating intervals of tan, olive, dark gray, and black silt, sand, and organic clay to a depth of approximately 18 feet bgs. Appendix B contains boring logs and monitoring well construction diagrams for Area 7 wells.

Shallow groundwater at Area 7 occurs from 0.33 to 6.3 feet bgs. Figures 4.4-2 and 4.4-3 depict the shallow groundwater potentiometric surface and inferred flow direction for the site during low- and high-tide respectively. Shallow groundwater flow direction and gradient were consistent between tidal stages. Tidal variations of groundwater elevation range from 0.1 to 0.44 feet. Maximum average calculated groundwater velocity (utilizing the steepest gradient) was 0.228 feet/day based on an average porosity (0.359) and representative hydraulic conductivity (0.37 feet/day) determined during the Zone G RFI (EnSafe, February 1998).

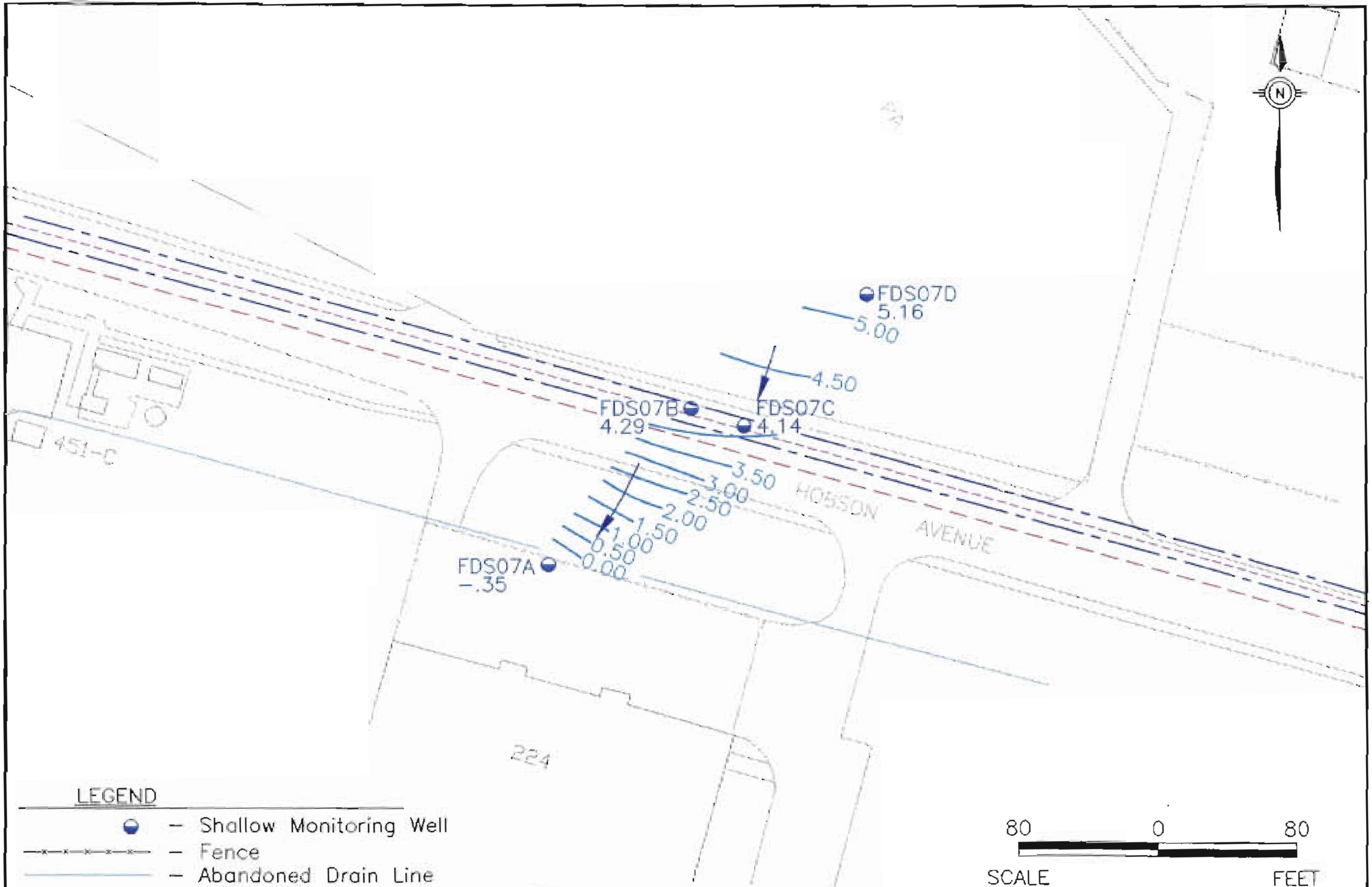

6" LINE TO STORAGE TANK 3909
18"
12"
FDS07D
FDS07B
FDS07C
FDSSC03001
HOBSON AVENUE
8" LINE ABANDONED
FDS07A
451-C
224
N
LEGEND
Soil Boring
Shallow Monitoring Well
Fence
Abandoned Drain Line
Diesel Line
Fuel Line
Sludge Line
80 0 80
SCALE FEET
FUEL DISTRIBUTION SYSTEM CONTAMINATION ASSESSMENT REPORT
NAVAL BASE CHARLESTON
CHARLESTON, S.C.
FIGURE 4.4-1
AREA 7
SOIL AND GROUNDWATER SAMPLE LOCATIONS
DWG DATE: 05/28/98
DWG NAME: 2907N004



FUEL DISTRIBUTION SYSTEM
CONTAMINATION
ASSESSMENT REPORT
NAVAL BASE CHARLESTON
CHARLESTON, S.C.

FIGURE 4.4-2
AREA 7
SHALLOW GROUNDWATER
LOW-TIDE POTENTIOMETRIC MAP

DWG DATE: 06/29/98 | DWG NAME: 2907N032



LEGEND

- Shallow Monitoring Well
- Fence
- Abandoned Drain Line
- Diesel Line
- Fuel Line
- Sludge Line
- Contour Interval = 0.5 Feet
- Arrow Indicates Flow Direction

80 0 80
SCALE FEET

FUEL DISTRIBUTION SYSTEM
CONTAMINATION
ASSESSMENT REPORT
NAVAL BASE CHARLESTON
CHARLESTON, S.C.

FIGURE 4.4-3
AREA 7
SHALLOW GROUNDWATER
HIGH-TIDE POTENTIOMETRIC MAP

DWG DATE: 06/29/98 | DWG NAME: 2907N033

4.4.2 Nature of Contamination in Subsurface Soil

Analytes detected in Area 7 subsurface soil samples are summarized in Table 4.4.1. Appendix C contains a complete analytical data report for all FDS samples.

TPH-DRO/GRO in Subsurface Soil

The Phase I soil sample FDSSC03001 exhibited TPH-DRO of 102 mg/kg, prompting subsequent Phase II soil and groundwater sampling within Area 7. TPH-GRO was also detected, at 9 μg/kg, in this sample. Nearby samples FDSSC02101 and FDSSC02401 identified no significant TPH contamination.

Volatile Organic Compounds in Subsurface Soil

No VOCs were detected in subsurface soil samples at Area 7.

Semivolatile Organic Compounds in Subsurface Soil

Eleven SVOCs were detected in Area 7 subsurface soil. All SVOC detections in Area 7 subsurface soil were far below their soil RBSLs (or SSLs if no RBSL is available).

Inorganics in Subsurface Soil

Nineteen metals were detected in Area 7 subsurface soil samples. No soil RBSLs are available for the inorganics detected. Arsenic slightly exceeded its SSL and Zone G background concentration. No other inorganic SSLs were exceeded.

4.4.3 Nature of Contamination in Shallow Groundwater

Analytes detected in Area 7 shallow groundwater samples are summarized in Table 4.4.2. No free product was observed in Area 7 monitoring wells. Appendix C contains a complete analytical data report for all FDS samples.

Table 4.4.1
Analytes Detected in Subsurface Soil
Area 7
Fuel Distribution System

Parameters	Location	Subsurface Conc.	RBSL/SSL	Subsurface Background
TPH - DRO (mg/kg)				
Diesel	FDSSC03001	102	NL/NL	NA
TPH - GRO (μg/kg)				
Gasoline	FDSSC03001	9	NL/NL	NA
Semivolatile Organic Compounds (μg/kg)				
Benzo(a)anthracene	FDSSC03001	96	73084/2000	NA
Benzo(b)fluoranthene	FDSSC03001	76	29097/5000	NA
Benzo(k)fluoranthene	FDSSC03001	87	231109/49000	NA
Benzo(g,h,i)perylene	FDSSC03001	79	NL/4.66E+08	NA
Benzo(a)pyrene	FDSSC03001	91	NL/8000	NA
Benzoic Acid	FDSSC03001	94	NL/400000	NA
bis(2-Ethylhexyl)phthalate	FDSSC03001	86	NL/3600000	NA
Chrysene	FDSSC03001	94	12998/160000	NA
Fluoranthene	FDSSC03001	180	NL/4300000	NA
Indeno(1,2,3-cd)pyrene	FDSSC03001	74	NL/14000	NA
Pyrene	FDSSC03001	180	NL/4200000	NA
Inorganics (mg/kg)				
Aluminum (Al)	FDSSC03001	26300	NL/1000000	23600
Arsenic (As)	FDSSC03001	33.5	NL/29	15.5[a]
Barium (Ba)	FDSSC03001	38.5	NL/1600	64.5
Beryllium (Be)	FDSSC03001	1.4	NL/63	1.63
Calcium (Ca)	FDSSC03001	13100	NL/NL	NL
Chromium (Cr)	FDSSC03001	47.3	NL/1000000	43.4[a]
Cobalt (Co)	FDSSC03001	9.1	NL/2000	8.14
Copper (Cu)	FDSSC03001	34.6	NL/920	32.6
Iron (Fe)	FDSSC03001	36800	NL/NL	NL
Lead (Pb)	FDSSC03001	55.1	NL/400	66.3

Table 4.4.1
Analytes Detected in Subsurface Soil
Area 7
Fuel Distribution System

Parameters	Location	Subsurface Conc.	RBSL/SSL	Subsurface Background
Magnesium (Mg)	FDSSC03001	7060	NL/NL	NL
Manganese (Mn)	FDSSC03001	602	NL/1100	291
Mercury (Hg)	FDSSC03001	0.31	NL/2.1	0.31
Nickel (Ni)	FDSSC03001	15.1	NL/130	18.3
Potassium (K)	FDSSC03001	3380	NL/NL	NL
Selenium (Se)	FDSSC03001	1.5	NL/5	1.26
Sodium (Na)	FDSSC03001	11000	NL/NL	NL
Vanadium (V)	FDSSC03001	92.4	NL/6000	72.5
Zinc (Zn)	FDSSC03001	126	NL/12000	145

Notes:
a = Background value for non-clay samples
NL = Not listed
NA = Not applicable
μg/kg = Micrograms per kilogram
mg/kg = Milligrams per kilogram
RBSLs from the *South Carolina Risk-Based Corrective Action for Petroleum Releases* (SCDHEC, January 5, 1998) and soil-to-groundwater SSLs (DAF=20) from the *Soil Screening Guidance: Technical Background Document* (USEPA, 1996b) were used as reference concentrations.
Bolded concentrations exceed RBSL or the SSL (if no RBSL is available)
All background values for Zone G are based on twice the mean of grid sample concentrations.

Table 4.4.2
Analytes Detected in Shallow Groundwater
Area 7
Fuel Distribution System

Parameters	Location	First Sampling Event	Second Sampling Event	RBSL/Tap Water RBC (μg/L)	Shallow Background
Semivolatile Organic Compounds (μg/L)					
Total PAHs	FDS07A	0	1	25/NL	NA
	FDS07B	3	12		
	FDS07C	3	4		
	FDS07D	**85**	**156**		
Acenaphthene	FDS07B	ND	2	10/220	NA
	FDS07C	ND	1		
	FDS07D	**51**	**71**		
Acenaphthylene	FDS07D	ND	1	10/150	NA
Anthracene	FDS07D	2	5	10/1100	NA
Fluoranthene	FDS07D	1	1	10/150	NA
Fluorene	FDS07B	2	3	10/150	NA
	FDS07C	2	2		
	FDS07D	**20**	**30**		
2-Methylnaphthalene	FDS07B	1	2	10/150	NA
	FDS07C	1	ND		
	FDS07D	ND	4		
Naphthalene	FDS07B	ND	3	10/150	NA
	FDS07D	ND	**24**		
Phenanthrene	FDS07A	ND	1	10/150	NA
	FDS07B	ND	2		
	FDS07C	ND	1		
	FDS07D	**11**	**20**		
Benzoic Acid	FDS07A	3	ND	NL/15000	NA
	FDS07C	5	1		
Dibenzofuran	FDS07B	ND	2	NL/15	NA
	FDS07C	ND	1		
	FDS07D	9	**16**		
Di-n-butylphthalate	FDS07A	1	ND	NL/370	NA
4-Methylphenol (p-Cresol)	FDS07A	ND	1	NL/18	NA
Inorganics (μg/L)					
Aluminum (Al)	FDS07A	77.8	17	NL/3700	692
	FDS07B	444	610		
	FDS07C	2,280	**6280**		
	FDS07D	ND	390		

Table 4.4.2
Analytes Detected in Shallow Groundwater
Area 7
Fuel Distribution System

Parameters	Location	First Sampling Event	Second Sampling Event	RBSL/Tap Water RBC (μg/L)	Shallow Background
Arsenic (As)	FDS07A	9.7	8.3	50/4.5E-02	17.8
	FDS07B	3.6	5.5		
	FDS07C	7.6	8.0		
	FDS07D	5.1	11.1		
Barium (Ba)	FDS07A	132	67.8	2000/260	31
	FDS07B	187	203		
	FDS07C	229	311		
	FDS07D	328	587		
Beryllium (Be)	FDS07B	**0.45**	ND	NL/1.6E-02	ND
	FDS07C	**0.59**	ND		
	FDS07D	**0.91**	ND		
Cadmium (Cd)	FDS07B	ND	1.4	5/1.8	0.53
	FDS07C	ND	1.3		
	FDS07D	ND	0.96		
Calcium (Ca)	FDS07A	165000	251000	NL/NL	NL
	FDS07B	220000	204000		
	FDS07C	218000	221000		
	FDS07D	281000	307000		
Chromium (Cr)	FDS07A	2.4	7.9	100/18	3.88
	FDS07B	ND	1.9		
	FDS07C	2.9	7.9		
Cobalt (Co)	FDS07A	1.5	1.7	NL/220	1.45
	FDS07B	ND	1.1		
	FDS07C	ND	1.4		
	FDS07D	3	1		
Cyanide (CN)	FDS07A	2.5	NT	NL/73	3.8
	FDS07B	2.8	NT		
	FDS07C	2	NT		
	FDS07D	2.4	NT		
Iron (Fe)	FDS07A	1820	4960	NL/NL	NL
	FDS07B	68700	74600		
	FDS07C	66600	68700		
	FDS07D	7790	73800		
Lead (Pb)	FDS07C	ND	8.5	15/15	4.6
	FDS07D	ND	4.1		
Magnesium (Mg)	FDS07A	503000	889000	NL/NL	NL
	FDS07B	440000	409000		
	FDS07C	586000	497000		
	FDS07D	562000	474000		

Table 4.4.2
Analytes Detected in Shallow Groundwater
Area 7
Fuel Distribution System

Parameters	Location	First Sampling Event	Second Sampling Event	RBSL/Tap Water RBC (μg/L)	Shallow Background
Manganese (Mn)	FDS07A	**170**	**222**	NL/84	2906
	FDS07B	**1240**	**1120**		
	FDS07C	**991**	**820**		
	FDS07D	**835**	**1080**		
Mercury (Hg)	FDS07A	ND	0.29	2/1.1	ND
	FDS07B	0.14	ND		
	FDS07C	0.16	0.1		
Nickel (Ni)	FDS07A	6.4	2.6	NL/73	4.08
	FDS07B	2.9	ND		
	FDS07D	4.4	ND		
Potassium (K)	FDS07A	206000	242000	NL/NL	NL
	FDS07B	119000	108000		
	FDS07C	153000	128000		
	FDS07D	140000	148000		
Silver (Ag)	FDS07A	ND	1.7	5/18	1.65
	FDS07B	ND	1.4		
Sodium (Na)	FDS07A	5790000	7890000	NL/NL	NL
	FDS07B	4620000	4440000		
	FDS07C	5500000	4810000		
	FDS07D	4700000	4820000		
Thallium (Tl)	FDS07A	ND	**7.3**	NL/0.29	ND
	FDS07B	**8**	ND		
	FDS07C	**9.9**	**6.8**		
	FDS07D	**7.1**	ND		
Tin (Sn)	FDS07B	4.5	ND	NL/2200	ND
	FDS07C	4.2	ND		
Vanadium (V)	FDS07A	8.9	10.5	NL/26	15.4
	FDS07B	2	2.2		
	FDS07C	3.5	7.6		
	FDS07D	2.3	5.2		
Zinc (Zn)	FDS07C	ND	8.2	NL/1100	15.6

Notes:
NL = Not listed
NA = Not applicable
NT = Not taken
ND = Not detected
μg/L = Micrograms per liter
RBSLs from the *South Carolina Risk-Based Corrective Action for Petroleum Releases* (SCDHEC, January 5, 1998) and tap water RBCs (THQ=0.1) from *Risk Based Concentration Table* (USEPA, October 22, 1997) were used as reference concentrations.
Bolded concentrations exceed RBSL or the tap water RBC (if no RBSL is available).
All background values for Zone G are based on twice the mean of grid sample concentrations. Background values for groundwater are based on two sampling rounds in two wells at each depth.

Volatile Organic Compounds in Shallow Groundwater

No VOCs were detected in shallow groundwater at Area 7.

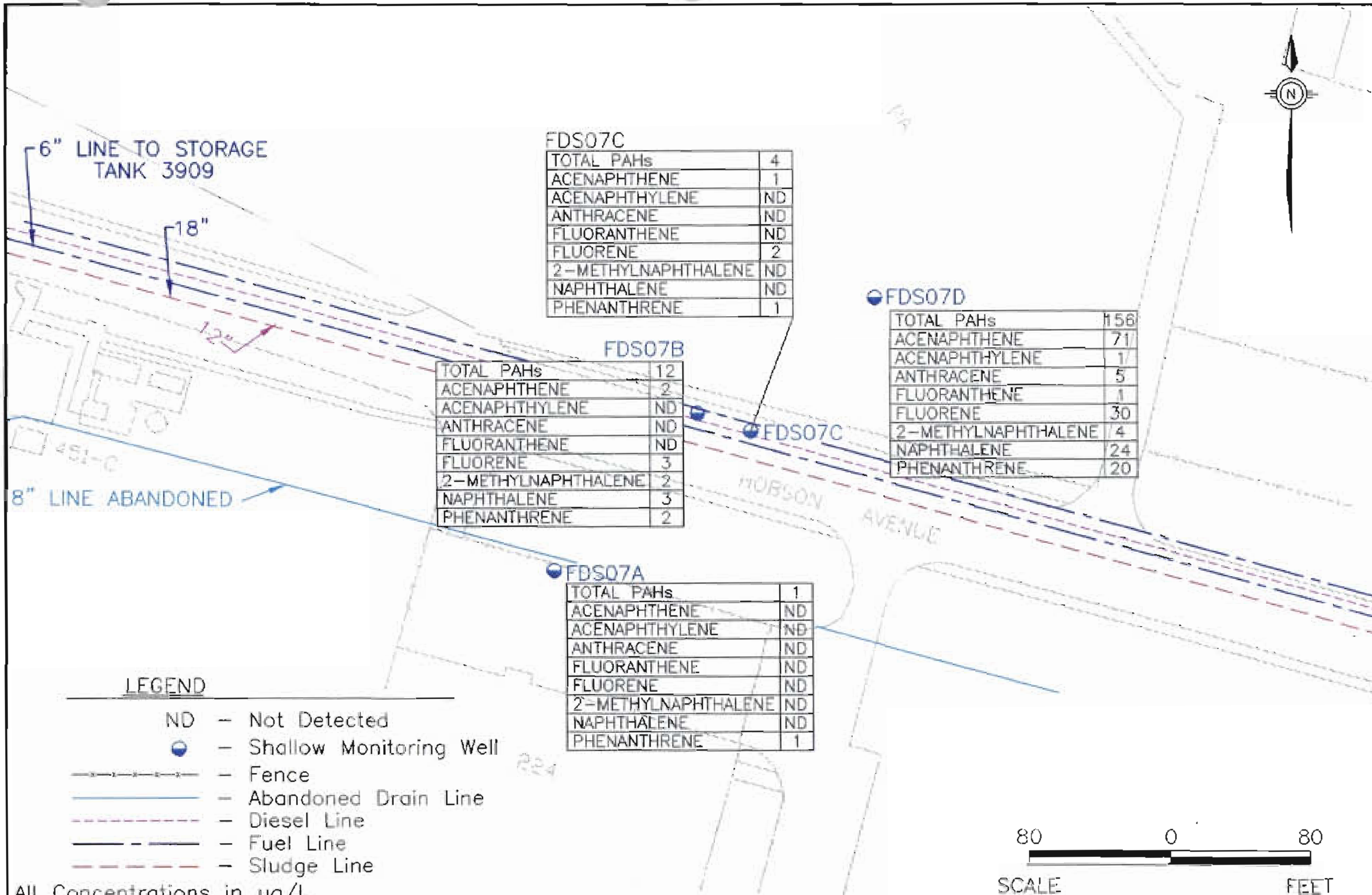
Semivolatile Organic Compounds in Shallow Groundwater

Twelve SVOCs, including eight PAHs, were detected in Area 7 groundwater samples. During the second sampling event, acenaphthene, fluorene, naphthalene, and phenanthrene each exceeded its RBSL for individual PAHs (10 μg/L) at well FDS07D. Concentrations of these analytes were 71 μg/L, 30 μg/L, 24 μg/L, and 20 μg/L, respectively. The total PAH concentration at well FDS07D (156 μg/L), obtained by summing all PAH concentrations in this well, also exceeded the RBSL for total PAHs (25μg/L). Concentrations of PAHs increased between the first and second sampling events. Dibenzofuran was also detected at well FDS07D during the second sampling event (16 μg/L) above its tap water RBC (15 μg/L). No RBSL is available for dibenzofuran. Figure 4.4-4 presents the distribution of PAHs in groundwater at Area 7.

Inorganics in Shallow Groundwater

Twenty-one metals plus cyanide were detected in Area 7 groundwater samples, but no RBSLs for groundwater metals were exceeded. Concentrations of aluminum, manganese, and thallium exceeded their respective tap water RBCs in the second sampling event.

Aluminum exceeded its background concentration and tap water RBC in one sample. Although concentrations of manganese exceeded its RBC, they were all below the Zone G background values. No background was established for thallium.



FDS07C

TOTAL PAHs	4
ACENAPHTHENE	1
ACENAPHTHYLENE	ND
ANTHRACENE	ND
FLUORANTHENE	ND
FLUORENE	2
2-METHYLNAPHTHALENE	ND
NAPHTHALENE	ND
PHENANTHRENE	1

FDS07D

TOTAL PAHs	156
ACENAPHTHENE	71
ACENAPHTHYLENE	1
ANTHRACENE	5
FLUORANTHENE	1
FLUORENE	30
2-METHYLNAPHTHALENE	4
NAPHTHALENE	24
PHENANTHRENE	20

FDS07B

TOTAL PAHs	12
ACENAPHTHENE	2
ACENAPHTHYLENE	ND
ANTHRACENE	ND
FLUORANTHENE	ND
FLUORENE	3
2-METHYLNAPHTHALENE	2
NAPHTHALENE	3
PHENANTHRENE	2

FDS07A

TOTAL PAHs	1
ACENAPHTHENE	ND
ACENAPHTHYLENE	ND
ANTHRACENE	ND
FLUORANTHENE	ND
FLUORENE	ND
2-METHYLNAPHTHALENE	ND
NAPHTHALENE	ND
PHENANTHRENE	1

All Concentrations in ug/L
Concentrations present are from the most recent sampling event
Groundwater RBSL for Total PAHs=25ug/L
Groundwater RBSL for Individual PAHs=10ug/L
(SCDHEC January 5, 1998)

FUEL DISTRIBUTION SYSTEM CONTAMINATION ASSESSMENT REPORT
NAVAL BASE CHARLESTON
CHARLESTON, S.C.

FIGURE 4.4-4
AREA 7
PAHs IN GROUNDWATER

DWG DATE: 07/06/98 | DWG NAME: 2907N022

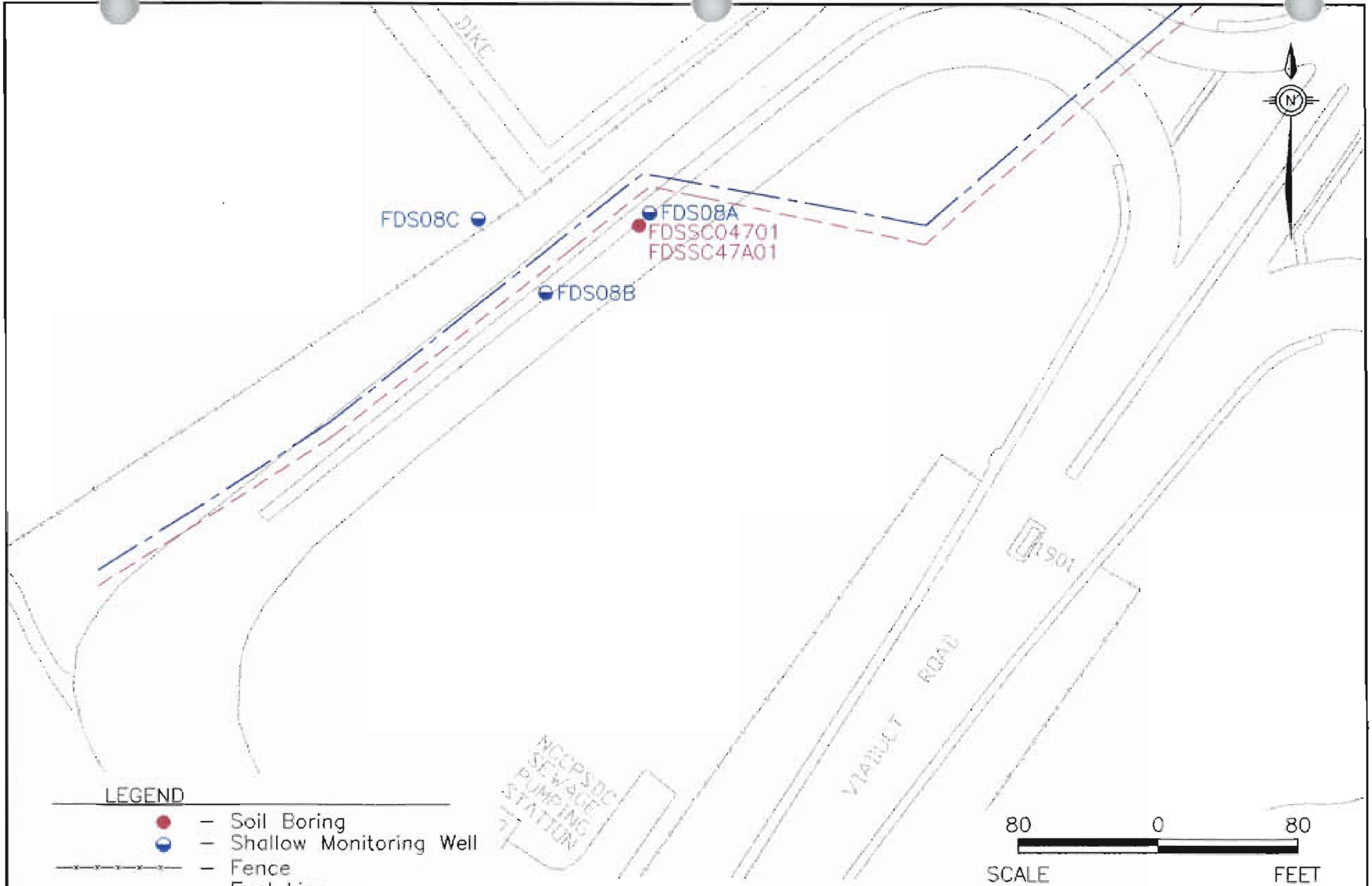
4.5 Area 8

Area 8 is associated with soil sample FDSSC04701 (collected from the 14 to 16 feet bgs depth interval) and FDSSC47A01 (13.5 to 15.5 feet bgs). This area of potential impact is north of the Viaduct Road overpass, along a road ramp. The Cooper River lies approximately 1,700 feet to the east. To investigate potential petroleum groundwater contamination, three shallow monitoring wells were installed: two in the grassy median north of the road ramp, and one on the southern edge of the athletic field north of the site. Figure 4.5-1 presents the soil boring and monitoring well locations for Area 8.

4.5.1 Site Geology and Hydrogeology

Based on well borings, the general stratigraphy at Area 8 is brown to gray silty, clayey sandy soil fill to a depth of approximately 5 feet bgs at location FDS08A. In contrast, a brown stiff, silty clay was observed from 0 to 2 feet bgs at location FDS08C. Alternating intervals of brown to dark gray to black silt, sand, and organic clay underlie the surficial soil to a depth of approximately 20 feet bgs. Strong petroleum odors were noted in stratigraphic soil samples collected from 11 feet bgs at boring FDS08B. Appendix B contains boring logs and monitoring well construction diagrams for Area 8.

