DRAFT REPORT

INSTALLATION RESTORATION STUDY
NAVAL SUBMARINE BASE - NEW LONDON
GROTON, CONNECTICUT

SECTION 1.0 INTRODUCTION
SECTION 2.0 SITE INVESTIGATION
SECTION 3.0 CHARACTERISTICS OF STUDY AREA

PREPARED FOR:

NORTHERN DIVISION
NAVAL FACILITIES ENGINEERING COMMAND
PHILADELPHIA, PENNSYLVANIA

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ATLANTIC PROJECT NO.: 1256-10
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ATLANTIC
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GLOSSARY	
ARARs	Applicable or Relevant and Appropriate Requirements
CBU	Construction Battalion Unit
CERCLA	Comprehensive Environmental Response, Compensation and Liability Act
CLP	Contract Laboratory Program
CRDL	Contract Required Detection Limit
CRQL	Contract Required Quantitation Limit
CTDEP	Connecticut Department of Environmental Protection
DDTR	DDT and residues
DQO	Data Quality Objective
DRMO	Defense Reutilization and Marketing Office
EIC	Engineer in Charge
EM	Electromagnetic
ESQD	Explosive Safety Quantity Distance
GC	Gas Chromatograph
gpd/ft^2	Gallons per day per square foot
gpm	Gallons per minute
GPR	Ground Penetrating Radar
IAS	Initial Assessment Study
IDL	Instrument Detection Limit
IR	Installation Restoration
MCL	Maximum Contaminant Level
MEK	Methyl Ethyl Ketone
NGVD	National Geodetic Vertical Datum

GLOSSARY

NACIP	Navy Assessments and Control of Installation Pollutants
NEESA	Naval Energy and Environmental Support Activity
NESO	Navy Environmental Support Office
NTUs	Nephelometric Turbidity Units
OBDA	Over Bank Disposal Area
OBDANE	Over Bank Disposal Area Northeast
PAHs	Polynuclear Aromatic Hydrocarbons
PCBs	Polychlorinated Biphenyls
PM10	Concentration of suspended particulate matter in air for a particle size fraction of ten microns or less.
POC	Point of Contact
ppb	parts per billion
ppm	parts per million
PVC	Polyvinyl Chloride
QA/QC	Quality Assurance/Quality Control
RCRA	Resource Conservation and Recovery Act
RI/FS	Remedial Investigation/Feasibility Study
RPD	Relative Percent Difference
RQD	Rock Quality Designation
SARA	Superfund Amendment and Reauthorization
SCS	Soil Conservation Service
SVOs	Semi-Volatile Organics
TAL	Target Analyte List

GLOSSARY	
TIC	Tentatively Identified Compounds
TRC	Technical Review Committee
TBC	"To be considered" values
TCLP	Toxicity Characteristic Leachate Procedure
TPH	Total Petroleum Hydrocarbons
USEPA	United States Environmental Protection Agency
USGS	United States Geological Survey
VOAs	Volatile Organic Compounds

1.0 INTRODUCTION

On May 15, 1990, Atlantic Environmental Services, Inc. (Atlantic) was retained by the Department of the Navy, Northern Division-Naval Facilities Engineering Command, Philadelphia, Pennsylvania to conduct an Installation Restoration (IR) Study at the Naval Submarine Base-New London (NSB-NLON) located in Groton, Connecticut. The work included tasks outlined in the Statement of Work for Architect/Engineer Contract N62472-88-C-1294 dated May 16, 1988.

This IR Study was conducted in accordance with the Final Plan of Action prepared by Atlantic and dated April 1989. The Plan of Action included a Field Sampling Plan, a Health and Safety Plan, and a Quality Assurance/Quality Control Plan.

On August 28, 1990, during the course of this study, NSB-NLON was placed on the National Priorities List (NPL) by the U.S. Environmental Protection Agency (USEPA), pursuant to the Comprehensive Environmental Response, Compensation and Liability Act (CERCLA) of 1980. The NPL, or Superfund list, is USEPA's data base of uncontrolled or abandoned hazardous waste sites identified for priority remedial actions which meet or surpass a predetermined hazardous ranking system score.

The IR consists of two levels of investigation and evaluation. The Step I Site Inspection phase is applicable to seven of the eleven identified sites at NSB-NLON. The objectives of the site inspection (Step I) are to determine the presence or absence, as well as the order of magnitude, of specific toxic or hazardous contaminants, or other contaminants which may be present in concentrations considered to be an environmental risk. Step I includes an initial field sampling program to identify if contamination is present onsite and warrants a Step II remedial investigation.

The Step II Remedial Investigation/Feasibility Study (RI/FS) is applicable to the remaining four sites, where onsite contamination was identified in previous investigations. Step II involves comprehensive onsite investigations in order to determine the extent of contamination, assess health and environmental risks and evaluate remediation alternatives.

Specific Step I and Step II sites are listed and described in subsequent sections of this report.

Atlantic's point of contact (POC) at NSB-NLON for this project is Mr. William Mansfield, Head of Environmental Branch. Ms. Adrienne Townsel is the Engineer-in-Charge (EIC) representing the Northern Division of the Naval Facilities Engineering Command, Philadelphia, Pennsylvania. Paul Marchessault is the Project Manager for the USEPA. A Technical Review Committee (TRC) was established and provided review and guidance throughout the project. TRC members are listed below.

Mr. W. Haas, Town Planner Town of Ledyard	Mr. Robert Fromer LEAF
Mr. Thomas Wagner Town of Waterford	Mr. Ronald Ochsner Citizen
Mr. Eugene A. Cioffi Citizen	Mr. Remy H. Davis City of New London

Mr. Chuck McGuire
CINCLANTFLT (N4423A)

Ms. Adrienne Townsel
NORTHNAVFACENGCOM (Code 14)

Ms. Deborah Jones
Wetlands Planner
Town of Groton

Norman Richards, Ph.D.
Environmental Consultant
City of Groton

Dr. Clifford Striba
Director of Health
Uncas Health District

CDR Nelson G. Goddard
Public Works Officer
Naval Submarine Base New London

Mr. Paul Jameson
Site Remediation and Closure
Waste Management Branch
Connecticut DEP

Mr. Richard Massad
Environmental Engineer
Naval Submarine Base New London

Mr. William Mansfield
Director, Environmental Office
Naval Submarine Base New London

Mr. Paul Burgess
Atlantic Environmental Services, Inc.

1.1 Purpose of Report

The purpose of this IR report is to present a description of the remedial investigation, the findings of that investigation, and an assessment of those findings in terms of risks to public health and the environment.

The Feasibility Study (FS), an evaluation of alternatives for remediation of the Step II sites, will be presented under separate cover.