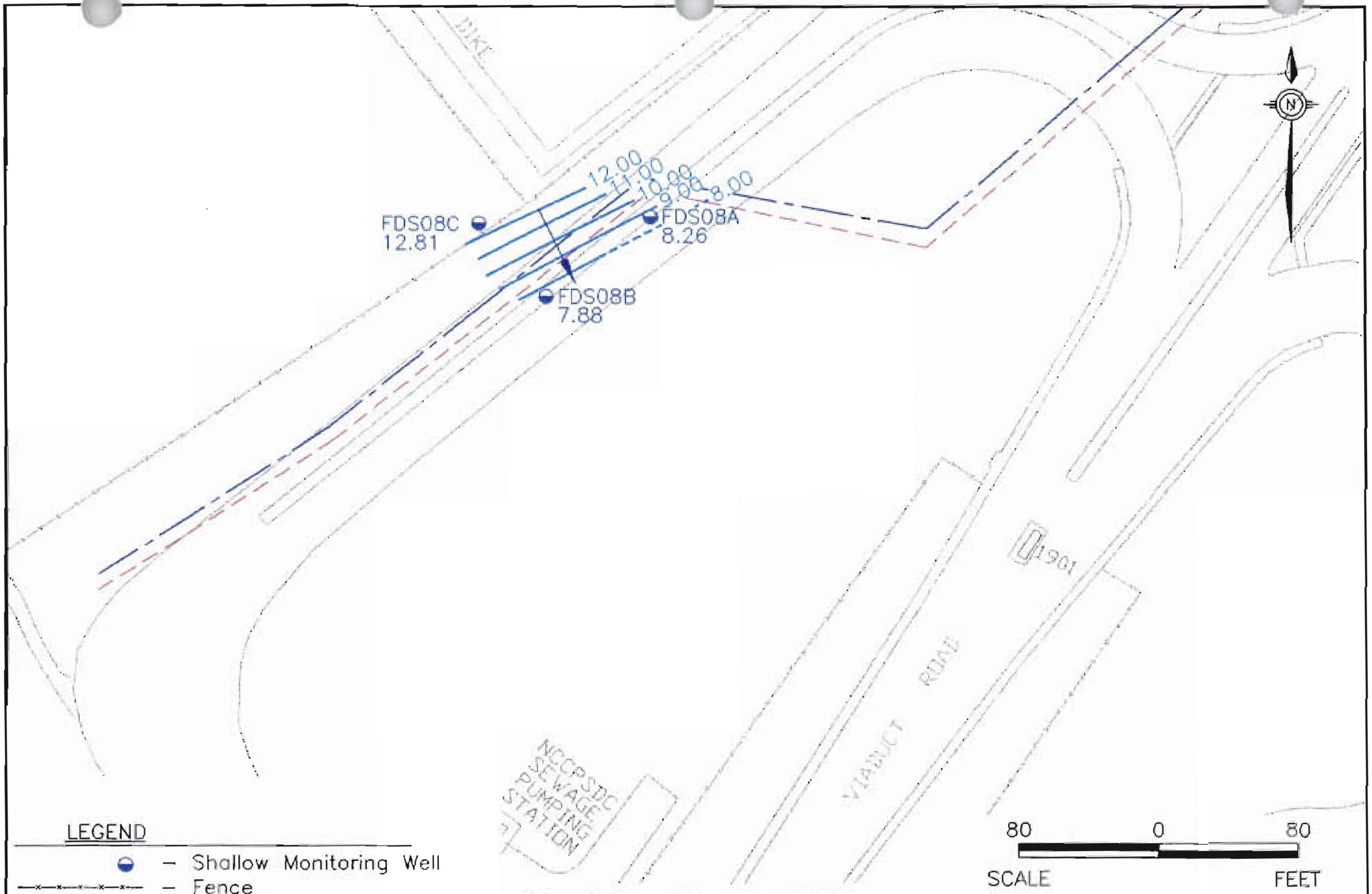
Shallow groundwater at Area 8 occurs from 1 to 8.6 feet bgs. Figures 4.5-2 and 4.5-3 depict the shallow groundwater potentiometric surface and inferred flow direction for the site during low- and high-tide, respectively. Shallow groundwater flow direction and gradient are consistent between tidal stages. Groundwater elevation changes due to tidal variation are minor, ranging from 0.11 to 0.36 feet. Maximum average calculated groundwater velocity (utilizing the steepest gradient) was 0.891 feet/day based on an average porosity (0.359) and representative hydraulic conductivity (3.9 feet/day) determined during the Zone G RFI (EnSafe, February 1998).



FUEL DISTRIBUTION SYSTEM
CONTAMINATION
ASSESSMENT REPORT
NAVAL BASE CHARLESTON
CHARLESTON, S.C.

FIGURE 4.5–1
AREA 8
SOIL AND GROUNDWATER
SAMPLE LOCATIONS

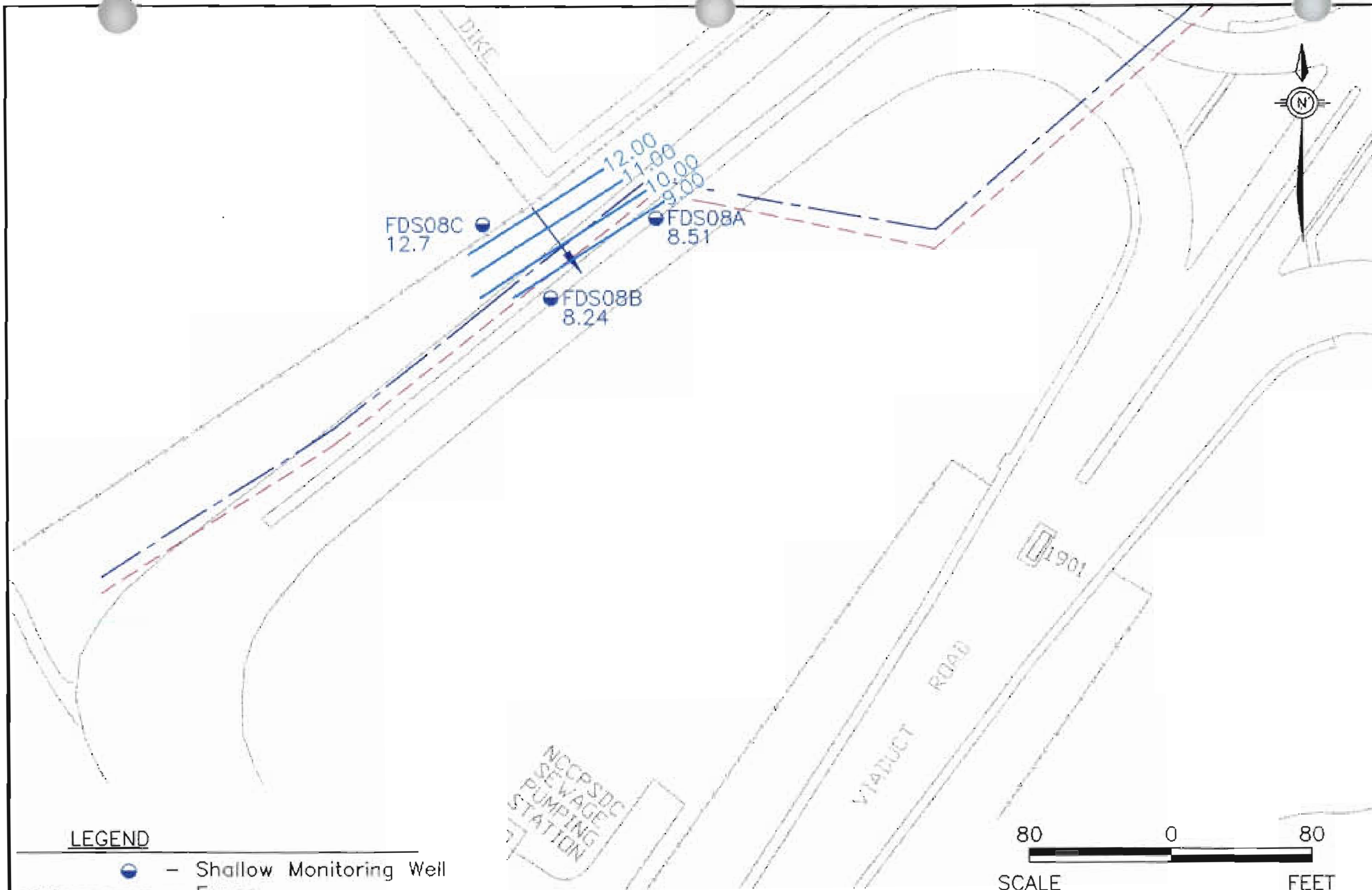
DWG DATE: 07/13/98 | DWG NAME: 2907N005



FUEL DISTRIBUTION SYSTEM
CONTAMINATION
ASSESSMENT REPORT
NAVAL BASE CHARLESTON
CHARLESTON, S.C.

FIGURE 4.5-2
AREA 8
SHALLOW GROUNDWATER
LOW-TIDE POTENTIOMETRIC MAP

DWG DATE: 07/13/98	DWG NAME: 2907N034



LEGEND

- Shallow Monitoring Well
- Fence
- Fuel Line
- Sludge Line
- Contour Interval = 1.0 Feet
- Arrow Indicates Flow Direction

FUEL DISTRIBUTION SYSTEM
CONTAMINATION
ASSESSMENT REPORT
NAVAL BASE CHARLESTON
CHARLESTON, S.C.

FIGURE 4.5-3
AREA 8
SHALLOW GROUNDWATER
HIGH-TIDE POTENTIOMETRIC MAP

DWG DATE: 07/13/98 | DWG NAME: 2907N035

4.5.2 Nature of Contamination in Subsurface Soil

Analytes detected in Area 8 subsurface soil are summarized in Table 4.5.1. Appendix C contains a complete analytical data report for all FDS samples.

TPH-GRO in Subsurface Soil

The Phase I soil sample FDSSC04701 exhibited 19,000 μg/kg TPH-GRO, prompting subsequent Phase II soil and groundwater sampling at Area 8. Nearby samples FDSSC04601, FDSSH00701, and FDSSH00801 identifed no significant TPH contamination.

Volatile Organic Compounds in Subsurface Soil

Toluene was the only VOC detected in Area 8 subsurface soil, at a concentration far below its RBSL.

Semivolatile Organic Compounds in Subsurface Soil

Ten SVOCs, were detected in Area 8 subsurface soil. The RBSL for total naphthalenes (210 μg/kg) was exceeded in FDSSC47A01. The total naphthalene concentration at this location (5,210 μg/kg) was derived by summing the concentrations of 2-methylnaphthalene (5,100 μg/kg) and naphthalene (110 μg/kg) detected. All other SVOC concentrations were far below their RBSLs if available and SSLs.

Inorganics in Subsurface Soil

Eighteen metals were detected in Area 8 subsurface soil. No soil RBSLs are available for the inorganics detected. All metal concentrations were below their SSLs and Zone G background concentrations with the exception of arsenic which only very slightly exceeded background.

Table 4.5.1
Analytes Detected in Subsurface Soil
Area 8
Fuel Distribution System

Parameters	Location	Subsurface Conc.	RBSL/SSL	Subsurface Background
TPH - GRO (μg/kg)				
Gasoline	FDSSC04701	19000	NL/NL	NA
Volatile Organic Compounds (μg/kg)				
Toluene	FDSSC47A01	4	1622/12000	NA
Semivolatile Organic Compounds (μg/kg)				
Total Naphthalenes	FDSSC47A01	5210	210/84000	NA
2-Methylnaphthalene	FDSSC47A01	5100	NL/126000	NA
Naphthalene	FDSSC47A01	110	NL/84000	NA
Acenaphthene	FDSSC47A01	430	NL/570000	NA
Anthracene	FDSSC47A01	280	NL/12000000	NA
Benzo(a)anthracene	FDSSC47A01	300	73084/2000	NA
Dibenzofuran	FDSSC47A01	330	NL/50000	NA
Fluoranthene	FDSSC47A01	190	NL/4300000	NA
Fluorene	FDSSC47A01	570	NL/560000	NA
Phenanthrene	FDSSC47A01	1600	NL/1380000	NA
Pyrene	FDSSC47A01	710	NL/4200000	NA
Inorganics (mg/kg)				
Aluminum (Al)	FDSSC47A01	15000	NL/1000000	23600
Arsenic (As)	FDSSC47A01	16	NL/29	15.5[a]
Barium (Ba)	FDSSC47A01	27.3	NL/1600	64.5
Beryllium (Be)	FDSSC47A01	1	NL/63	1.63
Calcium (Ca)	FDSSC47A01	30800	NL/NL	NL
Chromium (Cr)	FDSSC47A01	29.6	NL/1000000	43.4[a]
Cobalt (Co)	FDSSC47A01	5.6	NL/2000	8.14
Copper (Cu)	FDSSC47A01	18.9	NL/920	32.6
Iron (Fe)	FDSSC47A01	19600	NL/NL	NL
Lead (Pb)	FDSSC47A01	30.3	NL/400	66.3

Table 4.5.1
Analytes Detected in Subsurface Soil
Area 8
Fuel Distribution System

Parameters	Location	Subsurface Conc.	RBSL/SSL	Subsurface Background
Magnesium (Mg)	FDSSC47A01	4270	NL/NL	NL
Manganese (Mn)	FDSSC47A01	186	NL/1100	291
Mercury (Hg)	FDSSC47A01	0.09	NL/2.1	0.31
Potassium (K)	FDSSC47A01	1870	NL/NL	NL
Selenium (Se)	FDSSC47A01	1.00	NL/5	1.26
Sodium (Na)	FDSSC47A01	2300	NL/NL	NL
Vanadium (V)	FDSSC47A01	42.7	NL/6000	72.5
Zinc (Zn)	FDSSC47A01	77.9	NL/12000	145

Notes:
a = Background value for non-clay samples
NL = Not listed
NA = Not applicable
μg/kg = Micrograms per kilogram
mg/kg = Milligrams per kilogram
RBSLs from the *South Carolina Risk-Based Corrective Action for Petroleum Releases* (SCDHEC, January 5, 1998) and soil-to-groundwater SSLs (DAF=20) from the *Soil Screening Guidance: Technical Background Document* (USEPA, 1996b) were used as reference concentrations.
Bolded concentrations exceed RBSL or the SSL (if no RBSL is available).
All background values for Zone G are based on twice the mean of grid sample concentrations.

4.5.3 Nature of Contamination in Shallow Groundwater

Analytes detected in Area 8 shallow groundwater samples are summarized in Table 4.5.2. No free product was observed in Area 8 monitoring wells. Appendix C contains a complete analytical data report for all FDS samples.

Table 4.5.2
Analytes Detected in Shallow Groundwater
Area 8
Fuel Distribution System

Parameters	Location	First Sampling Event	Second Sampling Event	RBSL/Tap Water RBC (μg/L)	Shallow Background
Semivolatile Organic Compounds (μg/L)					
Total PAHs	FDS08B	**46**	21	25/NL	NA
Acenaphthene	FDS08B	**17**	6	10/220	NA
Anthracene	FDS08B	2	ND	10/1100	NA
Fluoranthene	FDS08B	6	4	10/150	NA
Fluorene	FDS08B	9	4	10/150	NA
2-Methylnaphthalene	FDS08B	2	2	10/150	NA
Phenanthrene	FDS08B	6	5	10/150	NA
Pyrene	FDS08B	4	2	10/110	NA
Benzoic acid	FDS08B	2	1	NL/15000	NA
Benzyl alcohol	FDS08C	ND	3	NL/1100	NA
Butylbenzylphthalate	FDS08C	ND	5	NL/730	NA
Dibenzofuran	FDS08B	4	2	NL/15	NA
Di-n-butylphthalate	FDS08C	ND	1	NL/370	NA
Inorganics (μg/L)					
Aluminum (Al)	FDS08A FDS08B FDS08C	**8900** 682 ND	381 116 72	NL/3700	692
Antimony (Sb)	FDS08B	ND	**2.7**	NL/1.5	4.85
Arsenic (As)	FDS08A FDS08B FDS08C	20.6 6.5 3.4	16.4 6.6 3.8	50/4.5E-02	17.8
Barium (Ba)	FDS08A FDS08B FDS08C	54.4 179 131	22.2 89.8 72.6	2000/260	31
Beryllium (Be)	FDS08A FDS08C	**1.3** **0.66**	ND ND	NL/1.6E-02	ND
Calcium (Ca)	FDS08A FDS08B FDS08C	88100 83800 170000	76500 90000 244000	NL/NL	NL

Table 4.5.2
Analytes Detected in Shallow Groundwater
Area 8
Fuel Distribution System

Parameters	Location	First Sampling Event	Second Sampling Event	RBSL/Tap Water RBC (μg/L)	Shallow Background
Chromium (Cr)	FDS08A	18.9	ND	100/18	3.88
	FDS08B	4.8	2.3		
Cobalt (Co)	FDS08A	3.1	ND	NL/220	1.45
	FDS08B	3.5	2.8		
	FDS08C	2.0	0.85		
Copper (Cu)	FDS08A	6.4	2.3	NL/13000	8.33
Iron (Fe)	FDS08A	15500	8630	NL/NL	NL
	FDS08B	3040	23800		
	FDS08C	828	1445		
Lead (Pb)	FDS08A	8.4	ND	15/15	4.6
Magnesium (Mg)	FDS08A	41900	37600	NL/NL	NL
	FDS08B	160000	157000		
	FDS08C	169000	127500		
Manganese (Mn)	FDS08A	**304**	**275**	NL/84	2906
	FDS08B	**386**	**561**		
	FDS08C	**332**	**435**		
Nickel (Ni)	FDS08A	8	1	NL/73	4.08
	FDS08B	13	1.6		
	FDS08C	5.8	0.88		
Potassium (K)	FDS08A	20500	20900	NL/NL	NL
	FDS08B	71500	63800		
	FDS08C	68600	51750		
Silver (Ag)	FDS08C	ND	1.4	5/18	1.65
Sodium (Na)	FDS08A	114000	59000	NL/NL	NL
	FDS08B	1960000	1850000		
	FDS08C	1210000	598000		
Thallium (Tl)	FDS08A	**4.1**	ND	NL/0.29	ND
	FDS08B	**5.8**	**7.8**		
	FDS08C	**8.4**	ND		
Vanadium (V)	FDS08A	22.9	4.5	NL/26	15.4
	FDS08B	13.1	6.6		
	FDS08C	2.8	18.1		
Zinc (Zn)	FDC08A	36	ND	NL/1100	15 6

Notes:
NL = Not listed
NA = Not applicable
ND = Not detected
μg/L = Micrograms per liter
RBSLs from the *South Carolina Risk-Based Corrective Action for Petroleum Releases* (SCDHEC, January 5, 1998) and tap water RBCs (THQ=0.1) from *Risk Based Concentration Table* (USEPA, October 22, 1997) were used as reference concentrations.
Bolded concentrations exceed RBSL or the tap water RBC (if no RBSL is available).
All background values for Zone G are based on twice the mean of grid sample concentrations. Background values for groundwater are based on two sampling rounds in two wells at each depth.

Volatile Organic Compounds in Groundwater

No VOCs were detected in groundwater at Area 8.

Semivolatile Organic Compounds in Groundwater

Twelve SVOCs, including seven PAHs, were detected in Area 8 groundwater samples. The RBSL for total PAHs was exceeded during the first, but not the second most recent, sampling event. No other groundwater SVOC concentrations exceeded individual RBSLs or tap water RBCs.

Inorganics in Groundwater

Twenty metals were detected in Area 8 groundwater samples, but no RBSLs were exceeded. Concentrations of antimony, manganese, and thallium exceeded their tap water RBCs in the second sampling event. Although concentrations of antimony and manganese exceeded RBCs, all these concentrations were below the Zone G background value. No background was established for thallium.

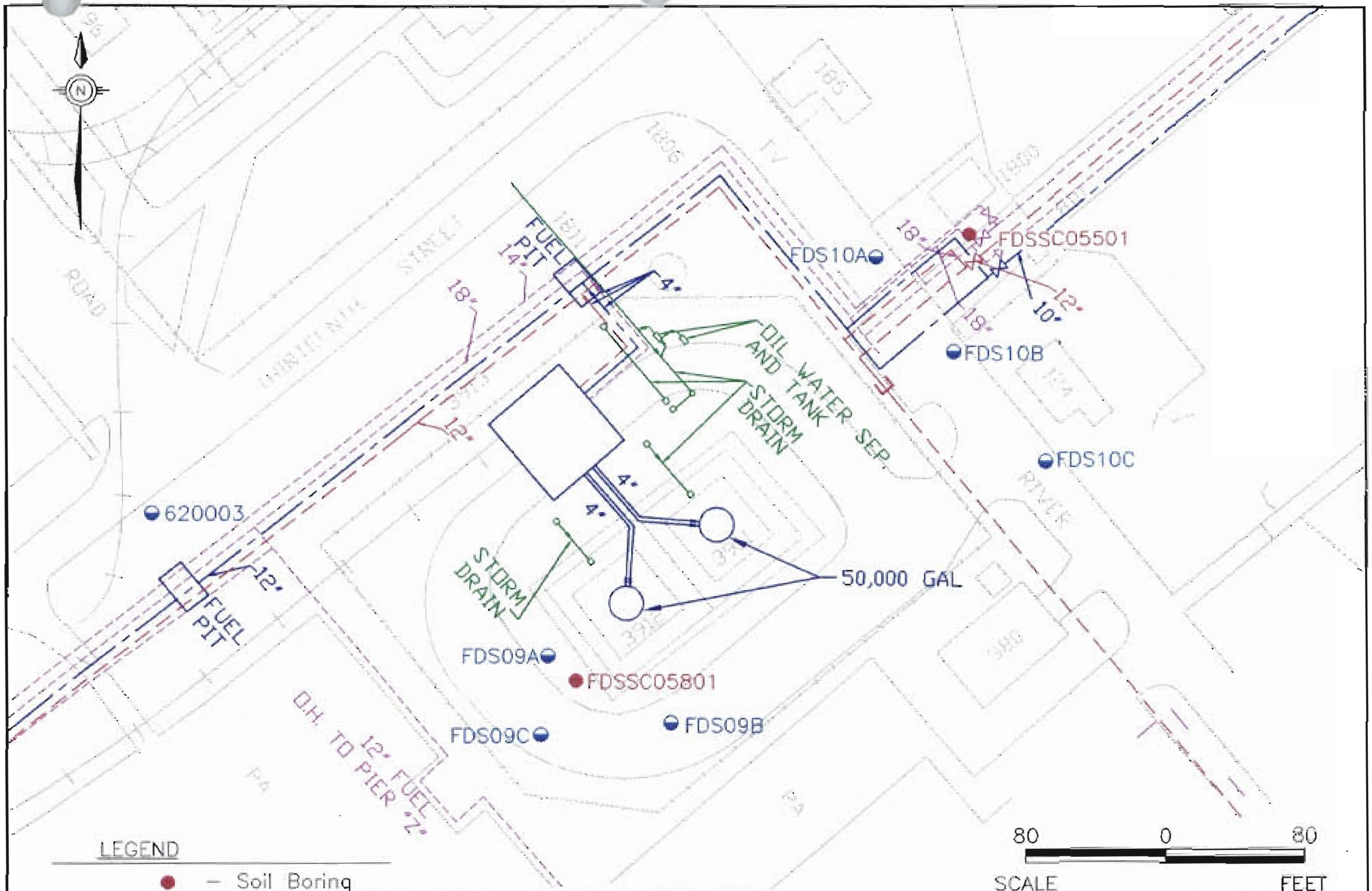
4.6 Areas 9 and 10

Areas 9 and 10 are associated with soil sample FDSSC05801 (collected from the 5 to 9 feet bgs depth interval) and FDSSC05501 (4 to 10 feet bgs), respectively. These areas of potential impact are immediately southwest of Fueling Pier Kilo (AOC 631). The Cooper River lies approximately 200 feet to the east. To investigate potential petroleum groundwater contamination, six shallow monitoring wells were installed within the two areas. The three wells for Area 9 were installed around boring FDSSC05801, which was advanced southwest of the two 50,000-gallon petroleum storage tanks associated with Pier Kilo. Three Area 10 wells were associated with sample FDSSC05501, these wells are situated along the eastern edge of River Road South, where this road passes Fueling Pier Kilo. Because of the proximity of shallow well 620003 (AOC 620 investigated during the Zone F RFI), analytical data from this well was included and reviewed relative to this investigation. Figure 4.6-1 presents the soil boring and monitoring well locations for Areas 9 and 10.

4.6.1 Site Geology and Hydrogeology

Based on well borings advanced at this site, the general stratigraphy at Areas 9 and 10 is dark brown to black clayey, sandy soil to approximately 5 feet bgs, overlying alternating intervals of tan to olive, gray to black silt, sand and organic clay to a depth of approximately 20 feet bgs. No petroleum odors or stains were noted in soil samples from monitoring well borings. Appendix B contains boring logs and monitoring well construction diagrams for these wells.

Shallow groundwater at Areas 9 and 10 occurs from 1.25 to 3.0 feet bgs. Figures 4.6-2 and 4.6-3 depict the shallow groundwater potentiometric surface and inferred flow direction for the site during low- and high-tide respectively. The overall flow direction was consistent between tides. The gradient was less during high-tide. Changes in groundwater elevation between tides were less than 0.35 feet.



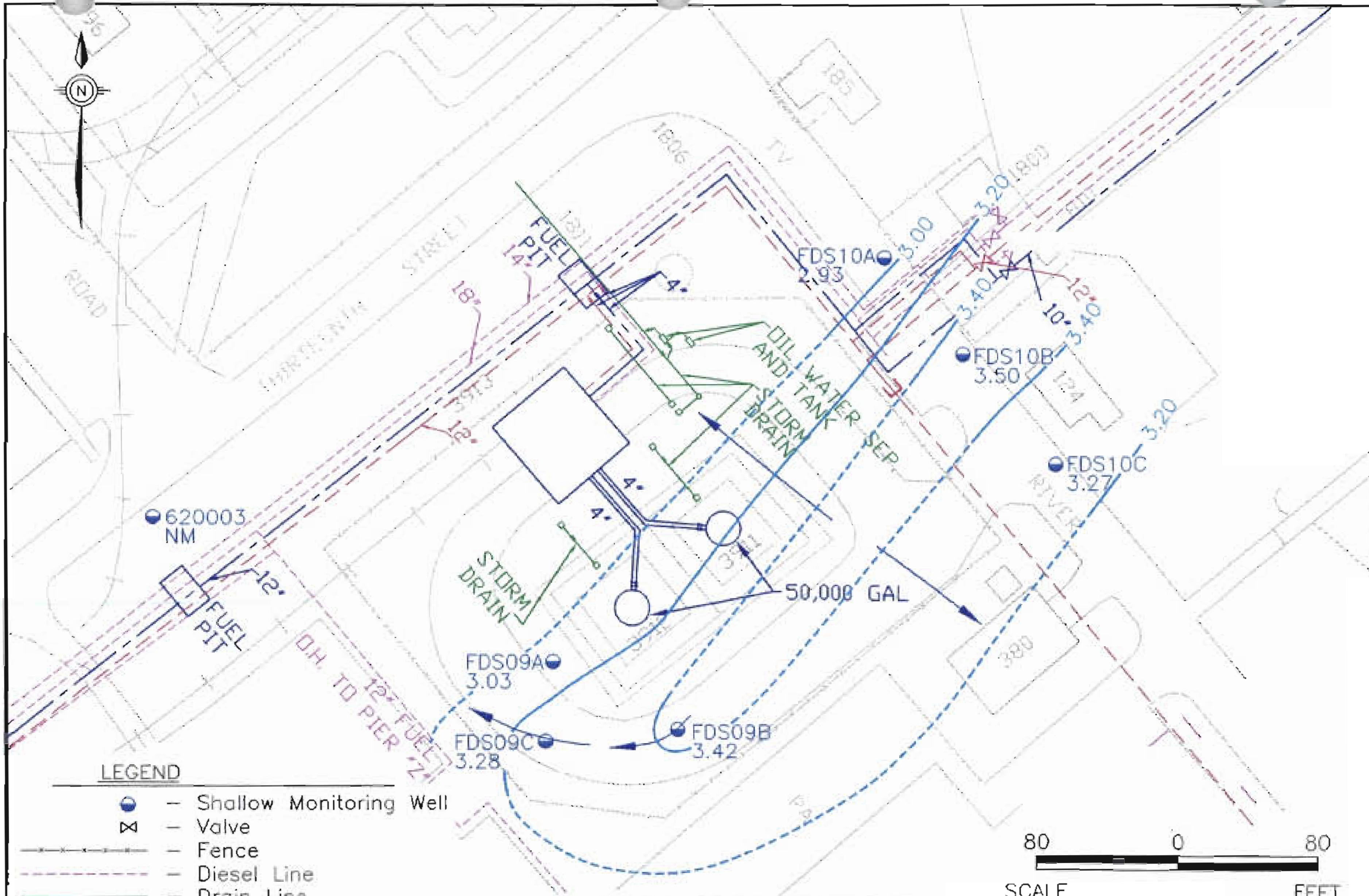
LEGEND

- ● – Soil Boring
- ◒ – Shallow Monitoring Well
- ⋈ – Valve
- –x–x–x– – Fence
- - - - - – Diesel Line
- —— – —— – Fuel Line
- — — — – Sludge Line

FUEL DISTRIBUTION SYSTEM CONTAMINATION ASSESSMENT REPORT
NAVAL BASE CHARLESTON
CHARLESTON, S.C.

FIGURE 4.6–1
AREAS 9 AND 10
SOIL AND GROUNDWATER SAMPLE LOCATIONS

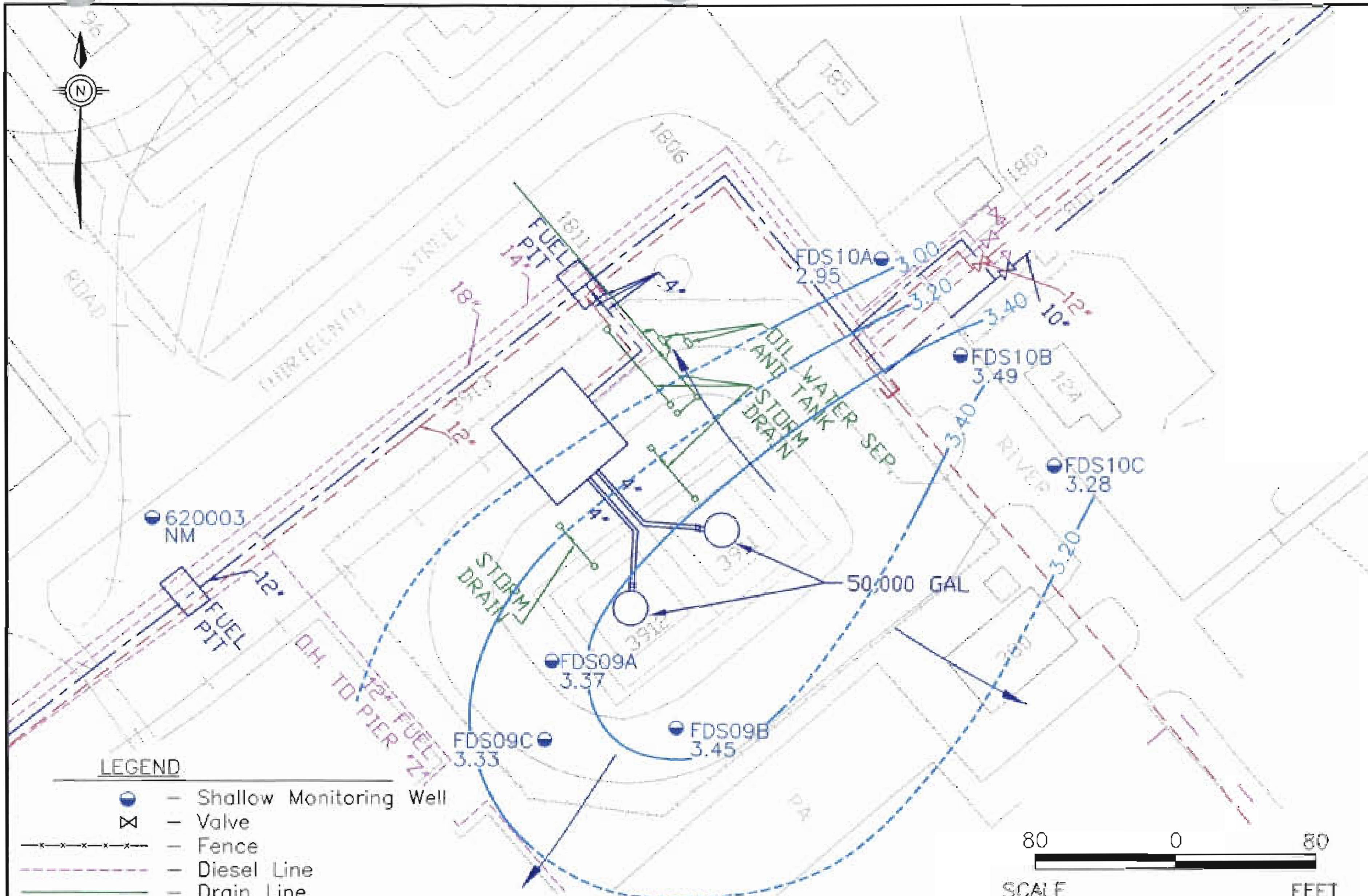
DWG DATE: 05/28/98 | DWG NAME: 2907N006



FUEL DISTRIBUTION SYSTEM CONTAMINATION ASSESSMENT REPORT
NAVAL BASE CHARLESTON
CHARLESTON, S.C.

FIGURE 4.6-2
AREAS 9 AND 10
SHALLOW GROUNDWATER
LOW-TIDE POTENTIOMETRIC MAP

DWG DATE: 06/29/98 | DWG NAME: 2907N038



LEGEND

- Shallow Monitoring Well
- Valve
- Fence
- Diesel Line
- Drain Line
- Fuel Line
- Sludge Line
- Contour Interval = 0.2 Feet
- Arrow Indicates Flow Direction

NM – Water Level Not Measured During This Event

FUEL DISTRIBUTION SYSTEM CONTAMINATION ASSESSMENT REPORT
NAVAL BASE CHARLESTON
CHARLESTON, S.C.

FIGURE 4.6–3
AREAS 9 AND 10
SHALLOW GROUNDWATER
HIGH–TIDE POTENTIOMETRIC MAP

DWG DATE: 06/29/98 | DWG NAME: 2907N039

Maximum average calculated groundwater velocity (utilizing the steepest gradient) was 0.008 feet/day based on an average porosity (0.359) and hydraulic conductivity (0.37 feet/day) determined during the Zone G RFI (EnSafe, February 1998).

4.6.2 Nature of Contamination in Subsurface Soil

Analytes detected in subsurface soil at Area 9 and 10 are summarized in Table 4.6.1. Appendix C contains a complete analytical data report for all FDS samples.

TPH-GRO in Subsurface Soil

The Phase I samples at Area 9 and 10 showed TPH-GRO concentrations of 63.7 μg/kg at FDSSC05501 and 10 μg/kg at FDSSC05801. FDSSC05501 was advanced to Phase II based on elevated TPH. FDSSC05801 was advanced to Phase II based on visual observations. Nearby samples FDSSC03801, FDSSC03901, FDSSC04001, FDSSC04101, FDSSC05701, FDSSC05901, FDSSC06001, and FDSSC06201 identified no significant TPH contamination.

Volatile Organic Compounds in Subsurface Soil

Toluene was the only VOC detected in subsurface soil at Area 9 and 10, at a concentration far below its RBSL and SSL.

Semivolatile Organic Compounds in Subsurface Soil

Twelve SVOCs were detected in subsurface soil at Area 9 and 10. The RBSL for total naphthalenes (210 μg/kg) was slightly exceeded at FDCSC05801. The total naphthalene concentration at this location (250 μg/kg) represents only 2-methylnaphthalene. All other SVOC concentrations were far below their RBSLs and SSLs. Figure 4.6-4 presents the distribution of naphthalenes in soil at Area 9 and 10.

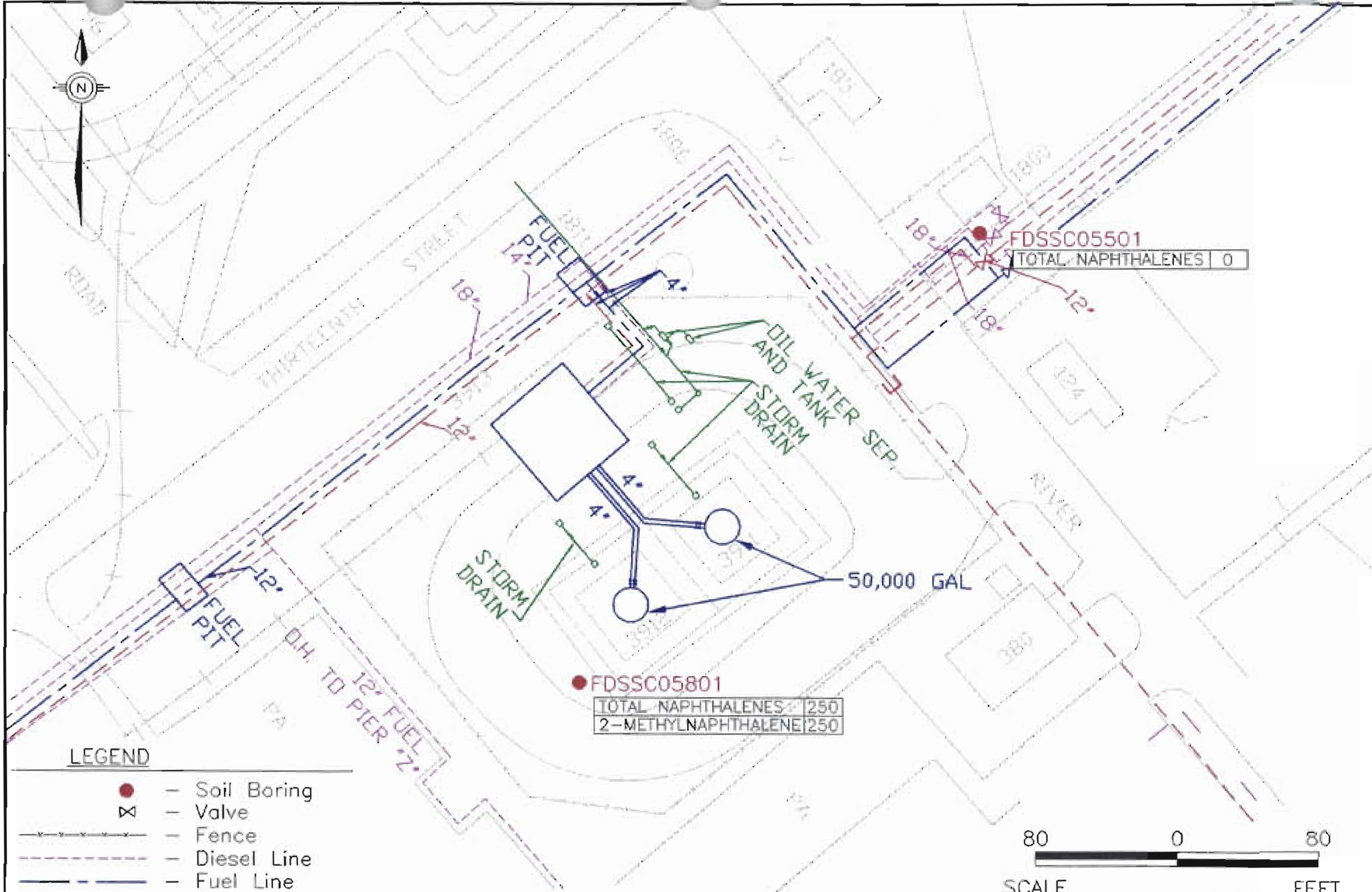
Table 4.6.1
Analytes Detected in Subsurface Soil
Areas 9 & 10
Fuel Distribution System

Parameters	Location	Subsurface Conc.	RBSL/SSL	Subsurface Background
TPH - GRO (µg/kg)				
Gasoline	FDSSC05501	63.7	NL/NL	NA
	FDSSC05801	10		
Volatile Organic Compounds (µg/kg)				
Toluene	FDSSC05501	2	1622/12000	NA
Semivolatile Organic Compounds (µg/kg)				
Total Naphthalenes	FDSSC05801	**250**	210/84000	NA
2-Methylnaphthalene	FDSSC05801	250	NL/126000	NA
Benzo(a)anthracene	FDSSC05501	74	73084/2000	NA
Benzo(b)fluoranthene	FDSSC05501	53	29097/5000	NA
Benzo(a)pyrene	FDSSC05501	68	NL/8000	NA
Benzo(g,h,i)perylene	FDSSC05501	65	NL/4.66E+08	NA
Benzoic acid	FDSSC05501	61	NL/400000	NA
Chrysene	FDSSC05501	150	12998/160000	NA
	FDSSC05801	140		
Dibenzofuran	FDSSC05801	64	NL/50000	NA
Fluoranthene	FDSSC05801	88	NL/4300000	NA
Fluorene	FDSSC05801	70	NL/560000	NA
Phenanthrene	FDSSC05801	160	NL/1380000	NA
Pyrene	FDSSC05501	45	NL/4200000	NA
	FDSSC05801	160		
Pesticides (µg/kg)				
4,4'-DDE	FDSSC05801	4.2	NL/54000	NA
alpha-Chlordane	FDSSC05801	3.4	NL/10000	NA
gamma-Chlordane	FDSSC05801	5.4	NL/10000	NA
Inorganics (mg/kg)				
Aluminum (Al)	FDSSC05501	3830	NL/1000000	23600
	FDSSC05801	6110		
Arsenic (As)	FDSSC05501	1.3	NL/29	15.5[a]
	FDSSC05801	5.4		
Barium (Ba)	FDSSC05501	5.9	NL/1600	64.5
	FDSSC05801	10.1		
Beryllium (Be)	FDSSC05501	.09	NL/63	1.63
	FDSSC05801	.45		
Cadmium (Cd)	FDSSC05501	.09	NL/8	0.48
Calcium (Ca)	FDSSC05501	22100	NL/NL	NL
	FDSSC05801	15500		
Chromium (Cr)	FDSSC05501	7.3	NL/1000000	43.4[a]
	FDSSC05801	12.8		
Cobalt (Co)	FDSSC05501	.71	NL/2000	8.14
	FDSSC05801	1.8		
Copper (Cu)	FDSSC05501	1.8	NL/920	32.6

Table 4.6.1
Analytes Detected in Subsurface Soil
Areas 9 & 10
Fuel Distribution System

Parameters	Location	Subsurface Conc.	RBSL/SSL	Subsurface Background
Iron (Fe)	FDSSC05501	2560	NL/NL	NL
	FDSSC05801	6960		
Lead (Pb)	FDSSC05501	3.2	NL/4000	66.3
	FDSSC05801	11.2		
Magnesium (Mg)	FDSSC05501	534	NL/NL	NL
	FDSSC05801	1670		
Manganese (Mn)	FDSSC05501	18.2	NL/1100	291
	FDSSC05801	87.8		
Nickel (Ni)	FDSSC05501	2.4	NL/130	18.3
Potassium (K)	FDSSC05801	767	NL/NL	NL
Sodium (Na)	FDSSC05501	478	NL/NL	NL
	FDSSC05801	2370		
Vanadium (V)	FDSSC05501	5.2	NL/6000	72.5
	FDSSC05801	15.2		
Zinc (Zn)	FDSSC05501	5.5	NL/12000	145

Notes:
a = Background value for non-clay samples
ND = Not detected
NL = Not listed
NA = Not applicable
μg/kg = Micrograms per kilogram
mg/kg = Milligrams per kilogram
RBSLs from the *South Carolina Risk-Based Corrective Action for Petroleum Releases* (SCDHEC, January 5, 1998) and soil-to-groundwater SSLs (DAF=20) from the *Soil Screening Guidance: Technical Background Document* (USEPA, 1996b) were used as reference concentrations.
Bolded concentrations exceed RBSL or the SSL (if no RBSL is available).
All background values for Zone G are based on twice the mean of grid sample concentrations.



FUEL DISTRIBUTION SYSTEM
CONTAMINATION
ASSESSMENT REPORT
NAVAL BASE CHARLESTON
CHARLESTON, S.C.

FIGURE 4.6-4
AREAS 9 AND 10
NAPHTHALENES IN SOIL

DWG DATE: 06/02/98 | DWG NAME: 2907N023

Pesticides in Subsurface Soil

Three pesticides were detected in subsurface soil at Area 9 and 10. No RBSLs are available for pesticides in soil. Concentrations of 4,4'-DDE, alpha-chlordane, and gamma-chlordane were detected at FDSSC05801 below SSLs.

Inorganics in Subsurface Soil

Eighteen metals were detected in subsurface soil at Area 9 and 10. No soil RBSLs are available. All detected metals concentrations were below SSLs and Zone G background concentrations.

4.6.3 Nature of Contamination in Shallow Groundwater

Analytes detected in groundwater at Areas 9 and 10 are summarized in Table 4.6.2. No free product was observed in these wells. Appendix C contains a complete analytical data report for all FDS samples. For Area 9 and 10, the FDS well data are based on two sampling events, January and June of 1997. Data for monitoring well 620003 are taken from sampling in May and September of 1997.

Volatile Organic Compounds in Shallow Groundwater

Acetone and xylene were the only VOCs detected in Area 9 and 10 groundwater. These parameters were detected in the most recent FDS09C samples at concentrations far below RBSLs and tap water RBCs.

Semivolatile Organic Compounds in Shallow Groundwater

Acenaphthene, benzoic acid, and 4-chloro-3-methylphenol were detected in Area 9 and 10 groundwater, from well 620003 adjacent to Areas 9 and 10, at concentrations far below RBSLs and tap water RBCs. Total PAHs was also far below the RBSL.

Table 4.6.2
Analytes Detected in Shallow Groundwater
Areas 9 & 10
Fuel Distribution System

Parameters	Location	First Sampling Event	Second Sampling Event	RBSL/Tap Water RBC ($\mu g/L$)	Shallow Background
Volatile Organic Compounds ($\mu g/L$)					
Acetone	FDS09C	ND	6	NL/370	NA
Xylene (Total)	FDS09C	ND	1	10000/1200	NA
Semivolatile Organic Compounds ($\mu g/L$)					
Total PAHs	620003	0	2	25/NL	NA
Acenaphthene	620003	ND	2	10/220	NA
Benzoic acid	620003	ND	4.0	NL/15000	NA
4-Chloro-3-methylphenol	620003	ND	1.0	NL/NL	NA
Dioxins (pg/L)					
Dioxin (2,3,7,8-TCDD TEQs[1])	FDS09B	0.004	NT	NL/0.45	NA
Inorganics ($\mu g/L$)					
Aluminum (Al)	620003	ND	182	NL/3700	692
	FDS09A	273	39.9		
	FDS09B	197.5	110.1		
	FDS09C	136	ND		
	FDS10A	230	ND		
	FDS10B	379	10.7		
	FDS10C	93.1	77		
Antimony (Sb)	FDS09B	**4.1**	ND	NL/1.5	4.85
	FDS10A	**2.6**	ND		
	FDS10B	**2.8**	ND		
	FDS10C	**2.4**	ND		
Arsenic (As)	620003	ND	11.1	50/0.045	17.8
	FDS09A	4	3.3		
	FDS09B	4.2	6.1		
	FDS09C	4.4	3.5		
	FDS10A	6.5	5.2		
Barium (Ba)	620003	32.9	67.2	2000/260	31
	FDS09A	45.4	37.6		
	FDS09B	202.5	237		
	FDS09C	37.8	33.7		
	FDS10A	411	247		
	FDS10B	182	200		
	FDS10C	42.6	33		
Beryllium (Be)	FDS09A	.38	ND	NL/0.016	ND
Cadmium (Cd)	620003	0.3	ND	5/1.8	0.53
	FDS10C	ND	0.32		
Calcium (Ca)	620003	129000	134000	NL/NL	NL
	FDS09A	144000	138000		
	FDS09B	23700	236500		
	FDS09C	143000	131000		
	FDS10A	133000	133000		
	FDS10B	191000	203000		
	FDS10C	170000	155000		
Chromium (Cr)	620003	ND	1.4	100/18	3.88
	FDS10A	ND	2.2		
	FDS10C	ND	2.5		

Table 4.6.2
Analytes Detected in Shallow Groundwater
Areas 9 & 10
Fuel Distribution System

Parameters	Location	First Sampling Event	Second Sampling Event	RBSL/Tap Water RBC (μg/L)	Shallow Background
Cobalt (Co)	FDS09A	2.9	ND	NL/220	1.45
	FDS09B	1.1	ND		
	FDS09C	1.9	ND		
	FDS10A	1.8	ND		
	FDS10B	.96	ND		
	FDS10C	1	ND		
Copper (Cu)	620003	2.5	ND	NL/13000	8.33
Cyanide (CN)	FDS09A	10.9	NT	NL/73	3.8
	FDS09C	16.7	NT		
	FDS10B	3.8	NT		
	FDS10C	8.1	NT		
Iron (Fe)	620003	6880	11700	NL/NL	NL
	FDS09A	1300	15200		
	FDS09B	23600	14700		
	FDS09C	10400	12400		
	FDS10A	7590	8390		
	FDS10B	5560	4650		
	FDS10C	13300	10600		
Lead (Pb)	FDS10A	2	ND	15/15	4.6
Magnesium (Mg)	620003	23100	18800	NL/NL	NL
	FDS09A	574000	462000		
	FDS09B	70450	53550		
	FDS09C	583000	485000		
	FDS10A	245000	199000		
	FDS10B	382000	280000		
	FDS10C	343000	297000		
Manganese (Mn)	620003	**749**	**604**	NL/84	2906
	FDS09A	**694**	**992**		
	FDS09B	**1475**	**1245**		
	FDS09C	**561**	**576**		
	FDS10A	**156**	**137**		
	FDS10B	**275**	**263**		
	FDS10C	**790**	**707**		
Nickel (Ni)	FDS09C	1	ND	NL/73	4.08
	FDS10A	3.7	2.4		
	FDS10B	1.2	ND		
	FDS10C	.92	ND		
Potassium (K)	620003	16800	19200	NL/NL	NL
	FDS09A	195000	164000		
	FDS09B	47300	38850		
	FDS09C	190000	168000		
	FDS10A	85800	74900		
	FDS10B	131000	107000		
	FDS10C	137000	120000		
Silver (Ag)	FDS09B	ND	1.9	5/18	1.65
	FDS10A	1.3	ND		
	FDS10B	ND	1.1		

Table 4.6.2
Analytes Detected in Shallow Groundwater
Areas 9 & 10
Fuel Distribution System

Parameters	Location	First Sampling Event	Second Sampling Event	RBSL/Tap Water RBC (μg/L)	Shallow Background
Sodium (Na)	620003	75900	71400	NL/NL	NL
	FDS09A	5320000	4380000		
	FDS09B	472000	394000		
	FDS09C	5260000	4710000		
	FDS10A	2370000	2150000		
	FDS10B	3550000	2940000		
	FDS10C	3050000	2920000		
Thallium (Tl)	620003	**5.2**	ND	NL/0.29	ND
	FDS09A	ND	**5.6**		
	FDS09B	ND	**6.7**		
	FDS09C	ND	**5.8**		
	FDS10A	ND	**7.1**		
Vanadium (V)	FDS09A	4.7	3.6	NL/26	15.4
	FDS09B	2.0	1.7		
	FDS09C	3.4	1.7		
	FDS10A	2.6	ND		
	FDS10B	3.6	1.8		
	FDS10C	3.3	2.7		
Zinc (Zn)	FDS10A	**2790**	**2340**	NL/1100	15.6

Notes:
1 = Calculated from methods described in USEPA Interim *Supplemental Guidance to RAGS: Human Health Risk Assessment*, Bulletin 2 (USEPA, 1995).
NL = Not listed
NA = Not applicable
ND = Not detected
NT = Not taken
TCDD = Tetrachlorodibenzo-p-dioxin
TEQ = TCDD equivalency quotient
μg/L = Micrograms per liter
pg/L = Picograms per liter
RBSLs from the *South Carolina Risk-Based Corrective Action for Petroleum Releases* (SCDHEC, January 5, 1998) and tap water RBCs (THQ=0.1) from *Risk Based Concentration Table* (USEPA, October 22, 1997) were used as reference concentrations.
Bolded concentrations exceed RBSL or the tap water RBC (if no RBSL is available).
All background values for Zone G are based on twice the mean of grid sample concentrations. Background values for groundwater are based on two sampling rounds in two wells at each depth.

Dioxins in Groundwater

Dioxin (2,3,7,8-tetrachlorodibenzo-p-dioxin equivalency quotient [TCDD TEQ]) was detected in the first groundwater sampling event at well FDS09B, far below its tap water RBC. No RBSL is available for this compound. Dioxin was not analyzed for during the second sampling event.

Inorganics in Shallow Groundwater

Twenty-one metals plus cyanide were detected in groundwater samples associated with Area 9 and 10. No RBSLs for groundwater metals were exceeded at Area 9 and 10. Concentrations of manganese, thallium, and zinc exceeded their tap water RBCs in the second sampling event. Although concentrations of manganese exceeded the tap water RBC, they were below the Zone G background value. No background or RBSL was established for thallium. Concentrations of zinc detected during both events exceeded the tap water RBC and Zone G background. No RBSL was established for zinc, the source of which is not known.

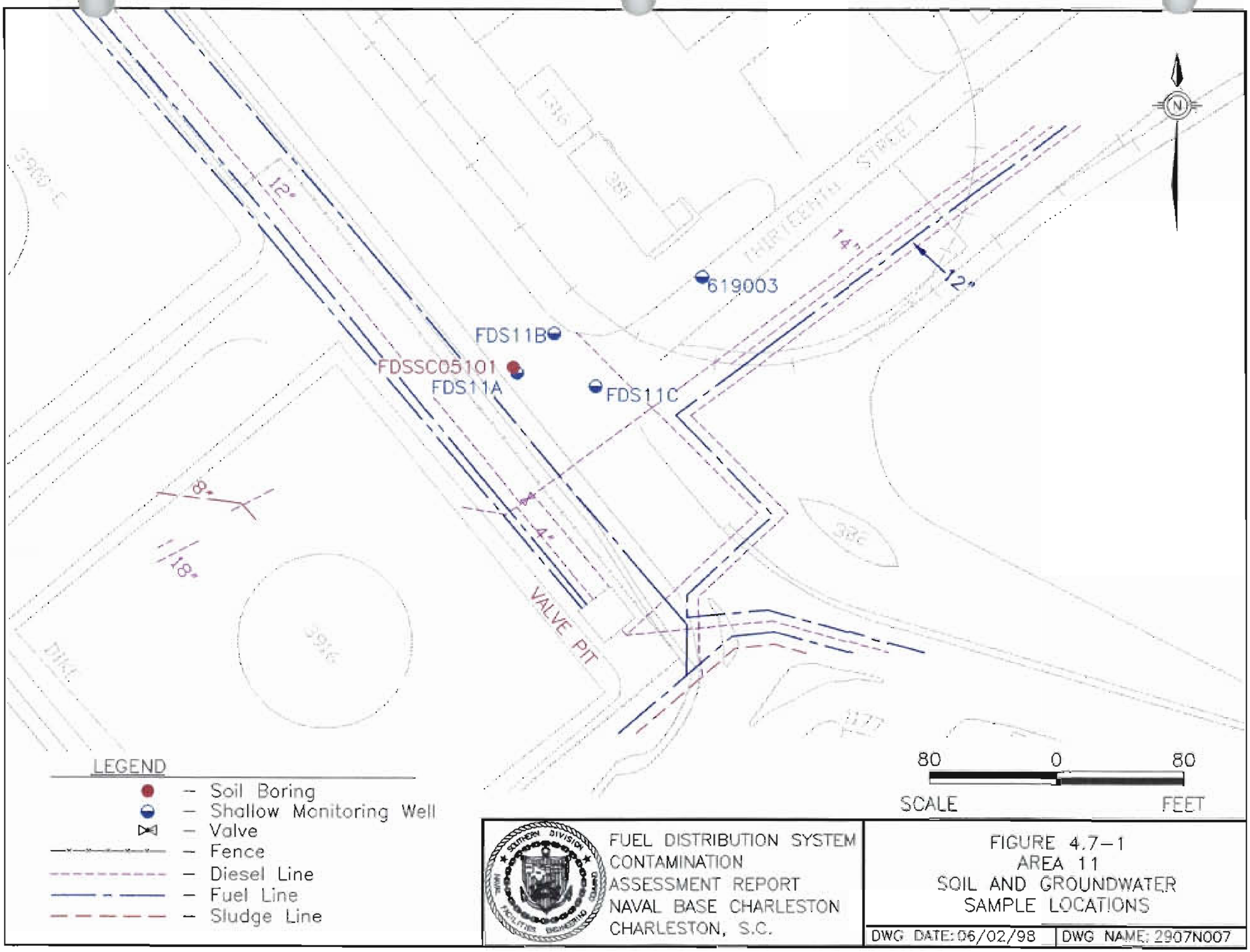
4.7 Area 11

Area 11 is associated with soil sample FDSSC05101 (collected from the 5.7 to 7.4 feet bgs depth interval). This area of potential impact is at the intersection of Thirteenth Street and Hobson Avenue. The Cooper River lies approximately 1,200 feet to the east. To investigate potential petroleum groundwater contamination, three shallow monitoring wells were installed in this area: two on the east side of Hobson Avenue at the intersection with Thirteenth Street, and one on the west side of Hobson Avenue directly across from the intersection. Because of the proximity of shallow well 619003 (AOC 619 investigated during the Zone F RFI), analytical data from this well was included and reviewed relative to this investigation. Figure 4.7-1 presents the soil boring and monitoring well locations for Area 11.

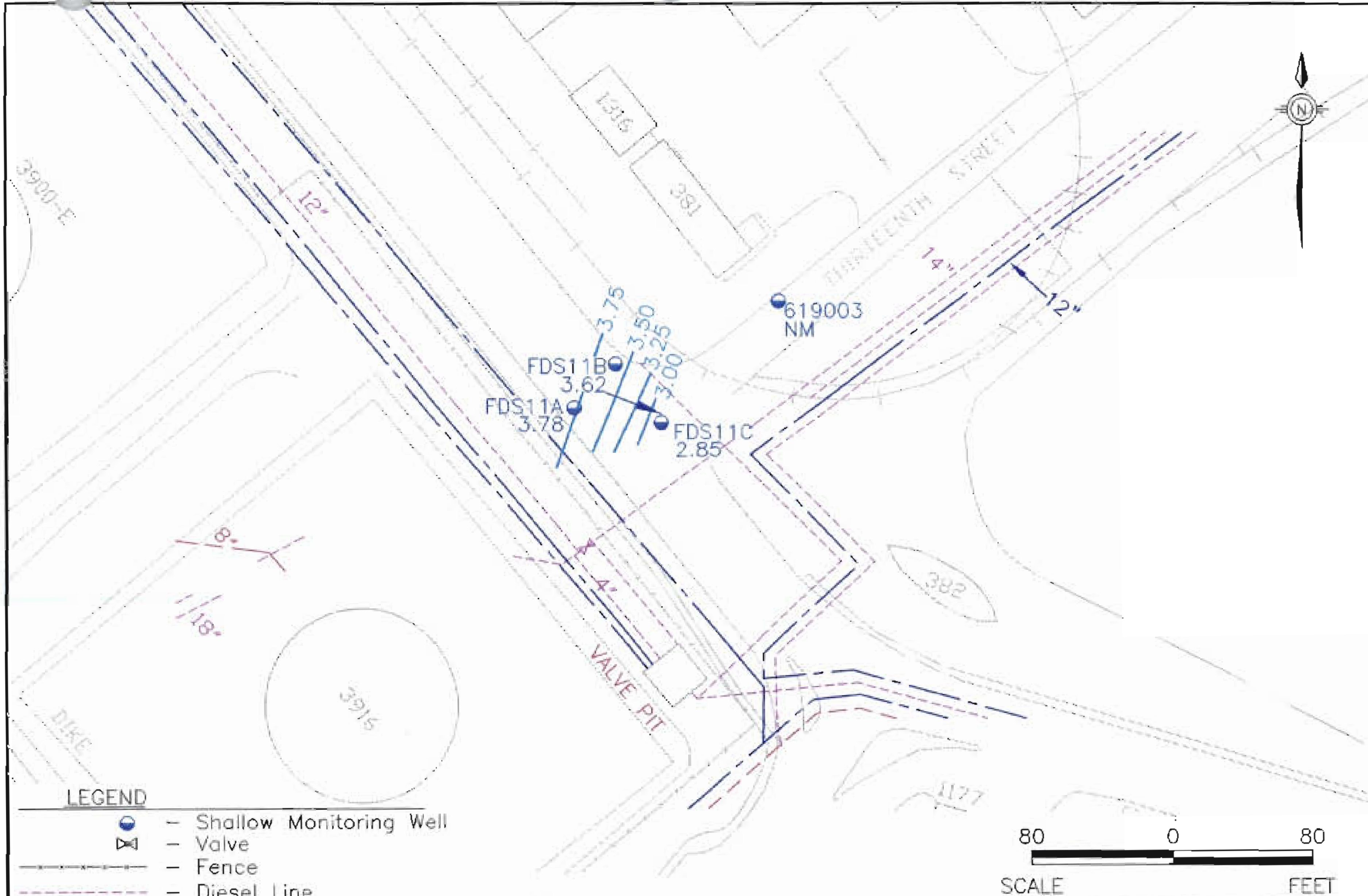
4.7.1 Site Geology and Hydrogeology

Based on well borings advanced at this site, the general stratigraphy at Area 11 is brown to gray to black sand with varying amounts of silt and clay. This soil lies beneath a considerable thickness of asphalt. Petroleum odors were noted in stratigraphic soil samples collected from 5 feet bgs at well borings FDS11A and FDS11B. Appendix B contains boring logs and monitoring well construction diagrams for these wells.

Shallow groundwater at Area 11 generally occurs from 3.8 to 4.25 feet bgs. Figures 4.7-2 and 4.7-3 depict the shallow groundwater potentiometric surface and inferred flow direction for the site during low- and high-tides, respectively. The overall flow direction and gradient were consistent between tidal stages. Tidal variation was less than 0.12 foot. Maximum average calculated groundwater velocity (utilizing the steepest gradient) was 0.018 feet/day based on an average porosity (0.359) and representative hydraulic conductivity (0.37 feet/day) determined during the Zone G RFI (EnSafe, February 1998).



12"
14"
12"
THIRTEENTH STREET
619003
FDS11B
FDSSC05101
FDS11A
FDS11C
8"
18"
4"
VALVE PIT
DIKE
80
0
80
SCALE
FEET
LEGEND
Soil Boring
Shallow Monitoring Well
Valve
Fence
Diesel Line
Fuel Line
Sludge Line
SOUTHERN DIVISION
NAVAL FACILITIES ENGINEERING COMMAND
FUEL DISTRIBUTION SYSTEM
CONTAMINATION
ASSESSMENT REPORT
NAVAL BASE CHARLESTON
CHARLESTON, S.C.
FIGURE 4.7-1
AREA 11
SOIL AND GROUNDWATER
SAMPLE LOCATIONS
DWG DATE: 06/02/98
DWG NAME: 2907N007



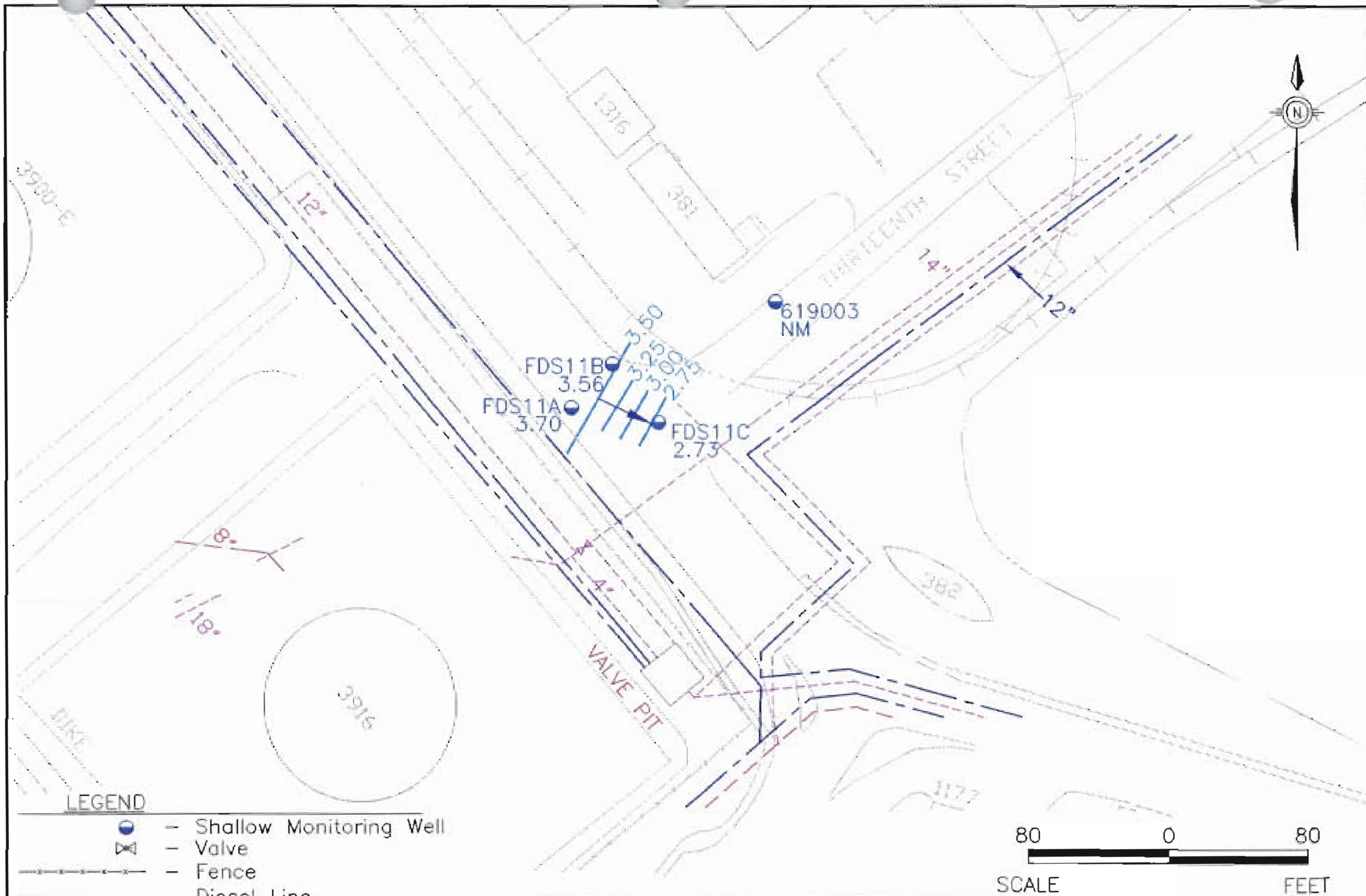
LEGEND

- Shallow Monitoring Well
- Valve
- Fence
- Diesel Line
- Fuel Line
- Sludge Line
- Contour Interval = 0.25 Feet
- Arrow Indicates Flow Direction
- NM – Water Level Not Measured During This Event

FUEL DISTRIBUTION SYSTEM CONTAMINATION ASSESSMENT REPORT
NAVAL BASE CHARLESTON
CHARLESTON, S.C.

FIGURE 4.7-2
AREA 11
SHALLOW GROUNDWATER
LOW-TIDE POTENTIOMETRIC MAP

DWG DATE: 06/30/98 | DWG NAME: 2907N030



FUEL DISTRIBUTION SYSTEM CONTAMINATION ASSESSMENT REPORT
NAVAL BASE CHARLESTON
CHARLESTON, S.C.

FIGURE 4.7–3
AREA 11
SHALLOW GROUNDWATER
HIGH–TIDE POTENTIOMETRIC MAP

DWG DATE: 06/29/98 | DWG NAME: 2907N031

4.7.2 Nature of Contamination in Subsurface Soil

Analytes detected in Area 11 subsurface soil are summarized in Table 4.7.1. Appendix C contains a complete analytical data report for all FDS samples.

TPH-GRO in Subsurface Soil

The Phase I sample results for soil boring FDSSC05101 detected 42.75 μg/kg of TPH-GRO. This value was determined by averaging the primary result (77.6 μg/kg) with the duplicate (7.9 μg/kg). To ensure a conservative investigation, subsequent Phase II soil and groundwater sampling was performed. Nearby soil samples FDSSC03501, FDSSH03001, and FDSSH03101 detected no significant TPH contamination.

Volatile Organic Compounds in Subsurface Soil

No VOCs were detected in subsurface soil at Area 11.

Semivolatile Organic Compounds in Subsurface Soil

Two SVOCs, bis(2-ethylhexyl)phthalate and chrysene, were detected in subsurface soil at FDSSC05101. Chrysene was present at a concentration below its RBSL. No RBSL is available for bis(2-ethyl(hexyl)phthalate. Which was detected at a concentration far below the SSL.

Inorganics in Subsurface Soil

Eighteen metals were detected in subsurface soil at Area 11. No RBSLs are available for metals in soil. All detected metals concentrations were below their SSLs and Zone G background concentrations.

Table 4.7.1
Analytes Detected in Subsurface Soil
Area 11
Fuel Distribution System

Parameters	Location	Subsurface Conc.	RBSL/SSL	Subsurface Background
TPH - GRO (μg/kg)				
Gasoline	FDSSC05101	42.75	NL/NL	NA
Semivolatile Organic Compounds (μg/kg)				
bis(2-Ethylhexyl)phthalate	FDSSC05101	1500	NL/3600000	NA
Chrysene	FDSSC05101	80	12998/160000	NA
Inorganics (mg/kg)				
Aluminum (Al)	FDSSC05101	5690	NL/1000000	23600
Barium (Ba)	FDSSC05101	23.3	NL/1600	64.5
Beryllium (Be)	FDSSC05101	0.24	NL/63	1.63
Cadmium (Cd)	FDSSC05101	0.05	NL/8	0.48
Calcium (Ca)	FDSSC05101	1770	NL/NL	NL
Chromium (Cr)	FDSSC05101	6.1	NL/1000000	43.4[d]
Cobalt (Co)	FDSSC05101	0.67	NL/2000	8.14
Copper (Cu)	FDSSC05101	2.6	NL/920	32.6
Iron (Fe)	FDSSC05101	4300	NL/NL	NL
Lead (Pb)	FDSSC05101	8.8	NL/400	66.3
Magnesium (Mg)	FDSSC05101	269	NL/NL	NL
Manganese (Mn)	FDSSC05101	27.1	NL/1100	291
Mercury (Hg)	FDSSC05101	0.25	NL/2.1	0.31
Nickel (Ni)	FDSSC05101	2.8	NL/130	18.3
Sodium (Na)	FDSSC05101	175	NL/NL	NL
Thallium (Tl)	FDSSC05101	0.41	NL/0.95	0.95
Vanadium (V)	FDSSC05101	15.5	NL/6000	72.5
Zinc (Zn)	FDSSC05101	9.9	NL/12000	145

Notes:

a = Background value for non-clay samples
NL = Not listed
NA = Not applicable
μg/kg = Micrograms per kilogram
mg/kg = Milligrams per kilogram
RBSLs from the *South Carolina Risk-Based Corrective Action for Petroleum Releases* (SCDHEC, January 5, 1998) and soil-to-groundwater SSLs (DAF=20) from the *Soil Screening Guidance: Technical Background Document* (USEPA, 1996b) were used as reference concentrations.
Bolded concentrations exceed RBSL or the SSL (if no RBSL is available).
All background values for Zone G are based on twice the mean of grid sample concentrations.

4.7.3 Nature of Contamination in Shallow Groundwater

Analytes detected in Area 11 groundwater are summarized in Table 4.7.2. No free product was observed in Area 11 monitoring wells. Appendix C contains a complete analytical data report for all FDS samples. Area 11, FDS well data are based on sampling in January and June of 1997. For monitoring well 619003, data are from November 1996 and May 1997 sampling events.

Volatile Organic Compounds in Shallow Groundwater

Two VOCs, chloromethane and toluene, were detected in Area 11 groundwater during the first sampling event only. No VOCs were detected during the second, most recent sampling event. No RBSL is available for chloromethane in groundwater. Chloromethane exceeded its tap water RBC in the first sampling event.

Semivolatile Organic Compounds in Shallow Groundwater

Nine SVOCs, including five PAHs, were detected in Area 11 groundwater samples. No SVOC RBSLs were exceeded. The tap water RBC for aniline was exceeded in the duplicate sample collected from FDS11C during the first sampling event. No RBSL is available for aniline in groundwater. Aniline was not analyzed for during the second sampling event. No other tap water RBCs were exceeded in this event.

Table 4.7.2
Analytes Detected in Shallow Groundwater
Area 11
Fuel Distribution System

Parameters	Location	First Sampling Event	Second Sampling Event	RBSL/Tap Water RBC (µg/L)	Shallow Background
Volatile Organic Compounds (µg/L)					
Chloromethane	619003	**8.0**	ND	NL/1.4	NA
Toluene	FDS11C	1	ND	1000/75	NA
Semivolatile Organic Compounds (µg/L)					
Total PAHs	FDS11A	1	2	25/NL	NA
	619003	13	1		
Acenaphthene	FDS11A	1.0	2.0	10/220	NA
	619003	2.0	ND		
Fluorene	619003	4.0	ND	10/150	NA
2-Methylnaphthalene	619003	3.0	ND	10/150	NA
Naphthalene	619003	2.0	1.0	10/150	NA
Phenanthrene	619003	2.0	ND	10/150	NA
Aniline	FDS11C	5	NT	NL/1	NA
Benzoic Acid	FDS11A	7	ND	NL/15000	NA
	FDS11C	ND	19		
Dibenzofuran	619003	2.0	ND	NL/15	NA
4-Methylphenol (p-Cresol)	FDS11C	ND	2.0	NL/18	NA
	619003	6.0	ND		
Dioxin (pg/L)					
Dioxin (2,3,7,8-TCDD TEQs[1])	FDS11C	0.1694	NT	NL/0.45	NA
Inorganics (µg/L)					
Aluminum (Al)	FDS11A	209	395	NL/3700	692
	FDS11B	174	86.2		
	FDS11C	466	169		
	619003	233	10.3		
Antimony (Sb)	FDS11A	**5.1**	ND	NL/1.5	4.85
	FDS11B	**4.2**	ND		
	FDS11C	**4.0**	ND		
	619003	ND	**4.9**		

Table 4.7.2
Analytes Detected in Shallow Groundwater
Area 11
Fuel Distribution System

Parameters	Location	First Sampling Event	Second Sampling Event	RBSL/Tap Water RBC (μg/L)	Shallow Background
Arsenic (As)	FDS11A	2.9	ND	50/4.5E-02	17.8
	FDS11C	3.2	2.9		
	619003	3.0	8.0		
Barium (Ba)	FDS11A	39.8	27.9	2000/260	31
	FDS11B	68.9	54		
	FDS11C	57.8	51.1		
	619003	92.2	69.2		
Beryllium (Be)	619003	ND	**0.39**	NL/.016	ND
Calcium (Ca)	FDS11A	101000	105000	NL/NL	NL
	FDS11B	93200	84500		
	FDS11C	125500	77800		
	619003	205000	200000		
Chromium (Cr)	FDS11A	0.96	1	100/18	3.88
	FDS11B	0.92	ND		
	FDS11C	1.1	ND		
	619003	1.0	1.5		
Cobalt (Co)	619003	ND	1.4	NL/220	1.45
Cyanide (CN)	FDS11B	3.2	NT	NL/73	3.8
	FDS11C	2.2	NT		
Iron (Fe)	FDS11A	2260	2920	NL/NL	NL
	FDS11B	15800	17300		
	FDS11C	7690	7120		
	619003	32000	17000		
Magnesium (Mg)	FDS11A	34000	28500	NL/NL	NL
	FDS11B	67900	54100		
	FDS11C	191500	99650		
	619003	356000	497000		
Manganese (Mn)	FDS11A	**300**	**348**	NL/84	2,906
	FDS11B	**913**	**814**		
	FDS11C	**527**	**500**		
	619003	**1420**	**702**		
Mercury (Hg)	FDS11C	ND	0.11	2/1.1	ND
Nickel (Ni)	FDS11A	0.96	ND	NL/73	4.08
	FDS11B	3	ND		
	FDS11C	1	ND		
	619003	ND	1.5		

Table 4.7.2
Analytes Detected in Shallow Groundwater
Area 11
Fuel Distribution System

Parameters	Location	First Sampling Event	Second Sampling Event	RBSL/Tap Water RBC (µg/L)	Shallow Background
Potassium (K)	FDS11A	27300	18300	NL/NL	NL
	FDS11B	38200	31200		
	FDS11C	54050	39650		
	619003	163000	158000		
Sodium (Na)	FDS11A	380000	185000	NL/NL	NL
	FDS11B	587000	433000		
	FDS11C	908000	1030000		
	619003	3840000	4600000		
Thallium (Tl)	619003	**6.6**	ND	NL/0.29	ND
Tin (Sn)	FDS11C	3.3	ND	NL/2200	ND
Vanadium (V)	FDS11A	0.67	ND	NL/26	15.4
	FDS11B	ND	ND		
	FDS11C	0.67	ND		
	619003	ND	7.5		

Notes:
1 = Calculated from methods described in USEPA Interim *Supplemental Guidance to RAGS: Human Health Risk Assessment*, Bulletin 2 (USEPA, 1995).
NL = Not listed
NA = Not applicable
ND = Not detected
NT = Not taken
µg/L = Micrograms per liter
pg/L = Picograms per liter
RBSLs from the *South Carolina Risk-Based Corrective Action for Petroleum Releases* (SCDHEC, January 5, 1998) and tap water RBCs (THQ=0.1) from *Risk Based Concentration Table* (USEPA, October 22, 1997) were used as reference concentrations.
Bolded concentrations exceed RBSL or the tap water RBC (if no RBSL is available).
All background values for Zone G are based on twice the mean of grid sample concentrations. Background values for groundwater are based on two sampling rounds in two wells at each depth.

Dioxins in Shallow Groundwater

Dioxin (2,3,7,8-TCDD TEQ) was detected in Area 11 groundwater during the first sampling event in the duplicate sample from well FDS11C. This analyte was detected at a concentration far below the tap water RBC.

Inorganics in Shallow Groundwater

Eighteen metals plus cyanide were detected in Area 11 groundwater samples. No RBSLs for metals were exceeded in shallow groundwater at Area 11. Antimony, beryllium, and manganese exceeded their tap water RBCs during the second sampling event. Antimony was detected exceeding its tap water RBC in the three Area 11 wells during the initial sampling event, but not in these same wells during the second event. Well 619003 exhibited elevated antimony during the second event. All antimony concentrations were below or very near the Zone G background, suggesting these are ambient concentrations. Beryllium was also detected in 619003 above its tap water RBC. No background was established for beryllium in Zone G. Although concentrations of manganese exceeded the tap water RBC, all concentrations were below the Zone G background value. Thallium exceeded the tap water RBC during the first sampling event from well 619003, but was not detected in the second sampling event. No background value was established for thallium.

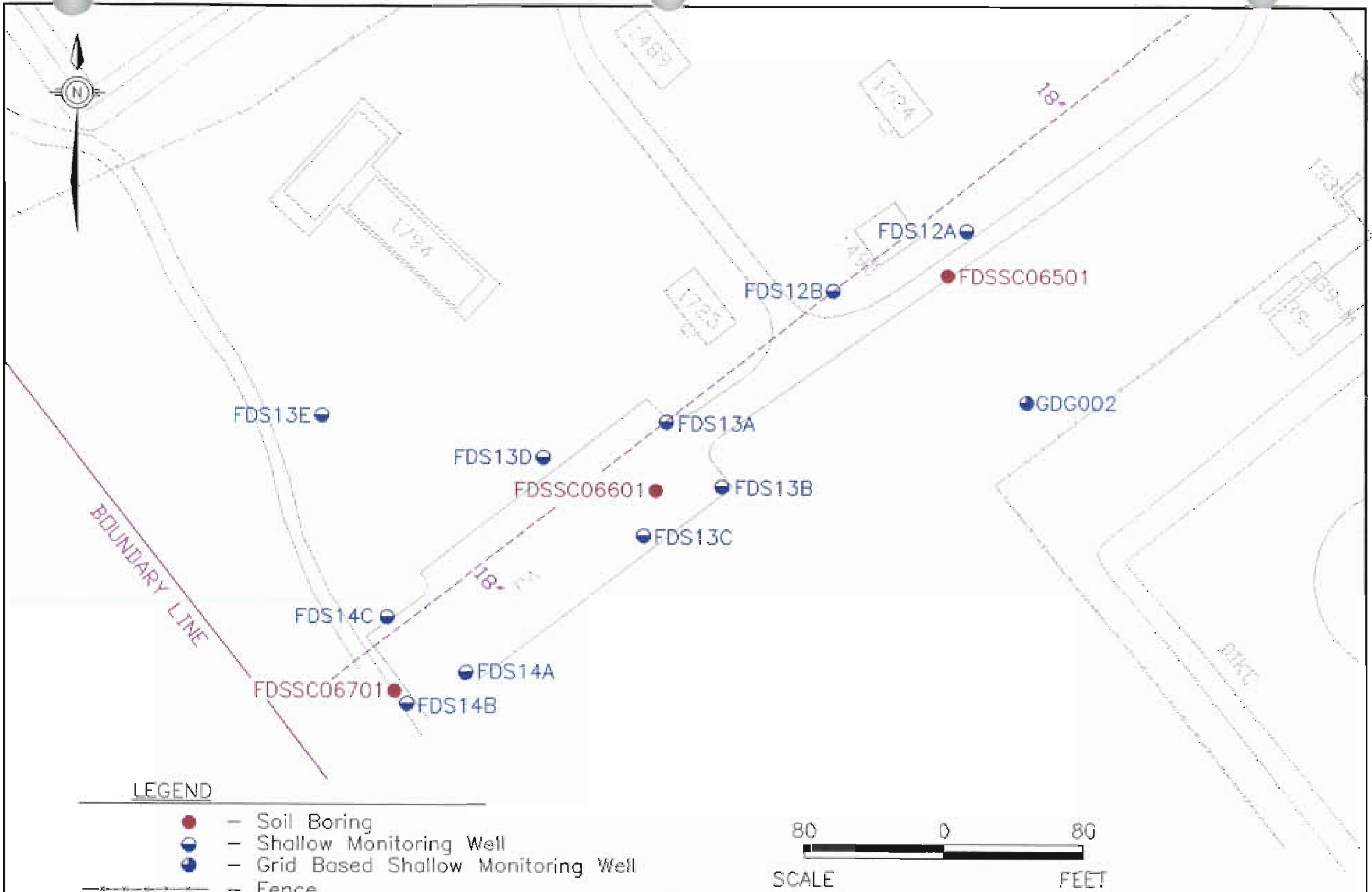
4.8 Areas 12, 13, and 14

Areas 12, 13, and 14 are associated with soil samples FDSSC06501 (collected from the 6.3 to 10.6 feet bgs depth interval), FDSSC06601 (collected from the 8.5 to 10.5 feet bgs depth interval), and FDSSC06701 (collected from the 8.5 to 10.5 feet bgs depth interval), respectively. These areas of potential impact, were grouped together for discussion due to their proximity. They are located in the NAVBASE Recreation Area, near the west boundary fence. The Cooper River lies approximately 2,000 feet to the east. To investigate potential groundwater petroleum contamination, 10 shallow monitoring wells were installed in the combined area. Because of the proximity of shallow grid-well GDG002 (investigated during the Zone G RFI), situated approximately 100 feet southeast of Areas 12, 13, and 14, analytical data from this well were included and reviewed relative to this investigation. Figure 4.8-1 presents the soil boring and monitoring well locations for Areas 12, 13, and 14.

4.8.1 Site Geology and Hydrogeology

Based on well borings advanced at this site, the general stratigraphy at Areas 12, 13, and 14 is brown to gray silty, clayey, and sandy soil to a depth of approximately 4 feet bgs, overlying alternating intervals of brown to gray silt, sand, and organic clay to a depth of approximately 17 feet bgs. Petroleum odors were noted in stratigraphic soil samples collected from 5 feet bgs at boring FDS12A. Appendix B contains boring logs and monitoring well construction diagrams for these wells.

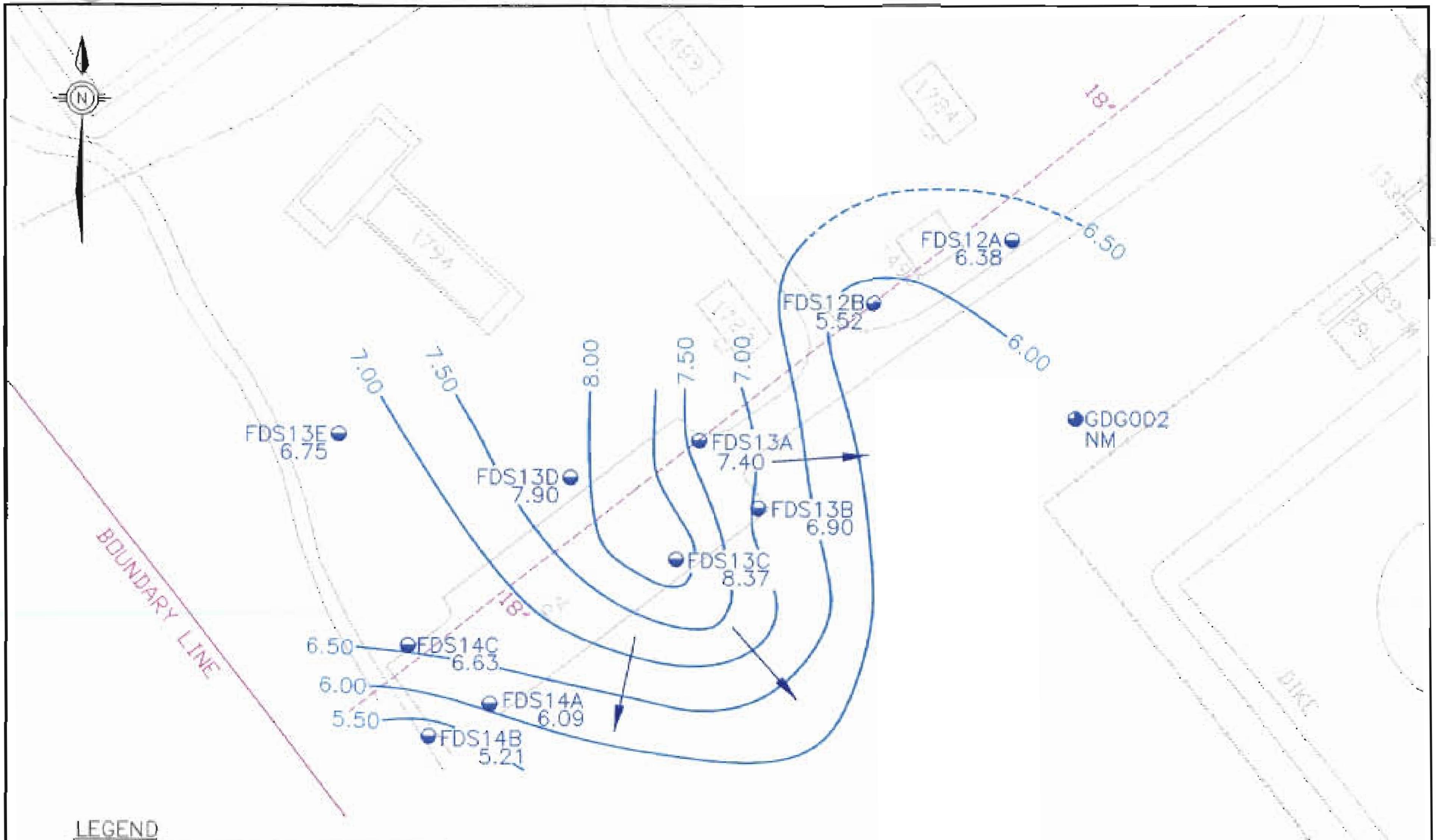
Shallow groundwater at Areas 12, 13, and 14 occurs from 1.18 to 3.48 feet bgs. Figures 4.8-2 and 4.8-3 depict the shallow groundwater potentiometric surface and inferred flow direction for the site during low- and high-tide respectively. Shallow groundwater flow direction and gradient were consistent between tidal stages. Tidal variation ranges from 0.00 to 0.12 feet. Maximum average calculated groundwater velocity (utilizing the steepest gradient) was 0.015 feet/day based on an average porosity (0.359) and representative hydraulic conductivity (0.32 feet/day) determined during the Zone G RFI (EnSafe, February 1998).



FUEL DISTRIBUTION SYSTEM
CONTAMINATION
ASSESSMENT REPORT
NAVAL BASE CHARLESTON
CHARLESTON, S.C.

FIGURE 4.8-1
AREAS 12, 13, AND 14
SOIL AND GROUNDWATER
SAMPLE LOCATIONS

DWG DATE: 05/28/98 | DWG NAME: 2907N008



LEGEND

- Shallow Monitoring Well
- Grid Based Shallow Monitoring Well
- Fence
- Diesel Line
- Contour Interval = 0.5 Feet
- Arrow Indicates Flow Direction

NM – Water Level Not Measured During This Event

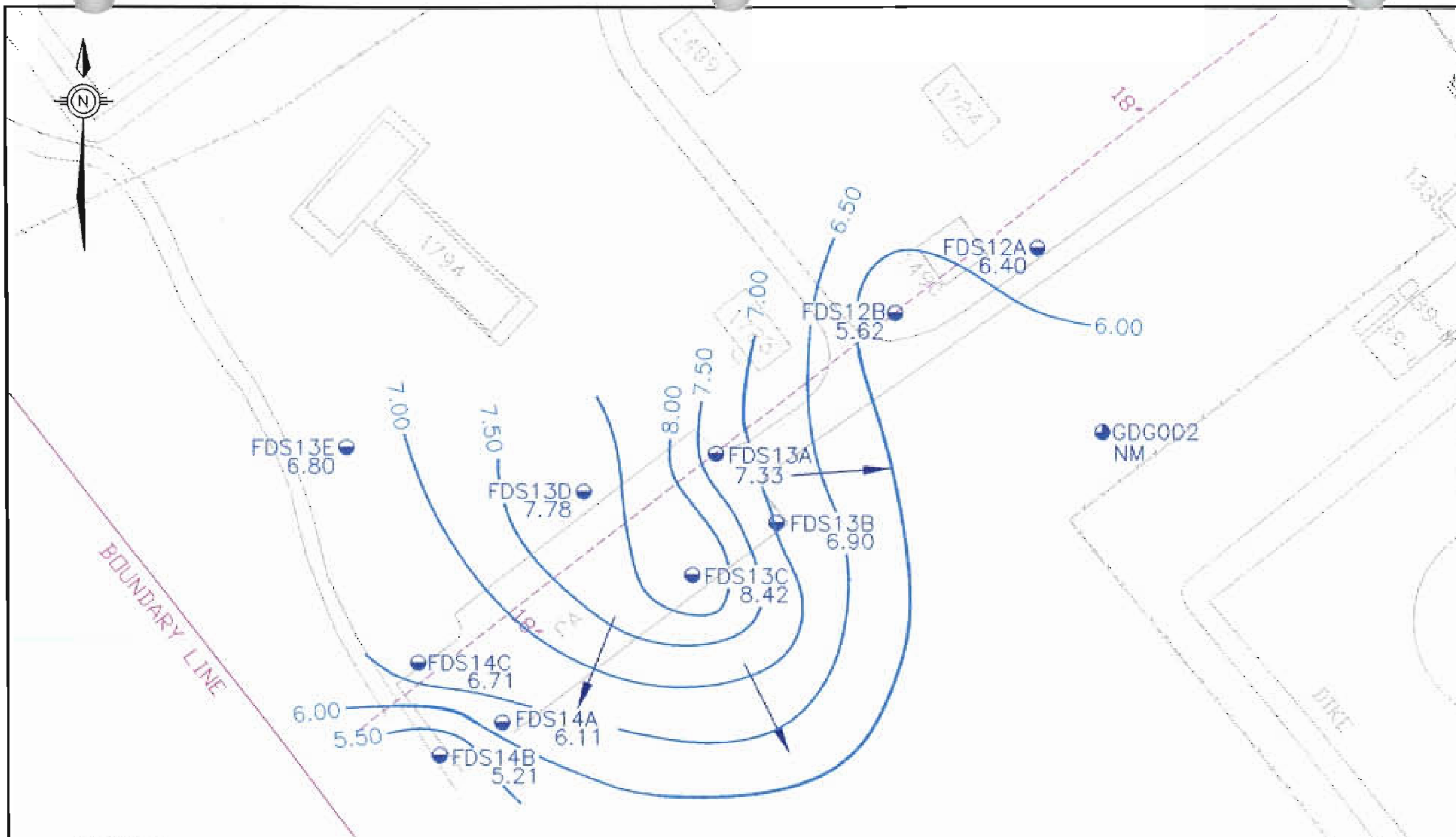
80 0 80

SCALE FEET

FUEL DISTRIBUTION SYSTEM
CONTAMINATION
ASSESSMENT REPORT
NAVAL BASE CHARLESTON
CHARLESTON, S.C.

FIGURE 4.8-2
AREAS 12, 13, AND 14
SHALLOW GROUNDWATER
LOW-TIDE POTENTIOMETRIC MAP

DWG DATE: 07/06/98 | DWG NAME: 2907N042



LEGEND

◒	–	Shallow Monitoring Well
◕	–	Grid Based Shallow Monitoring Well
—x—x—x—	–	Fence
- - - - -	–	Diesel Line
———	–	Contour Interval = 0.5 Feet
◄——	–	Arrow Indicates Flow Direction
NM	–	Water Level Not Measured During This Event

80 0 80

SCALE FEET

FUEL DISTRIBUTION SYSTEM
CONTAMINATION
ASSESSMENT REPORT
NAVAL BASE CHARLESTON
CHARLESTON, S.C.

FIGURE 4.8-3
AREAS 12, 13, AND 14
SHALLOW GROUNDWATER
HIGH-TIDE POTENTIOMETRIC MAP

DWG DATE: 07/06/98 | DWG NAME: 2907N043

4.8.2 Nature of Contamination in Subsurface Soil

Analytes detected in the combined area subsurface soil samples are summarized in Table 4.8.1. Appendix C contains a complete analytical data report for all FDS samples.

TPH-GRO in Subsurface Soil

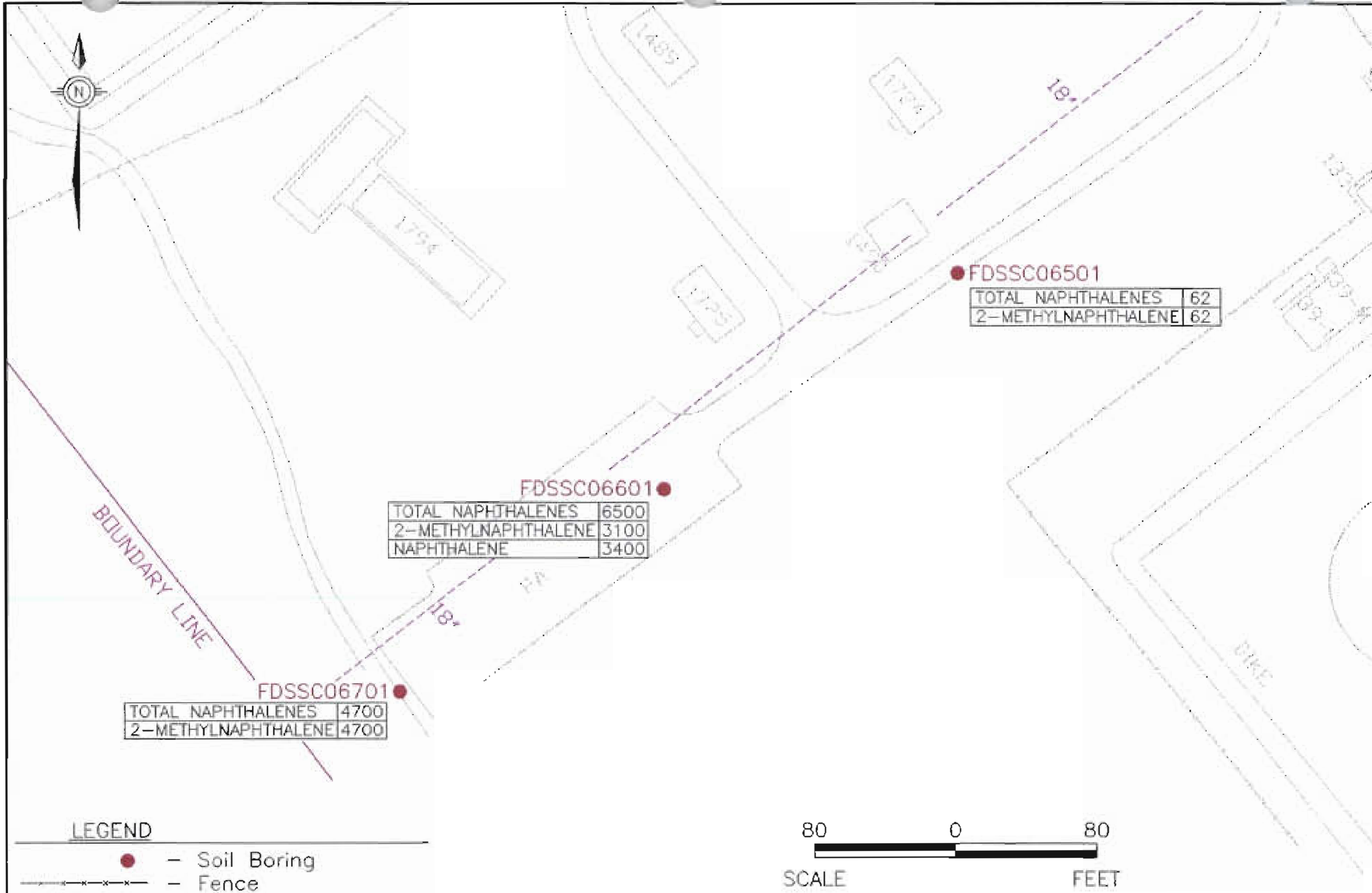
The Phase I sample results for soil borings FDSSC06501, FDSSC06601, and FDSSC06701 exhibited TPH-GRO of 147 μg/kg, 67 μg/kg, and 106 μg/kg, respectively, prompting subsequent Phase II soil and groundwater sampling. Nearby samples FDSSC06801, FDSSH01201, FDSSH01301, and FDSSH01401 identified no significant TPH contamination.

Volatile Organic Compounds in Subsurface Soil

Carbon disulfide, toluene and xylene were the only VOCs detected in subsurface soil at the combined areas. All concentrations were far below their RBSLs or SSLs, if no RBSL was available.

Semivolatile Organic Compounds in Subsurface Soil

Eighteen SVOCs were detected in subsurface soil at Areas 12, 13, and 14. The RBSL for total naphthalenes (210 μg/kg) was exceeded at FDCSC06601 and FDSSC06701. The total naphthalene concentration at FDSSC06601 (6,500 μg/kg) was derived by summing the concentrations for 2-methylnaphthalene (3,100 μg/kg) and naphthalene (3,400 μg/kg) at this location. Total naphthalene at FDSSC06701 (4,700 μg/kg) represents only the 2-methylnaphthalene concentration. All other SVOC concentrations were far below their RBSLs or SSLs if no RBSLs were available. Figure 4.8-4 presents the distribution of naphthalenes in soil at the combined area.



LEGEND

- ● – Soil Boring
- –x–x–x– – Fence
- - - - - – Diesel Line

All Concentrations in ug/kg
Soil RBSL for Total Naphthalenes=210 ug/kg
(SCDHEC January 5, 1998)

FUEL DISTRIBUTION SYSTEM CONTAMINATION ASSESSMENT REPORT
NAVAL BASE CHARLESTON
CHARLESTON, S.C.

FIGURE 4.8-4
AREAS 12, 13, AND 14
NAPHTHALENES IN SOIL

DWG DATE: 06/02/98 | DWG NAME: 2907N024

Table 4.8.1
Analytes Detected in Subsurface Soil
Areas 12, 13, & 14
Fuel Distribution System

Parameters	Location	Subsurface Conc.	RBSL/SSL	Subsurface Background
TPH - GRO (μg/kg)				
Gasoline	FDSSC06501	147	NL/NL	NA
	FDSSC06601	67		
	FDSSC06701	106		
Volatile Organic Compounds (μg/kg)				
Carbon disulfide	FDSSC06601	2	NL/32000	NA
	FDSSC06701	1		
Toluene	FDSSC06501	47	1622/12000	NA
	FDSSC06601	4		
	FDSSC06701	12		
Xylene (Total)	FDSSC06601	45	42471/148000	NA
	FDSSC06701	3		
Semivolatile Organic Compounds (μg/kg)				
Total Naphthalenes	FDSSC06501	62	210/84000	NA
	FDSSC06601	**6500**		
	FDSSC06701	**4700**		
2-Methylnaphthalene	FDSSC06501	62	NL/126000	NA
	FDSSC06601	3100		
	FDSSC06701	4700		
Naphthalene	FDSSC06601	3400	NL/84000	NA
Acenaphthlene	FDSSC06501	130	NL/570000	NA
	FDSSC06601	3000		
	FDSSC06701	1400		
Anthracene	FDSSC06501	110	NL/12000000	NA
	FDSSC06601	3900		
	FDSSC06701	1450		
Benzo(a)anthracene	FDSSC06501	86	73084/2000	NA
	FDSSC06601	1800		
	FDSSC06701	1355		
Benzo(b)fluoranthene	FDSSC06501	72	29097/5000	NA
	FDSSC06601	630		
	FDSSC06701	615		
Benzo(k)fluoranthene	FDSSC06601	710	231109/49000	NA
	FDSSC06701	670		
Benzo(a)pyrene	FDSSC06601	930	NL/8000	NA
	FDSSC06701	935		
Benzo(g,h,i)perylene	FDSSC06601	550	NL/4.66E+08	NA
	FDSSC06701	655		
Chrysene	FDSSC06501	70	12998/160000	NA
	FDSSC06601	2000		
	FDSSC06701	1510		
Dibenz(a,h)anthracene	FDSSC06601	120	87866/2000	NA
	FDSSC06701	170		
Dibenzofuran	FDSSC06601	2700	NL/50000	NA
	FDSSC06701	1085		
Di-n-octyl phthalate	FDSSC06701	45	NL/10000000	NA

Table 4.8.1
Analytes Detected in Subsurface Soil
Areas 12, 13, & 14
Fuel Distribution System

Parameters	Location	Subsurface Conc.	RBSL/SSL	Subsurface Background
Fluoranthene	FDSSC06501	120	NL/4300000	NA
	FDSSC06601	6000		
	FDSSC06701	2700		
Fluorene	FDSSC06501	140	NL/560000	NA
	FDSSC06601	4400		
	FDSSC06701	2000		
Indeno(1,2,3-cd)pyrene	FDSSC06601	460	NL/14000	NA
	FDSSC06701	460		
Phenanthrene	FDSSC06501	240	NL/1380000	NA
	FDSSC06601	15000		
	FDSSC06701	6150		
Pyrene	FDSSC06501	290	NL/4200000	NA
	FDSSC06601	5300		
	FDSSC06701	3700		
Dioxin (ng/kg)				
Dioxin(2,3,4,8-TCDD TEQs[1])	FDSSC06701	0.0847	NL/1900	NA
Inorganics (mg/kg)				
Aluminum (Al)	FDSSC06501	28400	NL/1000000	23600
	FDSSC06601	15400		
	FDSSC06701	12050		
Antimony (Sb)	FDSSC06501	.51	NL/5	ND
Arsenic (As)	FDSSC06501	17	NL/29	15.5[a]
	FDSSC06601	10.2		
	FDSSC06701	10.35		
Barium (Ba)	FDSSC06501	40.6	NL/1600	64.5
	FDSSC06601	33.9		
	FDSSC06701	25.65		
Beryllium (Be)	FDSSC06501	1.3	NL/63	1.63
	FDSSC06601	.76		
	FDSSC06701	.62		
Calcium (Ca)	FDSSC06501	14500	NL/NL	NL
	FDSSC06601	40000		
	FDSSC06701	24100		
Chromium (Cr)	FDSSC06501	42.9	NL/1000000	43.4[a]
	FDSSC06601	28.7		
	FDSSC06701	24.55		
Cobalt (Co)	FDSSC06501	6.3	NL/2000	8.14
	FDSSC06601	3.4		
	FDSSC06701	3.1		
Copper (Cu)	FDSSC06501	24.8	NL/920	32.6
	FDSSC06601	18.5		
	FDSSC06701	14.25		
Iron (Fe)	FDSSC06501	30700	NL/NL	NL
	FDSSC06601	17800		
	FDSSC06701	23900		
Lead (Pb)	FDSSC06501	42.9	NL/400	66.3
	FDSSC06601	28.2		
	FDSSC06701	27.6		

Table 4.8.1
Analytes Detected in Subsurface Soil
Areas 12, 13, & 14
Fuel Distribution System

Parameters	Location	Subsurface Conc.	RBSL/SSL	Subsurface Background
Magnesium (Mg)	FDSSC06501	4840	NL/NL	NL
	FDSSC06601	6460		
	FDSSC06701	2585		
Manganese (Mn)	FDSSC06501	582	NL/1100	291
	FDSSC06601	163		
	FDSSC06701	238.5		
Mercury (Hg)	FDSSC06501	.22	NL/2.1	0.31
	FDSSC06601	.2		
	FDSSC06701	.175		
Nickel (Ni)	FDSSC06501	13.9	NL/130	18.3
	FDSSC06601	10.1		
	FDSSC06701	8.15		
Potassium (K)	FDSSC06501	2580	NL/NL	NL
	FDSSC06601	2260		
	FDSSC06701	1455		
Selenium (Se)	FDSSC06501	1.1	NL/5	1.26
	FDSSC06701	.87		
Sodium (Na)	FDSSC06601	5770	NL/NL	NL
	FDSSC06701	2340		
Thallium (Tl)	FDSSC06501	.57	NL/0.95	0.95
Vanadium (V)	FDSSC06501	69.1	NL/6000	72.5
	FDSSC06601	30.2		
	FDSSC06701	34.8		
Zinc (Zn)	FDSSC06501	97	NL/12000	145
	FDSSC06601	69		
	FDSSC06701	58.55		

Notes:

1 = Calculated from methods described in USEPA Interim *Supplemental Guidance to RAGS: Human Health Risk Assessment*, Bulletin 2 (USEPA, 1995).
a = Background value for non-clay samples
NL = Not listed
NA = Not applicable
μg/kg = Micrograms per kilogram
mg/kg = Milligrams per kilogram
ng/kg = Nanograms per kilogram

RBSLs from the *South Carolina Risk-Based Corrective Action for Petroleum Releases* (SCDHEC, January 5, 1998) and soil-to-groundwater SSLs (DAF=20) from the *Soil Screening Guidance: Technical Background Document* (USEPA, 1996b) were used as reference concentrations.
Bolded concentrations exceed RBSL or the SSL (if no RBSL is available)
All background values for Zone G are based on twice the mean of grid sample concentrations.

Dioxins in Subsurface Soil

Dioxin (2,3,7,8-TCDD TEQ) was detected in subsurface soil at Areas 12, 13, and 14. The detection was at FDSSC06701, at a concentration far below its SSL. No RBSL is available for dioxin in soil.

Inorganics in Subsurface Soil

Twenty-one metals were detected in subsurface soil at Areas 12, 13, and 14. No soil RBSLs are available for inorganics. All detected metals concentrations were below their SSLs. Concentrations of aluminum and manganese exceeded the Zone G background concentrations.

4.8.3 Nature of Contamination in Shallow Groundwater

Analytes detected in Areas 12, 13, and 14 groundwater are summarized in Table 4.8.2. No free product was observed in the combined area wells. Appendix C contains a complete analytical data report for all FDS samples. FDS well data are based on sampling events in January and June of 1997. For monitoring well GDG002, data are from November 1996 and June 1997 sampling events.

Volatile Organic Compounds in Shallow Groundwater

No VOCs were detected in Areas 12, 13, and 14 groundwater.

Semivolatile Organic Compounds in Shallow Groundwater

Three SVOCs, 2-methylnaphthalene, 4-nitrophenol, and benzoic acid, were detected in groundwater at concentrations below their RBSLs or if unavailable tap water RBCs. Total PAHs were below the RBSL of 25 μg/L.

Table 4.8.2
Analytes Detected in Shallow Groundwater
Areas 12, 13, & 14
Fuel Distribution System

Parameters	Location	First Sampling Event	Second Sampling Event	RBSL/Tap Water RBC (μg/L)	Shallow Background
Semivolatile Organic Compounds (μg/L)					
Total PAHs	FDS13A	1	5	25/NL	NA
2-Methylnaphthalene	FDS13A	1	5	10/150	NA
4-Nitrophenol	FDS14A	ND	1	NL/230	NA
Benzoic acid	FDS13A	2	ND	NL/15000	NA
	FDS13B	2	ND		
	FDS14A	ND	2		
	FDS14B	ND	1		
Inorganics (μg/L)					
Aluminum (Al)	FDS12A	514	288	NL/3700	692
	FDS12B	ND	213		
	FDS13A	1360	692		
	FDS13B	787	74.4		
	FDS13C	1730	1600		
	FDS13D	1850	2820		
	FDS13E	215	1290		
	FDS14A	ND	2940		
	FDS14B	ND	201		
	FDS14C	738	250		
	GDG002	176	ND		
Antimony (Sb)	FDS13E	**3.4**	ND	NL/1.5	4.85
	GDG002	ND	**3.8**		
Arsenic (As)	FDS12A	6.55	22.95	50/0.045	17.8
	FDS12B	28	49.3		
	FDS13A	27	**210**		
	FDS13B	5.2	16.8		
	FDS13C	3.9	6		
	FDS13D	ND	16.7		
	FDS13E	22.5	29.9		
	FDS14A	**50.3**	21 8		
	FDS14B	6.9	22.5		
	FDS14C	14	24.9		
	GDG002	7.8	10		
Barium (Ba)	FDS12A	268	196.5	2000/260	31
	FDS12B	78.9	70.4		
	FDS13A	138	28.1		
	FDS13B	144	29.8		
	FDS13C	27.3	17		
	FDS13D	35.6	31.9		
	FDS13E	32.9	30.4		
	FDS14A	45.2	59.6		
	FDS14B	52	46.2		
	FDS14C	51.5	33.1		
	GDG002	13.6	17.4		
Beryllium (Be)	FDS13B	**.45**	ND	NL/0 016	ND
	FDS13C	**.53**	ND		
	FDS14C	**.64**	ND		

Table 4.8.2
Analytes Detected in Shallow Groundwater
Areas 12, 13, & 14
Fuel Distribution System

Parameters	Location	First Sampling Event	Second Sampling Event	RBSL/Tap Water RBC (μg/L)	Shallow Background
Cadmium (Cd)	FDS12A	ND	.46	5/1.8	0.53
	FDS12B	ND	.52		
	FDS13A	ND	.44		
	FDS13C	ND	.68		
	FDS14A	ND	.31		
	FDS14B	ND	.41		
	GDG002	ND	.4		
Calcium (Ca)	FDS12A	274500	215500	NL/NL	NL
	FDS12B	172000	160000		
	FDS13A	161000	155000		
	FDS13B	197000	185000		
	FDS13C	69800	49400		
	FDS13D	8930	3580		
	FDS13E	155000	161000		
	FDS14A	177000	137000		
	FDS14B	127000	137000		
	FDS14C	201000	151000		
	GDG002	91400	90700		
Chromium (Cr)	FDS12A	1.2	ND	100/18	3.88
	FDS12B	.82	ND		
	FDS13A	4.2	1.9		
	FDS13B	2.6	1.9		
	FDS13C	1 3	2.9		
	FDS13D	3.6	5.3		
	FDS13E	ND	3.3		
	FDS14A	2	9.6		
	FDS14B	4.3	2.8		
	FDS14C	1.4	2.4		
Cobalt (Co)	FDS12A	17.85	18.7	NL/220	1.45
	FDS12B	31	29.6		
	FDS13A	4.1	ND		
	FDS13B	3.1	1.9		
	FDS13C	29	23.4		
	FDS13D	3.4	1.4		
	FDS14A	1.9	2.1		
	FDS14B	3	1.6		
	FDS14C	1.6	.98		
Copper (Cu)	FDS13A	5.2	ND	NL/13000	8.33
	FDS13B	ND	2.2		
	FDS13D	ND	1.8		
	FDS14A	ND	3.7		
	FDS14B	3.8	ND		
	FDS14C	5	ND		
Cyanide (CN)	FDS13E	2.6	NT	NL/73	3.8
	FDS14B	2.2	NT		
	FDS14C	8.4	NT		

Table 4.8.2
Analytes Detected in Shallow Groundwater
Areas 12, 13, & 14
Fuel Distribution System

Parameters	Location	First Sampling Event	Second Sampling Event	RBSL/Tap Water RBC (μg/L)	Shallow Background
Iron (Fe)	FDS12A	10800	19850	NL/NL	NL
	FDS12B	18500	32200		
	FDS13A	14700	37200		
	FDS13B	2110	9150		
	FDS13C	73800	64500		
	FDS13D	4640	8280		
	FDS13E	10700	19000		
	FDS14A	20100	15600		
	FDS14B	4240	25600		
	FDS14C	2830	4930		
	GDG002	28200	35700		
Lead (Pb)	FDS13A	ND	1	15/15	4.6
	FDS13D	ND	1.9		
	FDS13E	ND	1.3		
	FDS14A	ND	3.5		
Magnesium (Mg)	FDS12A	58000	53400	NL/NL	NL
	FDS12B	106000	112000		
	FDS13A	203000	75700		
	FDS13B	428000	214000		
	FDS13C	153000	113000		
	FDS13D	6130	2730		
	FDS13E	131000	137000		
	FDS14A	257000	281000		
	FDS14B	266000	217000		
	FDS14C	170000	197000		
	GDG002	100000	81000		
Manganese (Mn)	FDS12A	**3650**	**3180**	NL/84	2906
	FDS12B	**3370**	**3240**		
	FDS13A	**1370**	**2480**		
	FDS13B	**286**	**292**		
	FDS13C	**1680**	**1300**		
	FDS13D	**163**	73.7		
	FDS13E	**1540**	**1660**		
	FDS14A	**607**	**354**		
	FDS14B	**329**	**405**		
	FDS14C	**3360**	**1510**		
	GDG002	**2630**	**2820**		
Nickel (Ni)	FDS12A	9.2	4.85	NL/73	4.08
	FDS12B	9.6	6.2		
	FDS13A	11	ND		
	FDS13B	7 7	4		
	FDS13C	10.5	7.9		
	FDS13D	4.8	2.2		
	FDS13E	.94	82		
	FDS14A	ND	4 8		
	FDS14B	7.7	1.4		
	FDS14C	ND	2.3		
	GDG002	2	ND		

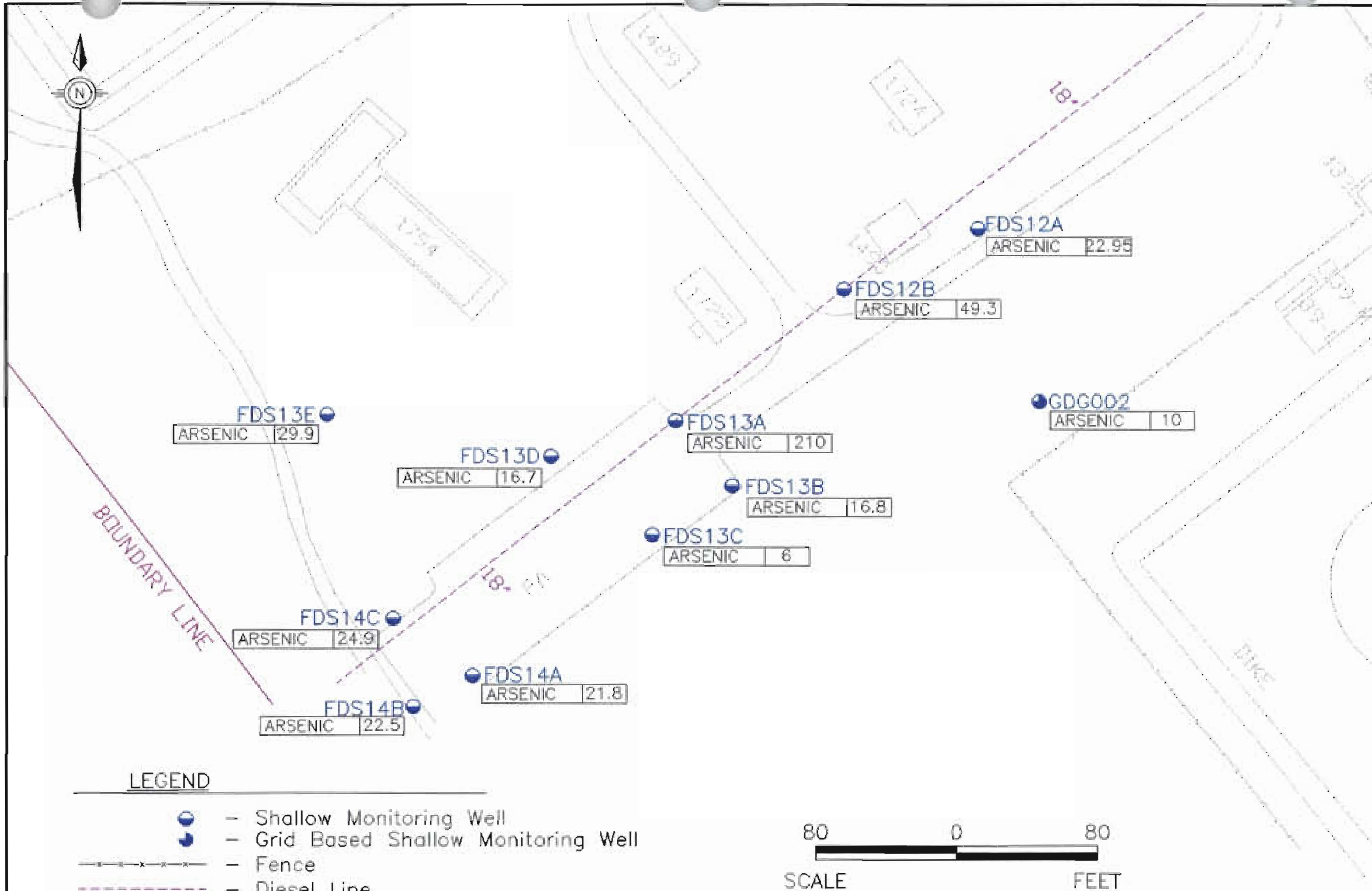
Table 4.8.2
Analytes Detected in Shallow Groundwater
Areas 12, 13, & 14
Fuel Distribution System

Parameters	Location	First Sampling Event	Second Sampling Event	RBSL/Tap Water RBC (μg/L)	Shallow Background
Potassium (K)	FDS12A	7140	5935	NL/NL	NL
	FDS12B	41200	43900		
	FDS13A	75200	42100		
	FDS13B	123000	86500		
	FDS13C	40300	30300		
	FDS13D	3610	2910		
	FDS13E	57400	67000		
	FDS14A	91500	109000		
	FDS14B	90000	81600		
	FDS14C	63100	94300		
	GDG002	46400	49800		
Selenium (Se)	GDG002	ND	4.1	50/18	4.3
Silver (Ag)	GDG002	1.7	ND	5/18	1.65
Sodium (Na)	FDS12A	427000	388000	NL/NL	NL
	FDS12B	876000	1010000		
	FDS13A	1850000	425000		
	FDS13B	3860000	2080000		
	FDS13C	1620000	1260000		
	FDS13D	163000	104000		
	FDS13E	538000	795000		
	FDS14A	1970000	2510000		
	FDS14B	2240000	2020000		
	FDS14C	1030000	1750000		
	GDG002	694000	576000		
Thallium (Tl)	FDS12A	4.5	ND	NL/0.29	ND
	FDS12B	3.2	ND		
	FDS13A	5.7	ND		
	FDS13B	7.1	ND		
	FDS13D	4.2	ND		
	FDS14A	3.5	ND		
	FDS14B	3.2	ND		
	FDS14C	5.3	ND		
Vanadium (V)	FDS12A	1.35	ND	NL/26	15.4
	FDS13A	4.7	5.1		
	FDS13B	9.1	20.5		
	FDS13C	1.6	2.9		
	FDS13D	3.7	6.1		
	FDS13E	3.7	5.3		
	FDS14A	5	20.2		
	FDS14B	8.4	13.2		
	FDS14C	5.4	17.3		
	GDG002	2.7	3.1		
Zinc (Zn)	FDS12A	ND	8.4	NL/1100	15.6
	FDS12B	ND	16.3		
	FDS13A	ND	7.8		
	FDS13C	ND	21.7		
	FDS13D	ND	12.9		
	FDS14A	ND	10.4		

Notes:
NL = Not listed
NA = Not applicable
ND = Not detected
NT = Not taken
μg/L = Micrograms per liter
RBSLs from the *South Carolina Risk-Based Corrective Action for Petroleum Releases* (SCDHEC, January 5, 1998) and tap water RBCs (THQ=0.1) from *Risk Based Concentration Table* (USEPA, October 22, 1997) were used as reference concentrations.
Bolded concentrations exceed RBSL or the tap water RBC (if no RBSL is available).
All background values for Zone G are based on twice the mean of grid sample concentrations. Background values for groundwater are based on two sampling rounds in two wells at each depth.

Inorganics in Shallow Groundwater

Twenty-two metals plus cyanide were detected in groundwater samples at Areas 12, 13, and 14. Arsenic was the only metal which exceeded its RBSL. The RBSL, tap water RBC and background for arsenic were exceeded during the second sampling event at location FDS13A (210 μg/L). Antimony exceeded its tap water RBC in the second sampling event at GDG002. This concentration was below the Zone G shallow groundwater background concentration. Beryllium exceeded the tap water RBC during the first sampling event, but was not detected in the second sampling event. Manganese exceeded its tap water RBC in 10 of 11 wells at the combined area during the second sampling event. However, only two of these locations, FDS12A and FDS12B, also exceeded the Zone G shallow groundwater background concentration. Thallium exceeded the tap water RBC in eight of 11 wells in the first sampling event, but was not detected during the second. Figure 4.8-5 depicts the distribution of arsenic in groundwater at Areas 12, 13, and 14.



LEGEND

- Shallow Monitoring Well
- Grid Based Shallow Monitoring Well
- Fence
- Diesel Line

All Concentrations in ug/L
Concentrations present are from the most recent sampling event
Groundwater RBSL for Arsenic = 50 ug/L (SCDHEC January 5, 1998)

FUEL DISTRIBUTION SYSTEM CONTAMINATION ASSESSMENT REPORT
NAVAL BASE CHARLESTON
CHARLESTON, S.C.

FIGURE 4.8-5
AREAS 12, 13, AND 14
ARSENIC IN GROUNDWATER

DWG DATE: 06/01/98 | DWG NAME: 2907N021

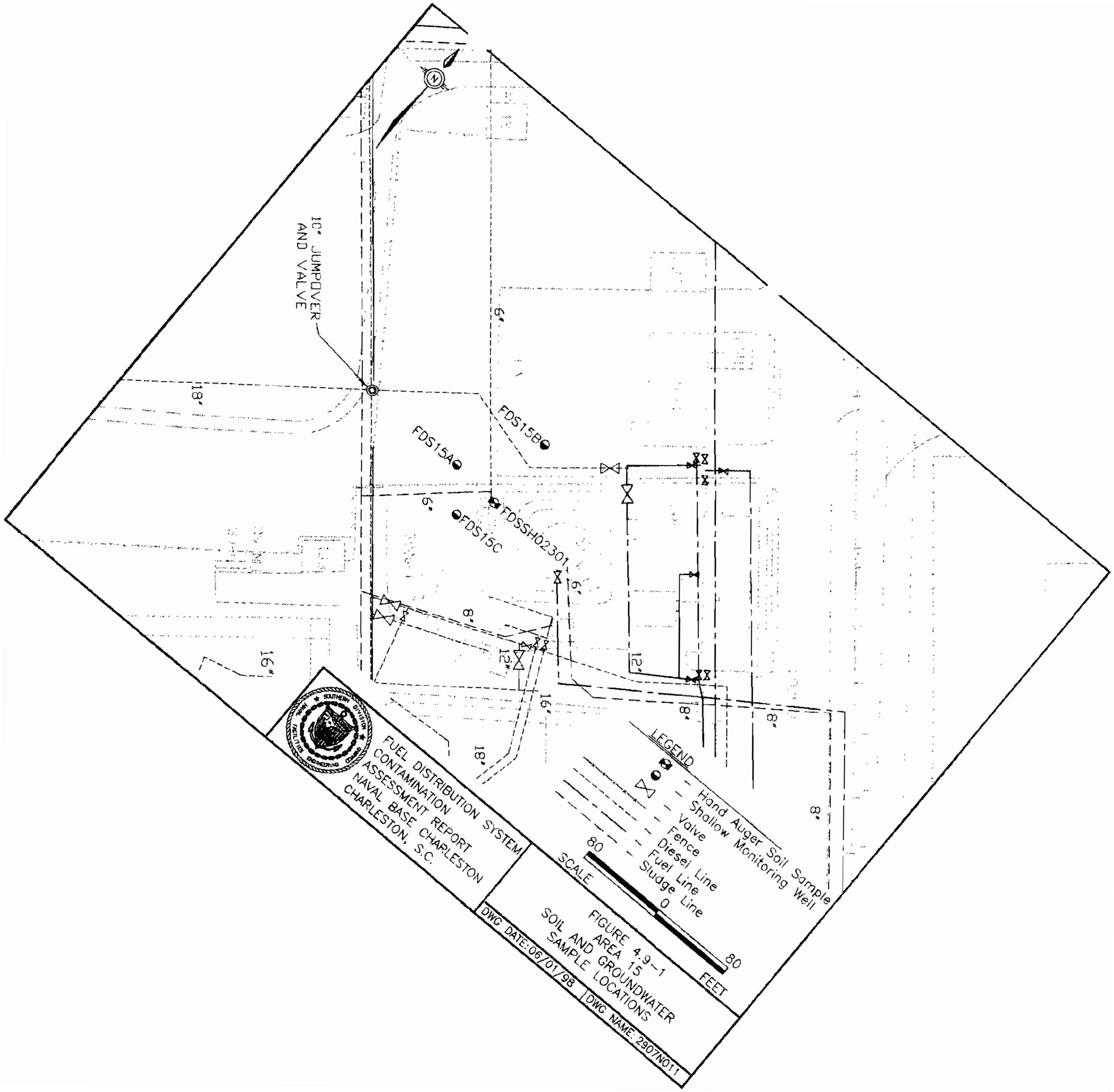
4.9 Area 15

Area 15 is associated with hand-augered sample FDSSH02301 (collected from the 0 to 1 feet bgs depth interval). Surface soil was collected at this area because a surficial release was the most likely means of potential impact. This area is immediately north of AOC 622, the Ballast Water Treatment Facility at Building 3926, and adjacent to Petroleum Storage Tank 3901-A. The Cooper River lies approximately 1,400 feet to the east. To investigate potential petroleum groundwater contamination, three shallow monitoring wells were installed. Wells were installed northwest and southwest of Petroleum Storage Tank 3901-A. Figure 4.9-1 presents the soil boring and monitoring well locations for Area 15.

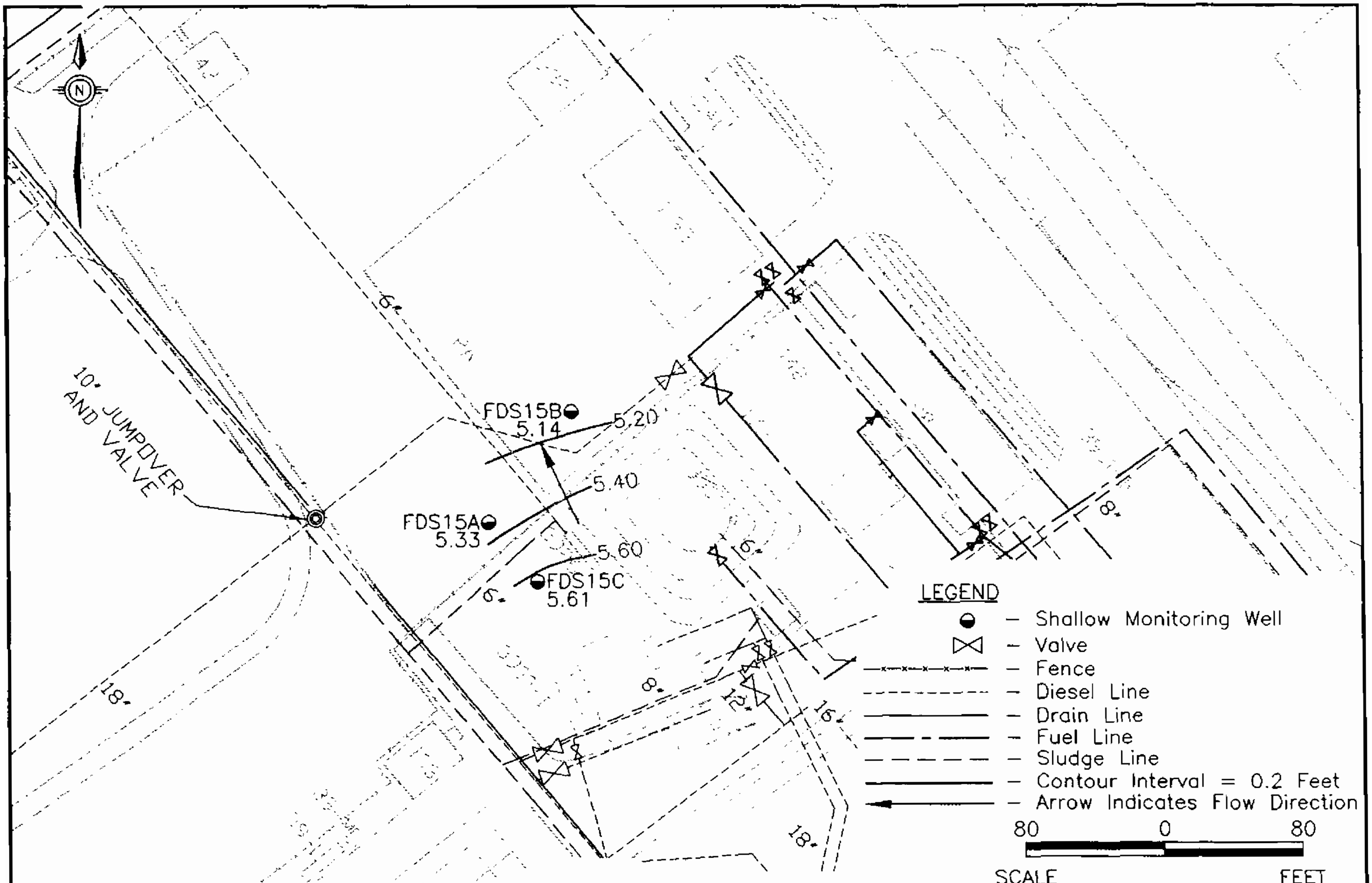
4.9.1 Site Geology and Hydrogeology

Based on well borings advanced at this site, the general stratigraphy at Area 15 is brown clayey, silty soil to a depth of approximately 5 feet bgs, overlying alternating intervals of brown to gray sand, and gray silty, sandy organic clay to approximately 17 feet bgs. Petroleum odors were noted in stratigraphic soil samples collected from 7 to 10 feet bgs at borings FDS15A and FDS15C. Appendix B contains boring logs and monitoring well construction diagrams for Area 15 wells.

Shallow groundwater at Area 15 occurs from approximately 5.07 to 6.71 feet bgs. Figures 4.9-2 and 4.9-3 depict the shallow groundwater potentiometric surface and inferred flow direction for the site during low- and high-tides, respectively. Shallow groundwater flow direction was consistent during tidal stages. The gradient during high-tide was almost twice as steep as the low-tide. Tidal variation was relatively low at less than 0.27 feet. Maximum average calculated groundwater velocity (utilizing the steepest gradient) was 0.004 feet/day based on an average porosity (0.359) and representative hydraulic conductivity (0.32 feet/day) determined during the Zone G RFI (EnSafe, February 1998).



N
10" JUMPOVER
AND VALVE
18"
6"
FDS15B
FDS15A
FDSSH02301
FDS15C
8"
12"
16"
18"
LEGEND
- Hand Auger Soil Sample
- Shallow Monitoring Well
- Valve
- Fence
- Diesel Line
- Fuel Line
- Sludge Line
SCALE
80 0 80
FEET
FUEL DISTRIBUTION SYSTEM
CONTAMINATION
ASSESSMENT REPORT
NAVAL BASE CHARLESTON
CHARLESTON, S.C.
FIGURE 4.9-1
AREA 15
SOIL AND GROUNDWATER
SAMPLE LOCATIONS
DWG DATE: 06/01/98
DWG NAME: 2907N011



FUEL DISTRIBUTION SYSTEM
CONTAMINATION
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CHARLESTON, S.C.

FIGURE 4.9–2
AREA 15
SHALLOW GROUNDWATER
LOW–TIDE POTENTIOMETRIC MAP

DWG DATE: 06/29/98 | DWG NAME: 2907N036

4.9.2 Nature of Contamination in Surface Soil

Analytes detected in Area 15 surface soil are summarized in Table 4.9.1. Appendix C contains a complete analytical data report for all FDS samples.

TPH-GRO in Surface Soil

The Phase I sample results for soil sample FDSSH02301 exhibited 501 μg/kg of TPH-GRO, prompting subsequent Phase II soil and groundwater sampling within Area 15. Nearby subsurface samples FDSSC06401, FDSSC07101, FDSSC07601, FDSSC07801, FDSSC07901 and FDSSC08401 identified no significant TPH contamination.

Volatile Organic Compounds in Surface Soil

Six VOCs were detected in surface soil at Area 15, at concentrations far below RBSLs or SSLs if no RBSL is available.

Semivolatile Organic Compounds in Surface Soil

Six SVOCs were detected in surface soil at Area 15. No individual SVOC or the total naphthalene concentrations exceed RBSLs. The total naphthalene concentration at FDSSH02301 (8,500 μg/kg) was derived by summing the concentrations of 2-methylnaphthalene (6,800 μg/kg) and naphthalene (1,700 μg/kg) at this location. All other SVOC concentrations were far below their RBSLs if available or the SSLs.

Pesticides in Surface Soil

Three pesticides were detected in surface soil at Area 15. No RBSLs are established for pesticides. Concentrations of endrin, heptachlor, and gamma-chlordane were detected at FDSSH02301, at concentrations far below their SSLs.

Table 4.9.1
Analytes Detected in Surface Soil
Area 15
Fuel Distribution System

Parameters	Location	Surface Conc.	RBSL/SSL	Surface Background
TPH - GRO (μg/kg)				
Gasoline	FDSSH02301	501	NL/NL	NA
Volatile Organic Compounds (μg/kg)				
1,1-Dichloroethane	FDSSH02301	85	NL/23000	NA
1,1,1-Trichloroethane	FDSSH02301	48	NL/2000	NA
Ethylbenzene	FDSSH02301	130	7800000/13000	NA
Tetrachloroethene	FDSSH02301	13	NL/60	NA
Toluene	FDSSH02301	22	160000000/12000	NA
Xylene (Total)	FDSSH02301	1800	160000000/148000	NA
Semivolatile Organic Compounds (μg/kg)				
Total Naphthalenes	FDSSH02301	8500	3100000/84000	NA
2-Methylnaphthalene	FDSSH02301	6800	NL/126000	NA
Naphthalene	FDSSH02301	1700	NL/84000	NA
Chrysene	FDSSH02301	240	88000/160000	NA
Fluorene	FDSSH02301	1900	NL/560000	NA
Phenanthrene	FDSSH02301	1900	NL/1380000	NA
Pyrene	FDSSH02301	590	NL/4200000	NA
Pesticides (μg/kg)				
Endrin	FDSSH02301	20	NL/1000	NA
Heptachlor	FDSSH02301	5.3	NL/23000	NA
gamma-Chlordane	FDSSH02301	3.4	NL/10000	NA
Inorganics (mg/kg)				
Aluminum (Al)	FDSSH02301	2820	NL/1000000	18700
Arsenic (As)	FDSSH02301	1.8	NL/29	17.2
Barium (Ba)	FDSSH02301	13.1	NL/1600	109
Cadmium (Cd)	FDSSH02301	0.19	NL/8	1.07
Calcium (Ca)	FDSSH02301	13,100	NL/NL	NL

Table 4.9.1
Analytes Detected in Surface Soil
Area 15
Fuel Distribution System

Parameters	Location	Surface Conc.	RBSL/SSL	Surface Background
Chromium (Cr)	FDSSH02301	9.3	NL/1000000	42.8
Cobalt (Co)	FDSSH02301	1.3	NL/2000	6.60
Iron (Fe)	FDSSH02301	4,860	NL/NL	NL
Lead (Pb)	FDSSH02301	29.5	NL/400	181
Magnesium (Mg)	FDSSH02301	499	NL/NL	NL
Manganese (Mn)	FDSSH02301	29.6	NL/1100	325
Mercury (Hg)	FDSSH02301	0.07	NL/2.1	1.03
Nickel (Ni)	FDSSH02301	4.2	NL/130	206
Potassium (K)	FDSSH02301	240	NL/NL	NL
Thallium (Tl)	FDSSH02301	0.47	NL/0.95	0.85
Vanadium (V)	FDSSH02301	10.6	NL/6000	60.9
Zinc (Zn)	FDSSH02301	66.8	NL/12000	519

Notes:
a = Background value for non-clay samples
NL = Not listed
NA = Not applicable
μg/kg = Micrograms per kilogram
mg/kg = Milligrams per kilogram
RBSLs for ingestion or dermal contact with surficial soil from the *South Carolina Risk-Based Corrective Action for Petroleum Releases* (SCDHEC, January 5, 1998) and soil-to-groundwater SSLs (DAF=20) from the *Soil Screening Guidance: Technical Background Document* (USEPA, 1996b) were used as reference concentrations.
Bolded concentrations exceed RBSL or the SSL (if no RBSL is available).
All background values for Zone G are based on twice the mean of grid sample concentrations.

Inorganics in Surface Soil

Seventeen metals were detected in the surface soil sample collected at Area 15. No RBSLs exist for metals detected in soil. All detected metals concentrations were below their SSLs and Zone G background concentrations.

4.9.3 Nature of Contamination in Shallow Groundwater

Analytes in Area 15 groundwater are summarized in Table 4.9.2. No free product was observed in Area 15 monitoring wells. Appendix C contains a complete analytical data report for all FDS samples.

Volatile Organic Compounds in Shallow Groundwater

Two VOCs were detected in Area 15 groundwater samples during the first sample event. No VOC RBSLs were exceeded in Area 15 groundwater samples. Toluene detected below the RBSL and tap water RBC during the first sampling event, was not detected during the second, most recent event. Chlorobenzene was detected above the tap water RBC during the initial sampling event but was not detected during the second. No RBSL is available for chlorobenzene. No other VOCs were detected in groundwater at Area 15.

Semivolatile Organic Compounds in Shallow Groundwater

Three SVOCs, phenol, 4-methylphenol, and benzoic acid, were detected at Area 15. No SVOC RBSLs were exceeded in Area 15 groundwater samples. Although 4-methylphenol was detected at FDS15A above its tap water RBC in this sampling event, its concentration dropped below the tap water RBC during the second event. Phenol and benzoic acid were detected in the first event only. No RBSLs are available for these compounds.

Pesticides in Shallow Groundwater

One pesticide, beta-BHC, exceeded the tap water RBC at FDS15A during the first sampling event, but was not detected in the second event. No RBSL is available for beta-BHC.

Inorganics in Shallow Groundwater

Sixteen metals plus cyanide were detected in Area 15 groundwater samples. No RBSL for groundwater metals were exceeded at Area 15. Manganese exceeded its tap water RBC in all three

Table 4.9.2
Analytes Detected in Shallow Groundwater
Area 15
Fuel Distribution System

Parameters	Location	First Sampling Event	Second Sampling Event	RBSL/Tap Water RBC (μg/L)	Shallow Background
Volatile Organic Compounds (μg/L)					
Toluene	FDS15A	3	ND	1000/75	NA
Chlorobenzene	FDS15A	6	ND	NL/3.9	NA
Semivolatile Organic Compounds (μg/L)					
Phenol	FDS15A	1	ND	NL/2200	NA
4-Methylphenol (p-cresol)	FDS15A	23	2	NL/18	NA
Benzoic acid	FDS15A	6	ND	NL/15000	NA
Pesticides (μg/L)					
beta-BHC	FDS15A	0.057	ND	NL/0.037	NA
Inorganics (μg/L)					
Aluminum (Al)	FDS15A	100	503	NL/3700	692
	FDS15B	3,010	209		
	FDS15C	962	474		
Antimony (Sb)	FDS15C	3.5	ND	NL/1.5	4.85
Arsenic (As)	FDS15A	19.4	26.7	50/0.045	17.8
	FDS15B	4.1	4.6		
Barium (Ba)	FDS15A	55.2	94.5	2000/260	31
	FDS15B	68.6	70.6		
	FDS15C	159	153		
Calcium (Ca)	FDS15A	126000	235000	NL/NL	NL
	FDS15B	98800	119000		
	FDS15C	268000	284000		
Chromium (Cr)	FDS15A	0.92	1.5	100/18	3.88
	FDS15B	4.7	ND		
	FDS15C	1.9	ND		
Cobalt (Co)	FDS15B	8.1	6.8	NL/220	1.45
	FDS15C	1.3	ND		
Copper (Cu)	FDS15A	3.6	ND	NL/13000	8.33
Cyanide (CN)	FDS15A	3	NT	NL/73	3.8
	FDS15B	7	NT		

Table 4.9.2
Analytes Detected in Shallow Groundwater
Area 15
Fuel Distribution System

Parameters	Location	First Sampling Event	Second Sampling Event	RBSL/Tap Water RBC (µg/L)	Shallow Background
Iron (Fe)	FDS15A	4920	6620	NL/NL	NL
	FDS15B	2060	675		
	FDS15C	1920	3040		
Magnesium (Mg)	FDS15A	12200	15800	NL/NL	NL
	FDS15B	26200	22800		
	FDS15C	19300	14000		
Manganese (Mn)	FDS15A	**721**	**515**	NL/84	2906
	FDS15B	**1050**	**813**		
	FDS15C	**806**	**465**		
Nickel (Ni)	FDS15A	3.7	0.84	NL/73	4.08
	FDS15B	3.2	1.6		
	FDS15C	1.7	0.9		
Potassium (K)	FDS15A	10800	5130	NL/NL	NL
	FDS15B	7410	8050		
	FDS15C	3440	3450		
Sodium (Na)	FDS15A	78300	157000	NL/NL	NL
	FDS15B	92400	158000		
	FDS15C	117000	114000		
Thallium (Tl)	FDS15C	**3.3**	ND	NL/0.29	ND
Vanadium (V)	FDS15A	1.3	1.6	NL/26	15.4
	FDS15B	6	1.1		
	FDS15C	1.9	1.6		

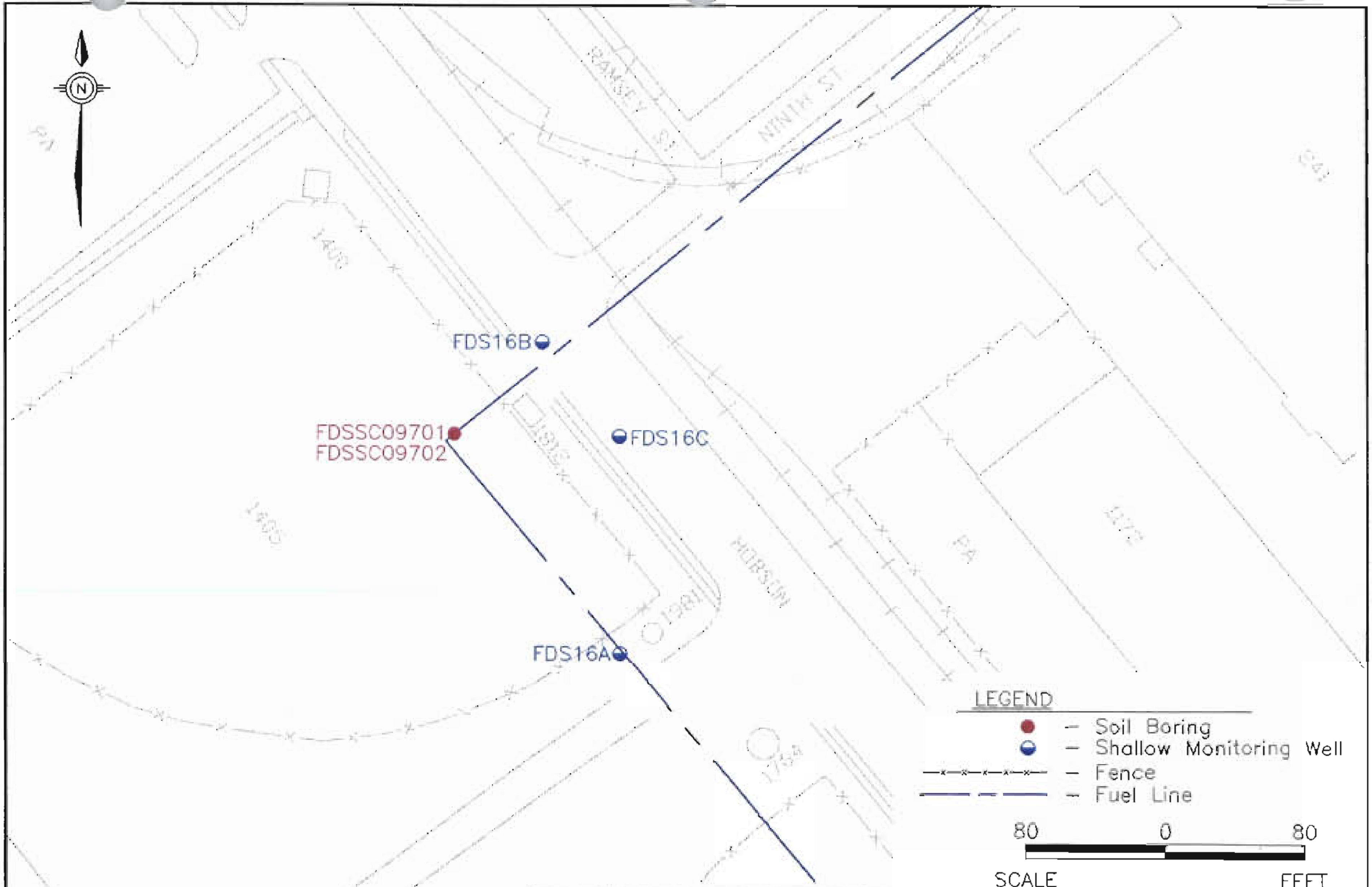
Notes:
NL = Not listed
NA = Not applicable
ND = Not detected
NT = Not taken
µg/L = Micrograms per liter
RBSLs from the *South Carolina Risk-Based Corrective Action for Petroleum Releases* (SCDHEC, January 5, 1998) and tap water RBCs (THQ=0.1) from *Risk Based Concentration Table* (USEPA, October 22, 1997) were used as reference concentrations.
Bolded concentrations exceed RBSL or the tap water RBC (if no RBSL is available).
All background values for Zone G are based on twice the mean of grid sample concentrations. Background values for groundwater are based on two sampling rounds in two wells at each depth.

Area 15 monitoring wells during both sampling events. Although concentrations of manganese exceeded the tap water RBC, all these concentrations were far below the Zone G background value. Antimony and thallium concentrations exceeded the tap water RBC during the first sampling event from FDS15C, but were not detected during the second sampling event. Antimony concentrations were below the Zone G background. No background value was determined for thallium.

4.10 Area 16

Area 16 is associated with soil samples FDSSC09701 (collected from the 7 to 9 feet bgs depth interval) and FDSSC09702 (collected from the 9 to 11 feet bgs depth interval). This area of potential impact is on the west side of Hobson Avenue, across the road from and west of Building 1172. The Cooper River lies approximately 1,200 feet to the east. To investigate potential petroleum groundwater contamination, three shallow monitoring wells were installed in this area: two along the west side of Hobson Avenue in the area described, and one to the south in a grassy median between Borie Street and Ballfield 1405. Figure 4.10-1 presents the soil and groundwater sampling locations for Area 16.

Analytical data from Area 16 shallow monitoring wells identified RCRA COCs. Consequently, the NAVBASE Project Team decided to evaluate this area using the RFI process. The area has since been designated as AOC 709. This site will be discussed in an addendum to the Zone F RFI report.



FUEL DISTRIBUTION SYSTEM
CONTAMINATION
ASSESSMENT REPORT
NAVAL BASE CHARLESTON
CHARLESTON, S.C.

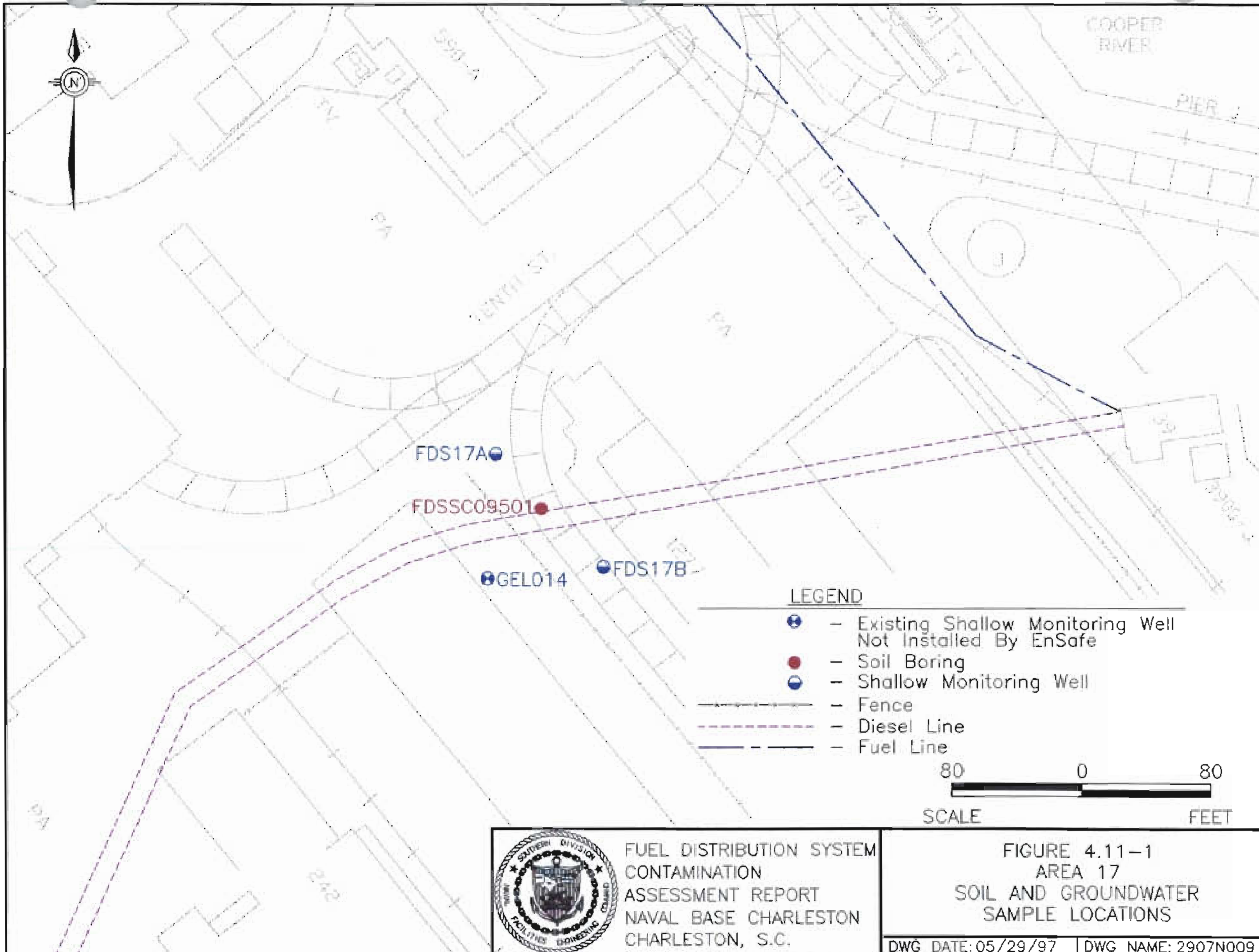
FIGURE 4.10-1
AREA 16
SOIL AND GROUNDWATER
SAMPLE LOCATIONS

DWG DATE: 06/01/98 | DWG NAME: 2907N010

4.11 Area 17

Area 17 is associated with sample FDSSC09501 (collected from the 7 to 9 feet bgs depth interval). This area of potential impact is east of AOCs 613 and 615, and SWMU 175, which were investigated during the Zone F RFI. The Cooper River lies approximately 450 feet to the east. To investigate potential petroleum groundwater contamination, two shallow monitoring wells were installed in this area. Because of its close proximity to Area 17, analytical data from shallow well GEL014 (investigated during the RFI for AOCs 613, 615 and SWMU 175), was included in the investigation. Well GEL014 was of particular interest to the FDS investigation, because it contained free petroleum product when sampled during the Zone F RFI. Figure 4.11-1 presents the soil boring and monitoring well locations for Area 17.

Analytical data from Area 11 shallow monitoring wells identified RCRA COCs. Consequently, the NAVBASE Project Team decided to evaluate this area using the RFI process. This area will be discussed relative to AOCs 613 and 615 and SWMU 175 in an addendum to the Zone F RFI report.



FUEL DISTRIBUTION SYSTEM CONTAMINATION ASSESSMENT REPORT
NAVAL BASE CHARLESTON
CHARLESTON, S.C.

FIGURE 4.11–1
AREA 17
SOIL AND GROUNDWATER SAMPLE LOCATIONS

DWG DATE: 05/29/97 | DWG NAME: 2907N009

4.12 Area 18

Area 18 is associated with sample FDSSC11401 (collected from the 3 to 5 feet bgs depth interval). This area of potential impact is along the waterfront of the Cooper River, in Zone E is immediately east of Building 247 and north of Dry Dock 5. To investigate potential petroleum groundwater contamination, one shallow monitoring well was installed. Because of the proximity of shallow grid-well GDE012 (investigated during the Zone E RFI), situated approximately 150 feet southeast of Area 18, analytical data from this well were included in the investigation of Area 18. Figure 4.12-1 presents the soil boring and monitoring well locations for Area 18.

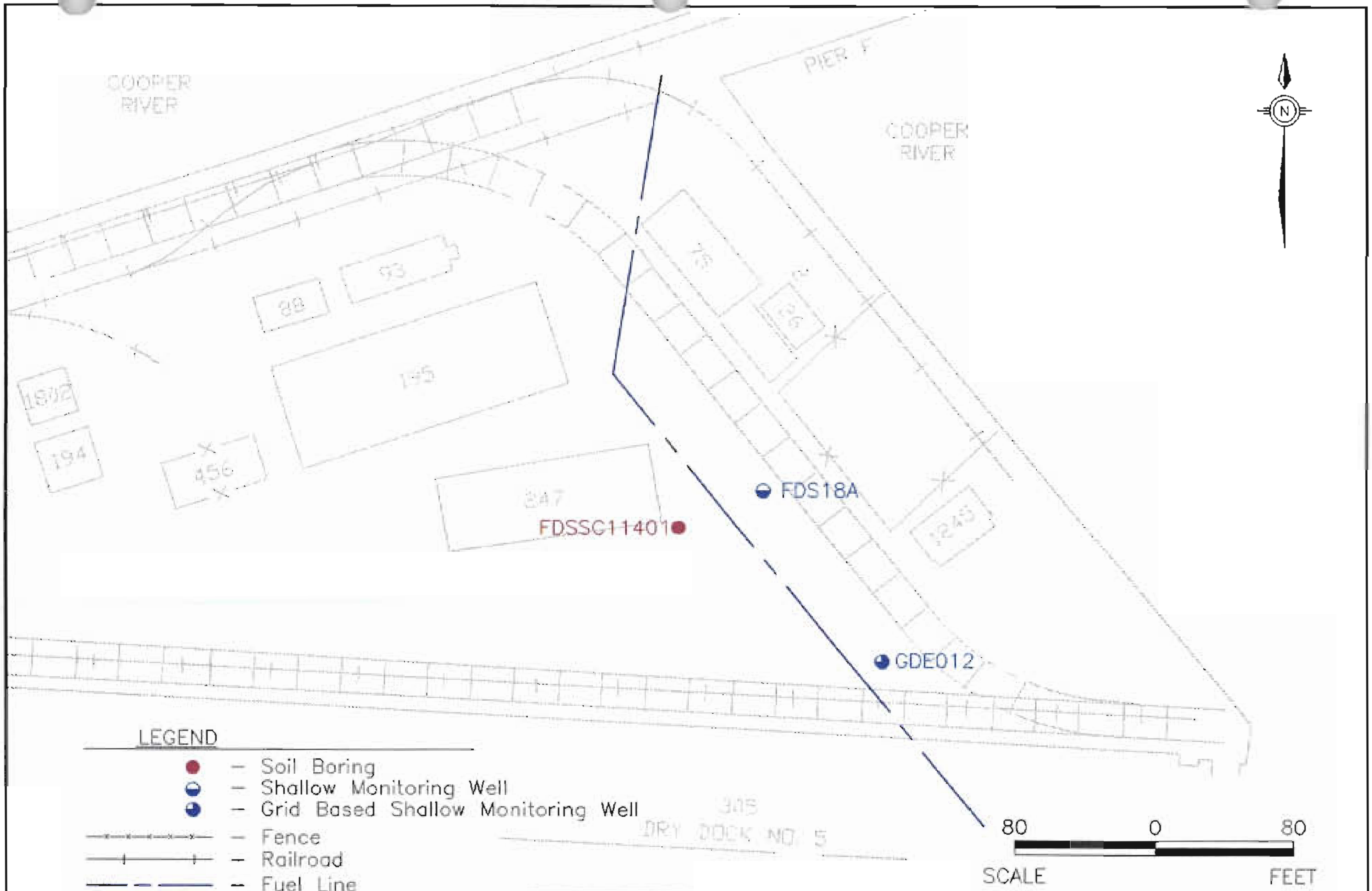
4.12.1 Site Geology and Hydrogeology

Based on well borings advanced at this site, the general stratigraphy at Area 18 is brown to gray silty, clayey sand to a depth of approximately 7 feet bgs, overlying gray organic clay with fine sand and silt, to a depth of approximately 12 feet bgs. No petroleum stain or odor was noted in stratigraphic soil samples collected from these locations. Appendix B contains boring logs and monitoring well construction diagrams for Area 18 wells.

Shallow groundwater at Area 18 occurs at approximately 6.29 feet bgs. In this area of NAVBASE, groundwater elevation and flow are controlled by the adjacent Cooper River. Consequently flow is toward the river through the quay wall. By design, the dry dock walls are substantially more competent, further substantiating flow to the river. The Zone E RFI contains a more detailed discussion of flow and gradient in this area.

4.12.2 Nature of Contamination in Subsurface Soil

Analytes detected in Area 18 subsurface soil are summarized in Table 4.12.1. Appendix C contains a complete analytical data report for all FDS samples.



FUEL DISTRIBUTION SYSTEM CONTAMINATION ASSESSMENT REPORT
NAVAL BASE CHARLESTON
CHARLESTON, S.C.

FIGURE 4.12-1
AREA 18
SOIL AND GROUNDWATER SAMPLE LOCATIONS

DWG DATE: 05/28/98 | DWG NAME: 2907N001

Table 4.12.1
Analytes Detected in Subsurface Soil
Area 18
Fuel Distribution System

Parameters	Location	Subsurface Conc.	RBSL/SSL	Subsurface Background
TPH - DRO (mg/kg)				
Diesel	FDSSC11401	336	NL/NL	NA
Semivolatile Organic Compounds (μg/kg)				
Anthracene	FDSSC11401	49	NL/12000000	NA
Benzo(a)anthracene	FDSSC11401	260	73084/2000	NA
Benzo(b)fluoranthene	FDSSC11401	120	29097/5000	NA
Benzo(k)fluoranthene	FDSSC11401	87	231109/49000	NA
Benzo(a)pyrene	FDSSC11401	60	NL/8000	NA
Benzo(g,h,i)perylene	FDSSC11401	55	NL/4.66E+08	NA
Benzoic acid	FDSSC11401	86	NL/400000	NA
bis(2-Ethylhexyl)phthalate (BEHP)	FDSSC11401	46	NL/3600000	NA
Chrysene	FDSSC11401	380	12998/160000	NA
Diethylphthalate	FDSSC11401	74	NL/470000	NA
Fluoranthene	FDSSC11401	520	NL/4300000	NL
Phenanthrene	FDSSC11401	130	NL/1380000	NA
Pyrene	FDSSC11401	470	NL/4200000	NA
Inorganics (mg/kg)				
Aluminum (Al)	FDSSC11401	9,220	NL/1000000	23600
Arsenic (As)	FDSSC11401	1.7	NL/29	15.5[a]
Barium (Ba)	FDSSC11401	23.2	NL/1600	64.5
Beryllium (Be)	FDSSC11401	0.39	NL/63	1.63
Calcium (Ca)	FDSSC11401	29,100	NL/NL	NL
Chromium (Cr)	FDSSC11401	12.5	NL/1000000	43.4[a]
Cobalt (Co)	FDSSC11401	1.4	NL/2000	8.14
Copper (Cu)	FDSSC11401	7.3	NL/920	32.6
Cyanide (CN)	FDSSC11401	0.95	NL/40	0.22
Iron (Fe)	FDSSC11401	4,850	NL/NL	NL

Table 4.12.1
Analytes Detected in Subsurface Soil
Area 18
Fuel Distribution System

Parameters	Location	Subsurface Conc.	RBSL/SSL	Subsurface Background
Lead (Pb)	FDSSC11401	9.9	NL/400	66.3
Magnesium (Mg)	FDSSC11401	680	NL/NL	NL
Manganese (Mn)	FDSSC11401	51	NL/1100	291
Nickel (Ni)	FDSSC11401	4.8	NL/130	18.3
Potassium (K)	FDSSC11401	443	NL/NL	NL
Sodium (Na)	FDSSC11401	450	NL/NL	NL
Vanadium (V)	FDSSC11401	13.2	NL/6000	72.5
Zinc (Zn)	FDSSC11401	16.5	NL/12000	145

Notes:
a = Background value for non-clay samples
NL = Not listed
NA = Not applicable
μg/kg = Micrograms per kilogram
mg/kg = Milligrams per kilogram
RBSLs from the *South Carolina Risk-Based Corrective Action for Petroleum Releases* (SCDHEC, January 5, 1998) and soil-to-groundwater SSLs (DAF=20) from the *Soil Screening Guidance: Technical Background Document* (USEPA, 1996b) were used as reference concentrations.
Bolded concentrations exceed RBSL or the SSL (if no RBSL is available)
All background values for Zone G are based on twice the mean of grid sample concentrations.

TPH-DRO in Subsurface Soil

The Phase I sample results from soil boring FDSSC11401 exhibited 336 mg/kg of TPH-DRO, prompting subsequent Phase II soil and groundwater sampling within Area 18. Nearby sample FDSSC11501 identified no significant TPH contamination.

Volatile Organic Compounds in Subsurface Soil

No VOCs were detected in subsurface soil at Area 18.

Semivolatile Organic Compounds in Subsurface Soil

Thirteen SVOCs, including 10 PAHs, were detected in subsurface soil at Area 18. All SVOC concentrations were far below their soil RBSLs and SSLs.

Inorganics in Subsurface Soil

Seventeen metals plus cyanide were detected in subsurface soil at Area 18. All detections were below their SSLs and Zone G background concentrations.

4.12.3 Nature of Contamination in Shallow Groundwater

Analytes detected in Area 17 groundwater are summarized in Table 4.12.2. No free product was observed in the Area 18 monitoring wells. Appendix C contains a complete analytical data report for all FDS samples.

Volatile Organic Compounds in Shallow Groundwater

No VOCs were detected in groundwater at Area 18.

Semivolatile Organic Compounds in Shallow Groundwater

Two SVOCs, benzoic acid and pentachlorophenol, were detected in the second sampling event at Area 18. Neither of these compounds has an RBSL assigned. Pentachlorophenol exceeded its tap water RBC during the second sampling event at FDS18A.

Inorganics in Shallow Groundwater

Eighteen metals plus cyanide were detected in groundwater samples at Area 18. No RBSLs for metals in groundwater were exceeded at Area 18. Antimony and vanadium exceeded their tap water RBCs and Zone G background concentrations during the second sampling event at FDS18A.

Table 4.12.2
Analytes Detected in Shallow Groundwater
Area 18
Fuel Distribution System

Parameters	Location	First Sampling Event	Second Sampling Event	RBSL/Tap Water RBC (μg/L)	Shallow Background
Semivolatile Organic Compounds (μg/L)					
Benzoic acid	FDS18A	ND	1.00	NL/15000	NA
Pentachlorophenol	FDS18A	ND	**10.00**	NL/0.56	NA
Inorganics (μg/L)					
Aluminum (Al)	GDE012	1620	2020	NL/3700	692
	FDS18A	2070	15.5		
Antimony (Sb)	FDS18A	ND	**5**	NL/1.5	4.85
Arsenic (As)	FDS18A	6.20	3.70	50/0.045	17.8
Barium (Ba)	GDE012	214	134	2000/260	31
	FDS18A	102	60.9		
Beryllium (Be)	GDE012	ND	**0.51**	NL/0.016	ND
Calcium (Ca)	GDE012	152000	103000	NL/NL	NL
	FDS18A	110000	149000		
Chromium (Cr)	GDE012	2.4	ND	100/18	3.88
	FDS18A	4.5	1.5		
Cobalt (Co)	FDS18A	2.00	2.40	NL/220	1.45
Copper (Cu)	GDE012	ND	1.9	NL/13000	8.33
	FDS18A	7.6	3.6		
Cyanide (CN)	FDS18A	10.10	NT	NL/73	3.8
Iron (Fe)	GDE012	7610	4600	NL/NL	NL
	FDS18A	1720	3970		
Lead (Pb)	GDE012	ND	1.9	15/15	4.6
Magnesium (Mg)	GDE012	149000	103000	NL/NL	NL
	FDS18A	234000	186000		
Manganese (Mn)	GDE012	**216**	**127**	NL/84	2906
	FDS18A	**257**	**317**		
Nickel (Ni)	GDE012	1.4	ND	NL/73	4.08
	FDS18A	7	5.6		
Potassium (K)	GDE012	47400	45100	NL/NL	NL
	FDS18A	111000	113000		
Sodium (Na)	GDE012	1760000	1140000	NL/NL	NL
	FDS18A	2200000	1750000		

Table 4.12.2
Analytes Detected in Shallow Groundwater
Area 18
Fuel Distribution System

Parameters	Location	First Sampling Event	Second Sampling Event	RBSL/Tap Water RBC (μg/L)	Shallow Background
Vanadium (V)	GDE012	3.4	4.2	NL/26	15.4
	FDS18A	**44.1**	**37**		
Zinc (Zn)	GDE012	ND	17.1	NL/1100	15.6
	FDS18A	41.9	ND		

Notes:
NL = Not listed
NA = Not applicable
ND = Not detected
NT = Not taken
μg/L = Micrograms per liter
RBSLs from the *South Carolina Risk-Based Corrective Action for Petroleum Releases* (SCDHEC, January 5, 1998) and tap water RBCs (THQ=0.1) from *Risk Based Concentration Table* (USEPA, October 22, 1997) were used as reference concentrations.
Bolded concentrations exceed RBSL or the tap water RBC (if no RBSL is available).
All background values for Zone G are based on twice the mean of grid sample concentrations. Background values for groundwater are based on two sampling rounds in two wells at each depth.

Beryllium also exceeded its RBC during the second sampling event,. No background concentration is available for beryllium in Zone G. The tap water RBC for manganese was exceeded in both Area 18 wells during both sampling events. However, all manganese concentrations were below the Zone G shallow groundwater background.

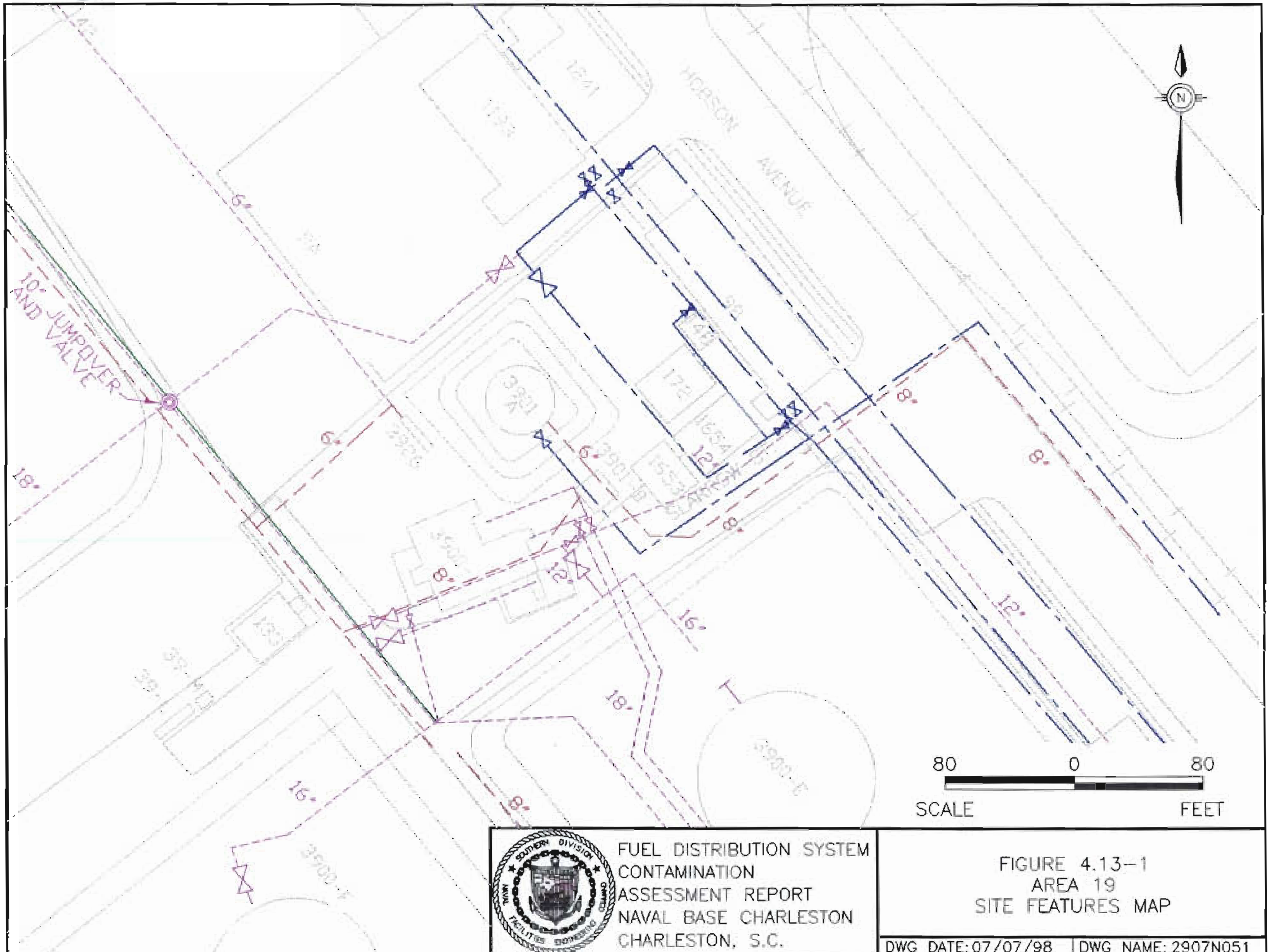
4.13 Area 19

Area 19 was identified, subsequent to the RFI, as requiring additional assessment during removal of UST 148, a stripper tank associated with the FDS pumphouse at Building 98, AOC 623. The area is located along the south side of Hobson Avenue, west of Slarrow Road. Figure 4.13-1 presents the Area 19 features.

S&ME, Inc. investigated TPH contamination in soil along a pipeline between Building 98 and Hobson Avenue in 1992. The investigation identified two areas of elevated TPH concentrations north and west of the building. Appendix D contains the S&ME report.

In August 1996, the Environmental Detachment Charleston initiated assessment and closure of UST 148. UST 148 was a poured concrete structure designed to temporarily hold fuel oil from the pumphouse in Building 98 while repairs and maintenance were performed on the pipeline. The tank was determined to be structurally sound prior to demolition. No spills or releases were documented from the UST. During removal, free product and oily soil were observed throughout the excavation. The area most contaminated was associated with the piping to Building 98. Following removal of the UST, the excavation remained open and collected rainwater runoff. The excavation was restricted and periodically inspected. No free product was observed, but an oil sheen was present. In July 1997, the water was removed and the excavation backfilled with clean fill. Appendix E contains the assessment and closure report for UST 148.

Area 19 was added to the FDS investigation in 1998 after the investigation of the other areas was complete. The objective of the Area 19 additional investigation will be to identify the extent of free product, if detected, and to assess the impact to soil and groundwater.



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CHARLESTON, S.C.

FIGURE 4.13-1
AREA 19
SITE FEATURES MAP

DWG DATE: 07/07/98 | DWG NAME: 2907N051

Prior to initiation of further assessment activities at Area 19, a Contamination Assessment Plan will be developed and submitted for SCDHEC approval. The results and recommendations of the assessment will be included in either the final contamination assessment report, or an addendum to the report.

4.14 Area 20

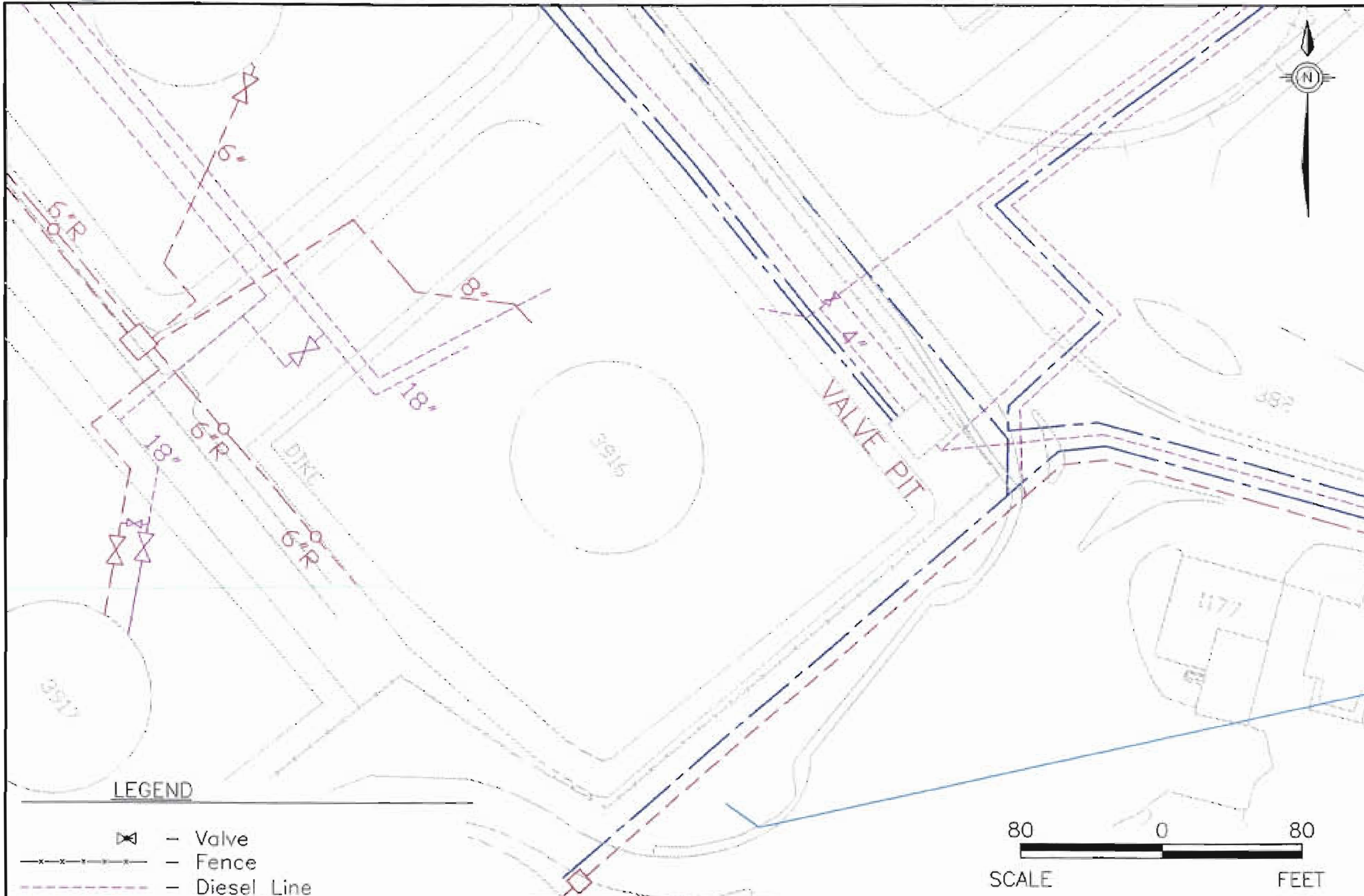
Area 20 was identified as requiring additional assessment during interim measures (IM) activities related to a fuel release near the corner of Hobson Avenue and Viaduct Road. The area is at the northeast corner of AOC 626, the Naval Supply Center Fuel Farm at NAVBASE. Figure 4.14-1 presents the of Area 20 features.

In September 1994, an unspecified volume of diesel fuel was released from the FDS at the southwest corner of Hobson Avenue and Viaduct Road. An existing leak in a fuel supply line was identified when a pressure test, associated with cleaning and closure of the pipelines, resulted in an eruption of oil and water at the surface. An IM was initiated to remove the impacted soil and implement a product recovery system. At completion of the IM in February 1997, 450 cubic yards of soil had been removed. Initial pumping recovered approximately 300 gallons of product. Appendix F contains a completion report of the IM.

A previous investigation of petroleum contamination near AOC 626 was conducted in 1995 using the Navy's SCAPS. Thirty-three SCAPS sample pushes were completed, and eight soil samples were collected and analyzed for confirmation. The results identified limited petroleum contamination. Appendix G contains the SCAPS Site Characterization Report.

Area 20 was added to the FDS investigation in 1998 after investigation of the other areas was complete. The objectives of the Area 20 additional investigation will be to identify the extent of free product, and to assess impact to soil and groundwater.

Prior to initiation of further assessment activities at Area 20, a contamination assessment plan will be developed and submitted for SCDHEC approval. The results of the assessment and recommendations for corrective action will be included in either the final contamination assessment report, or an addendum to the report.



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CHARLESTON, S.C.

FIGURE 4.14-1
AREA 20
SITE FEATURES MAP

DWG DATE: 07/07/98 | DWG NAME: 2907N052

5.0 CONCLUSIONS AND PRELIMINARY RECOMMENDATIONS

The contamination assessment of the FDS was conducted to determine which areas pose unacceptable risk to human health and the environment, and will require corrective action. The conclusions reached for each site are based on a technical data evaluation following procedures outlined in the NAVBASE Charleston *Comprehensive RFI Work Plan* (E/A&H, July 30, 1996b) and the *South Carolina Risk-Based Corrective Action for Petroleum Releases* guidance document. The NAVBASE Charleston project team has established a conservative protocol for using risk- and hazard-based thresholds to make preliminary recommendations. The recommendations will included no further action, additional assessment or monitoring, and risk-based corrective action.

Preliminary recommendations for all areas investigated in the FDS are summarized in Table 5.1. The following subsections summarize the affected media, analytical results, and recommendations for each area.

5.1 Area 1

Area 1 exhibits soil and groundwater contamination associated with the FDS. At soil sample location FDSSC002, the RBSL for total naphthalenes was exceeded. This was the only RBSL exceedence in Area 1 soil.

Although total naphthalenes exceeded the RBSL, the greatest risk is to groundwater, which will be monitored. Also, since the FDS pipelines have been cleaned and closed, the potential source of continuing soil contamination has been removed. Intrinsic corrective action is recommended for Area 1 soil.

Table 5.1
Conclusions and Recommendations
Fuel Distribution System

Site Designation	Conclusion/Recommendations
Area 1	Soil - Intrinsic corrective action Groundwater - Additional shallow well/resampling
Areas 2, 3, 4, 5, and 6	Soil - Limited active corrective action Groundwater - Additional shallow well/resampling
Area 7	Soil - Additional soil samples Groundwater - Additional shallow well/resampling
Area 8	Soil - Intrinsic corrective action Groundwater - Additional shallow well/sampling
Areas 9 and 10	Soil - Intrinsic corrective action Groundwater -No further action
Area 11	Soil -No further action Groundwater -No further action
Areas 12, 13, and 14	Soil - Intrinsic corrective action Groundwater - Limited resampling
Area 15	Soil - No further action Groundwater -No further action
Area 18	Soil -No further action Groundwater -No further action
Area 19	Soil - Additional assessment Groundwater - Additional assessment
Area 20	Soil -Additional assessment Groundwater - Additional assessment

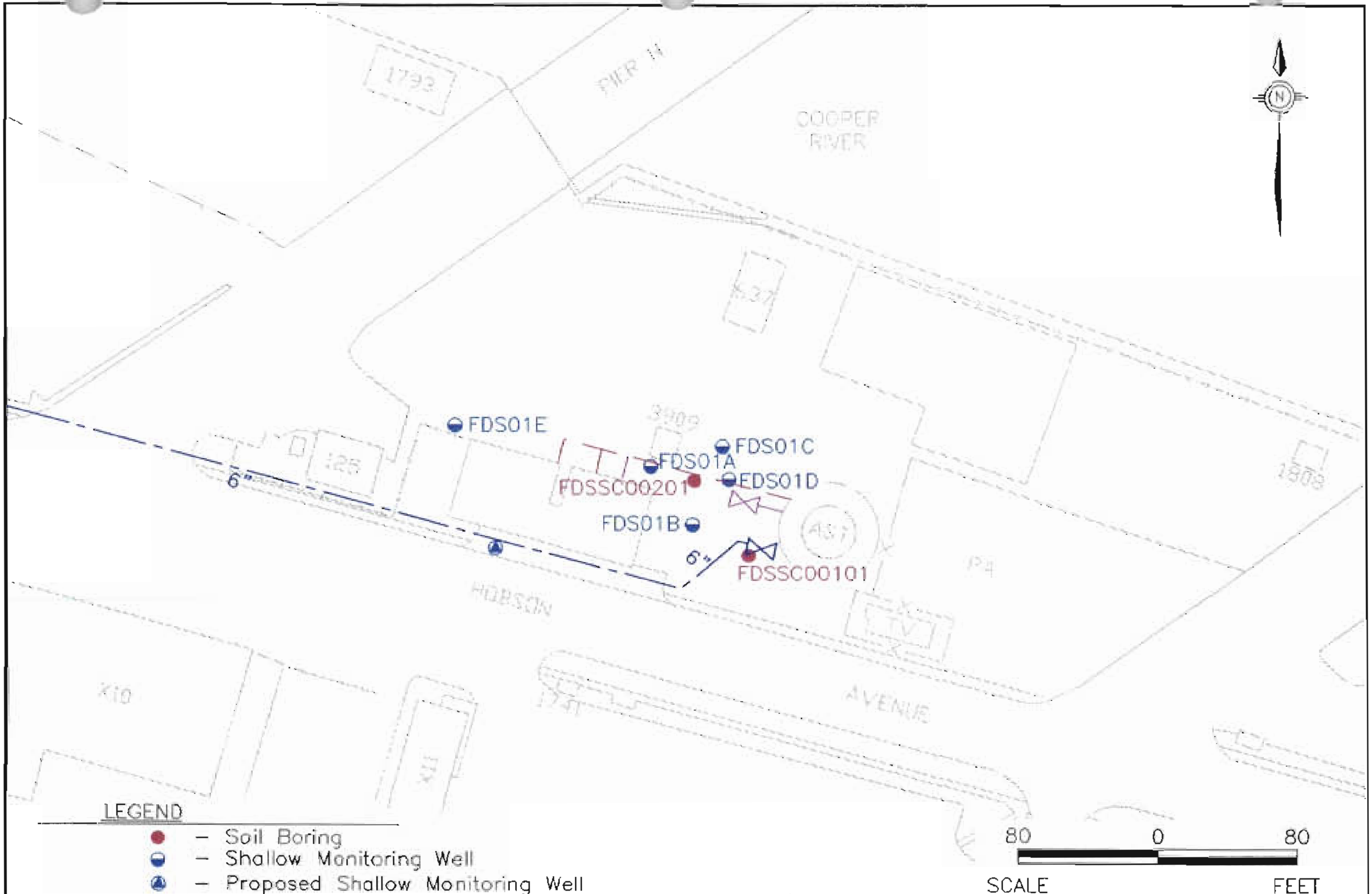
A thin (<0.5 feet thick) layer of free product was recently observed in monitoring well FDS01A. When the water levels were measured in April 1997, the free product was approximately 4.5 feet thick. This decrease is most likely due to the fact that the distribution system is no longer in service and the continuing product source has been removed.

The RBSLs for total PAHs and eight individual PAHs were exceeded in groundwater samples from two Area 1 monitoring wells. The greatest concentrations and number of PAH exceedences occurred in well FDS01A, which was installed in the pipeline backfill material downgradient of the soil sample location. With the exception of fluorene, all concentrations from well FDS01A decreased between the first and second sampling events. Monitoring well FDS01B exhibited RBSL exceedences of total PAHs and two individual PAHs. It is important to note that the PAH concentrations in FDS01B increased between sampling events, suggesting plume migration to the well. No other groundwater RBSLs were exceeded at Area 1.

To fill a potential data gap, an additional shallow monitoring well is proposed downgradient (high-tide) of FDS01A. This well is intended to help determine the extent of groundwater contamination. Figure 5-1 presents the proposed shallow well location. In addition, all Area 1 wells will be resampled for RBSL parameters, checked for free product and water levels recorded. If no parameters exceed RBSLs and the product is gone, intrinsic remediation is recommended. If after the initial resampling RBSLs are still exceeded, a risk assessment will be performed to determine if the groundwater poses an unacceptable human health risk. If free product remains in the well, corrective action will be implemented. If risk exceeds the 10^{-6} threshold, groundwater corrective action will be initiated. If risk is below the acceptable criteria, intrinsic remediation with monitoring will be recommended.

5.2 Areas 2, 3, 4, 5, and 6

Areas 2, 3, 4, 5, and 6 exhibit limited soil and groundwater contamination associated with the FDS. The soil RBSL and SSL for benzene were exceeded at FDSSC01201. In addition, the soil RBSL for total naphthalenes was exceeded at locations FDSSC012 and FDSSC013. Although benzene exceeded its soil RBSL and SSL at FDSSC01201, it was not detected in site groundwater. Benzene was also not detected in soil or groundwater samples at SWMU 8 and AOC 636, an RFI site immediately to the south which was investigated during the Zone G RFI. To mitigate the threat to groundwater, soil near FDSSC01201 should be remediated/removed. Intrinsic remediation is an appropriate corrective action for other impacted soil in the combined areas. Figure 5-2 presents the area of the proposed removal.



LEGEND

- Soil Boring
- Shallow Monitoring Well
- Proposed Shallow Monitoring Well
- Valve
- Fence
- Fuel Line
- Sludge Line

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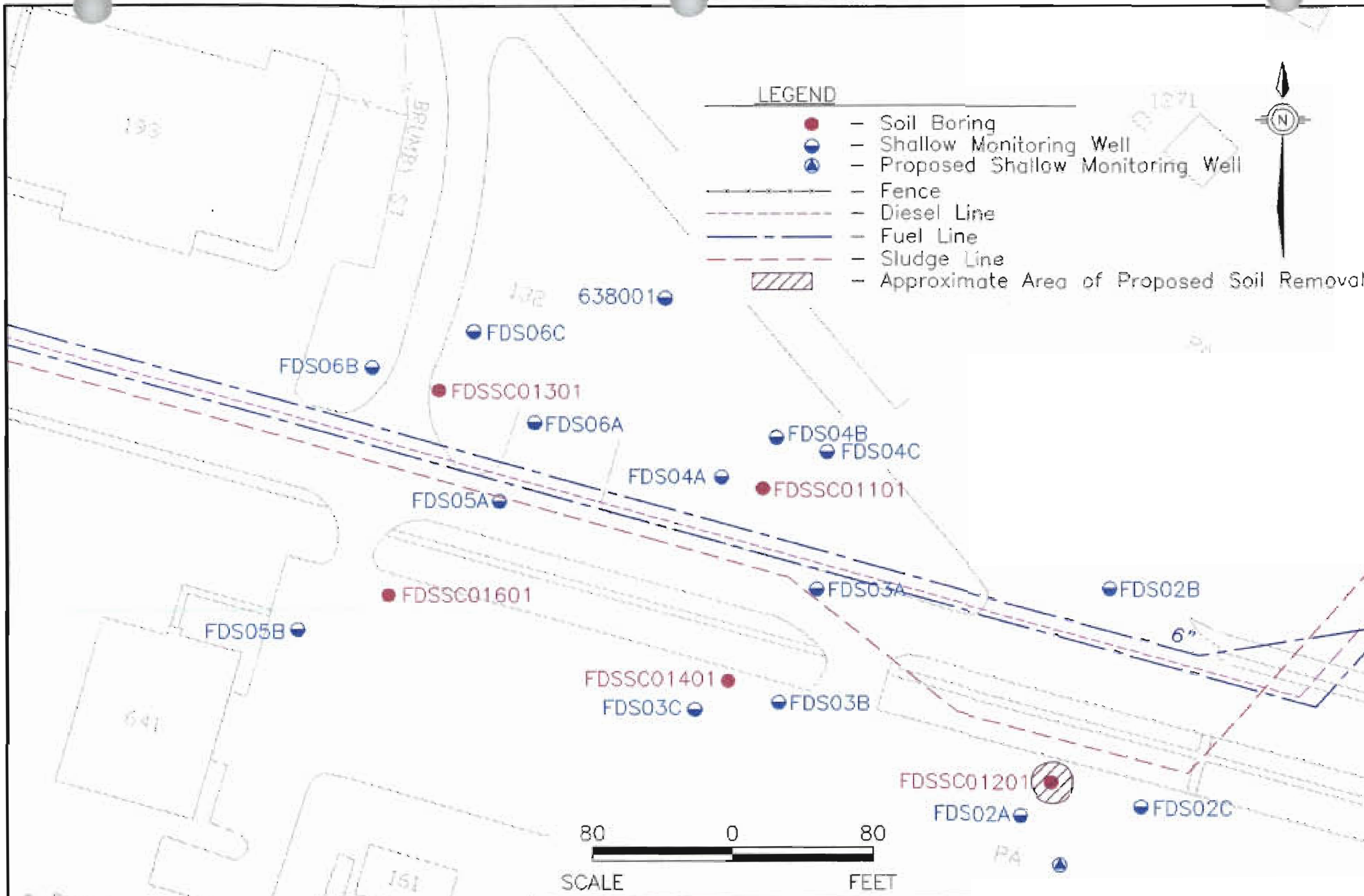
FIGURE 5-1
AREA 1
PROPOSED GROUNDWATER
SAMPLE LOCATIONS

DWG DATE: 07/08/98 | DWG NAME: 2907N046



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CHARLESTON, S.C.

FIGURE 5-2
AREAS 2, 3, 4, 5, AND 6
PROPOSED GROUNDWATER SAMPLE AND REMOVAL LOCATIONS

DWG DATE: 07/08/98 | DWG NAME: 2907N047

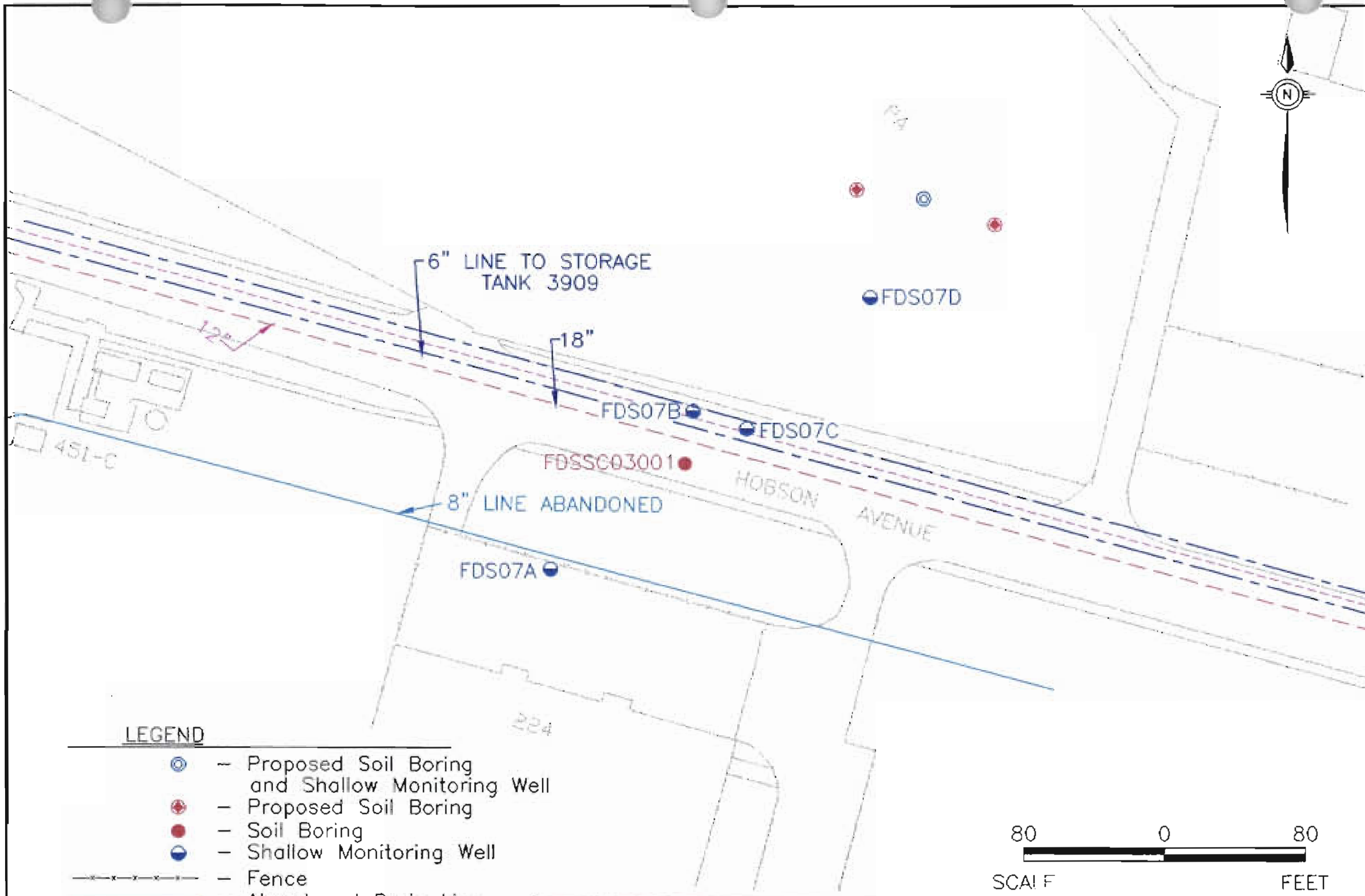

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FIGURE 5-3
AREA 7
PROPOSED SOIL AND GROUNDWATER
SAMPLE LOCATIONS

DWG DATE: 07/13/98 | DWG NAME: 2907N048

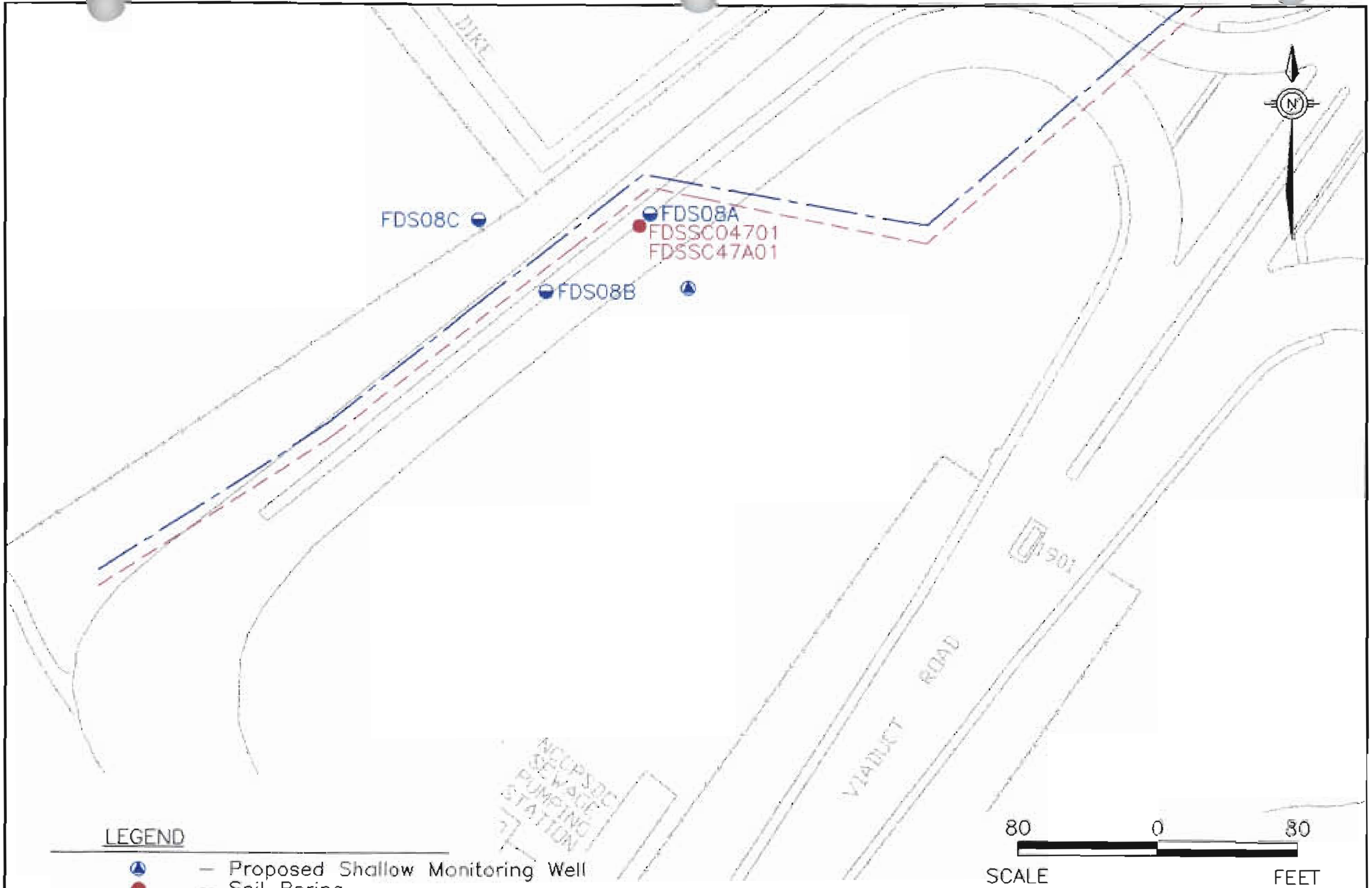

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FIGURE 5-4
AREA 8
PROPOSED GROUNDWATER SAMPLE LOCATIONS

DWG DATE: 07/13/98 | DWG NAME: 2907N049

No free-phase petroleum was observed in any of the combined area monitoring wells. The only RBSL exceeded in the site groundwater samples was the total PAHs detached in well FDS06B. A comparison of first and second sampling event analytical results shows a significant reduction in total PAHs.

To fill a potential data gap, an additional shallow well is proposed downgradient of soil sample FDSSC01201. This well is intended to determine if the benzene and total naphthalenes in soil are leaching to groundwater. Figure 5-2 also shows the proposed location of this well. In addition, all wells in the combined area will be resampled for RBSL parameters and water levels recorded. If PAH concentrations remain above the RBSL, a human health risk assessment will be performed to determine if the groundwater poses an unacceptable risk. If risk exceeds the 10^{-6} threshold, groundwater remediation will be recommended. If risk is below acceptable levels, intrinsic remediation with monitoring will be recommended.

5.3 Area 7

Area 7 exhibits no attributable soil contamination associated with the FDS. No soil RBSLs were exceeded at location FDSSC00301. Comparison of arsenic at this location to its site-specific SSL reveals a leaching threat to shallow groundwater. However, arsenic concentrations detected in Area 7 groundwater samples were all below both the groundwater RBSL and Zone G shallow groundwater background concentration for arsenic.

No free-phase petroleum was observed in Area 7 monitoring wells. The RBSLs for total PAHs and four individual PAHs were exceeded in well FDS07D, which is upgradient (approximately 100 feet) of the FDS pipeline corridor. This well is also upgradient of RFI sites SWMUs 6 and 7 and AOC 635. This is the only Area 7 well exhibiting RBSL exceedences, the source of which is unknown. Because of the distance from the FDS, no soil borings were advanced to correlate potential soil contamination with the parameters detected in FDS07D.

Additional assessment, is recommended at Area 7. Surface and subsurface soil samples should be collected, as shown on Figure 5-3, to identify a source. Also one of these borings should be converted to a shallow monitoring well to quantify upgradient water quality. A comprehensive water level measurement should also be performed at Area 7 and adjacent RFI wells to confirm the groundwater flow regime. Once the new well is installed and developed, all Area 7 wells should be resampled and analyzed for SVOC parameters. Further recommendations will depend on the results of the activities proposed.

5.4 Area 8

Area 8 exhibits limited soil contamination attributable to the FDS. Total naphthalenes at FDSSC47A01 was the only soil RBSL exceedance detected. Intrinsic corrective action is recommended for Area 8 soil.

No groundwater RBSLs were exceeded during the second, most recent sampling event. Comparison of first and second event analytical results reveals a significant decrease in individual and total PAHs. An additional shallow monitoring well is proposed to determine if SVOCs have impacted groundwater downgradient of FDSSC47A01. Figure 5-4 presents the proposed well location. This new well will be sampled for RBSL parameters only, and an Area 8 comprehensive water level measurement will be performed. If sampling results are below RBSLs, no further action will be recommended for Area 8 groundwater. If concentrations exceed RBSLs, a human health risk assessment will be performed.

5.5 Areas 9 and 10

Areas 9 and 10 exhibit very limited soil contamination potentially attributable to the FDS. The total naphthalenes concentration of 250 μg/kg detected at FDSSC05801 only slightly exceeded the

RBSL of 210 μg/kg. This was the only soil exceedance at the combined site. Intrinsic remediation is recommended to address the total naphthalenes detected in soil. No groundwater RBSLs were exceeded. No further action is recommended for groundwater at the combined site.

5.6 Area 11

Area 11 exhibits no soil or groundwater contamination attributable to the FDS. No soil or groundwater RBSLs were exceeded in any Area 11 samples. No further action is recommended for soil and groundwater in this area.

5.7 Areas 12, 13, and 14

Areas 12, 13, and 14 exhibit limited soil contamination attributable to the FDS. The soil RBSL for total naphthalenes was exceeded at only two locations. No other soil RBSL was exceeded. No individual naphthalene SSLs were exceeded, suggesting low probability of leaching to groundwater. Intrinsic corrective action is recommended to address the soil at Areas 12, 13, and 14.

The groundwater RBSL for arsenic was exceeded in the second sampling event at one Area 13 well, FDS13A. A preliminary risk assessment determined a risk to human health of approximately 5E-03 based on this single arsenic detection. When compared to the previous arsenic concentration at this well, the detection of 210 μg/L seems anomalous. No other groundwater RBSLs were exceeded in any of the Areas 12, 13, and 14 monitoring wells. Although wells FDS13B and FDS14B are directly downgradient of the soil locations that exhibited elevated total naphthalenes, neither of these wells detected any naphthalene compounds. Monitoring well FDS13A should be resampled for arsenic, if the result is below the RBSL no further action will be recommended for groundwater.

5.8 Area 15

Area 15 exhibits no soil or groundwater contamination associated with the FDS. No surface soil or groundwater RBSLs were exceeded in any of the Area 15 samples. No further action is recommended for soil and groundwater at Area 5.

5.9 Area 18

Area 18 exhibits no soil or groundwater contamination attributable to the FDS. No soil or groundwater RBSLs were exceeded in this area. No further action is recommended for Area 18 soil and groundwater.

5.10 Area 19

Soil contamination related to the former UST is documented by previous investigations at Area 19, however, the impact on groundwater quality has not been determined. Additional assessment of soil and groundwater at this site is recommended to assess the UST's impact. Prior to initiation of assessment activities, a contamination assessment plan will be developed and submitted to SCDHEC for approval. The results and recommendations from this assessment will be included in either the final CAR or an addendum.

5.11 Area 20

Soil contamination related to the former UST is documented by previous investigations at Area 20, but the impact on groundwater quality has not been determined. Additional assessment of soil and groundwater at this site is recommended to assess the UST's impact. Before such assessment begins, a contamination assessment plan will be developed and submitted to SCDHEC for approval. The results and recommendations from this assessment will be included in either the final CAR or an addendum.

6.0 REFERENCES

EnSafe/Allen & Hoshall (E/A&H). (June 6, 1995). *Final RCRA Facility Assessment for Naval Base Charleston.* Prepared for Department of the Navy, Southern Division Naval Facilities Engineering Command: Charleston, SC. Contract N62467-89-D-0318.

E/A&H. (June 13, 1996). *Final Zones D, F, and G RFI Work Plan.* Prepared for Department of the Navy, Southern Division Naval Facilities Engineering Command: Charleston, SC. Contract N62467-89-D-0318.

E/A&H. (July 30, 1996a). *Final Comprehensive Sampling and Analysis Plan RCRA Facility Investigation* (Revision No: 02). Prepared for Department of the Navy, Southern Division Naval Facilities Engineering Command: Charleston, SC. Contract N62467-89-D-0318.

E/A&H. (July 30, 1996b). *Final Comprehensive RCRA Facility Investigation Work Plan.* Prepared for Department of the Navy, Southern Division Naval Facilities Engineering Command: Charleston, SC. Contract N62467-89-D-0318.

EnSafe. (December, 1997). *Draft Zone F RCRA Facility Investigation Report.* Prepared for Department of the Navy, Southern Division Naval Facilities Engineering Command: Charleston, SC. Contract N62467-89-D-0318.

EnSafe. (February, 1998). *Draft Zone G RCRA Facility Investigation Report.* Prepared for Department of the Navy, Southern Division Naval Facilities Engineering Command: Charleston, SC. Contract N62467-89-D-0318.

Naval Facilities Engineering Service Center (NFESC). (April, 1996). *Site Characterization at Naval Base Charleston, Charleston, South Carolina.*

Park, A. Drennan. (1985). *The Groundwater Resources of Charleston, Berkeley, and Dorchester Counties, South Carolina.* State of South Carolina Water Resources Commission Report, Number 139.

S&ME, Inc. (May, 1992). *Report of the Soil Sampling and Analysis, Environmental Specifications Preparation, 800 foot, 18-inch Fuel Pipeline, Charleston Naval Supply Center.*

South Carolina Department of Health and Environmental Control (SCDHEC). (May 4, 1990). *Hazardous Waste Permit Number: SCO 170 022 560.* Issued for the Charleston Naval Shipyard by the Office of Environmental Quality Control, Bureau of Solid and Hazardous Waste Management.

SCDHEC. (January 5, 1998). *South Carolina Risk-Based Corrective Action for Petroleum Releases.* Bureau of Underground Storage Tank Management.

South Carolina SEA Grant Consortium. (1992). Untitled.

Supervisor of Shipbuilding, Conversion and Repair, USN, (SUPSHIP) Portsmouth, VA. (May, 1997). *Completion Report, Interim/Stabilization Measure for AOC 626 (Fuel Farm) Naval Base Charleston, Charleston, South Carolina.*

SUPSHIP. (July 1997). *Underground Storage Tank Assessment Report, Charleston Naval Base Complex, Building 148.*

United States Environmental Protection Agency (USEPA). (November 1995). Supplemental Guidance to RAGS: Region IV Bulletins *Human Health Risk Assessment*, Bulletin 2.

USEPA. (May 1996a). *Environmental Compliance Branch Standard Operating Procedures and Quality Assurance Manual.* Environmental Services Division, College Station Road, Athens, Georgia.

USEPA. (May 1996b). *Soil Screening Guidance: Technical Background Document.* OSWER-9355.4-1A, EPA/5401R-95/128.

USEPA. (October 22, 1997). *Risk Based Concentration Table.*

Weems, R.E. and Lemon, E.M. (1993). *Geology of the Cainhoy, Charleston, Fort Moultrie, and North Charleston Quadrangles, Charleston and Berkley Counties, South Carolina.* USGS Survey Map I-1935.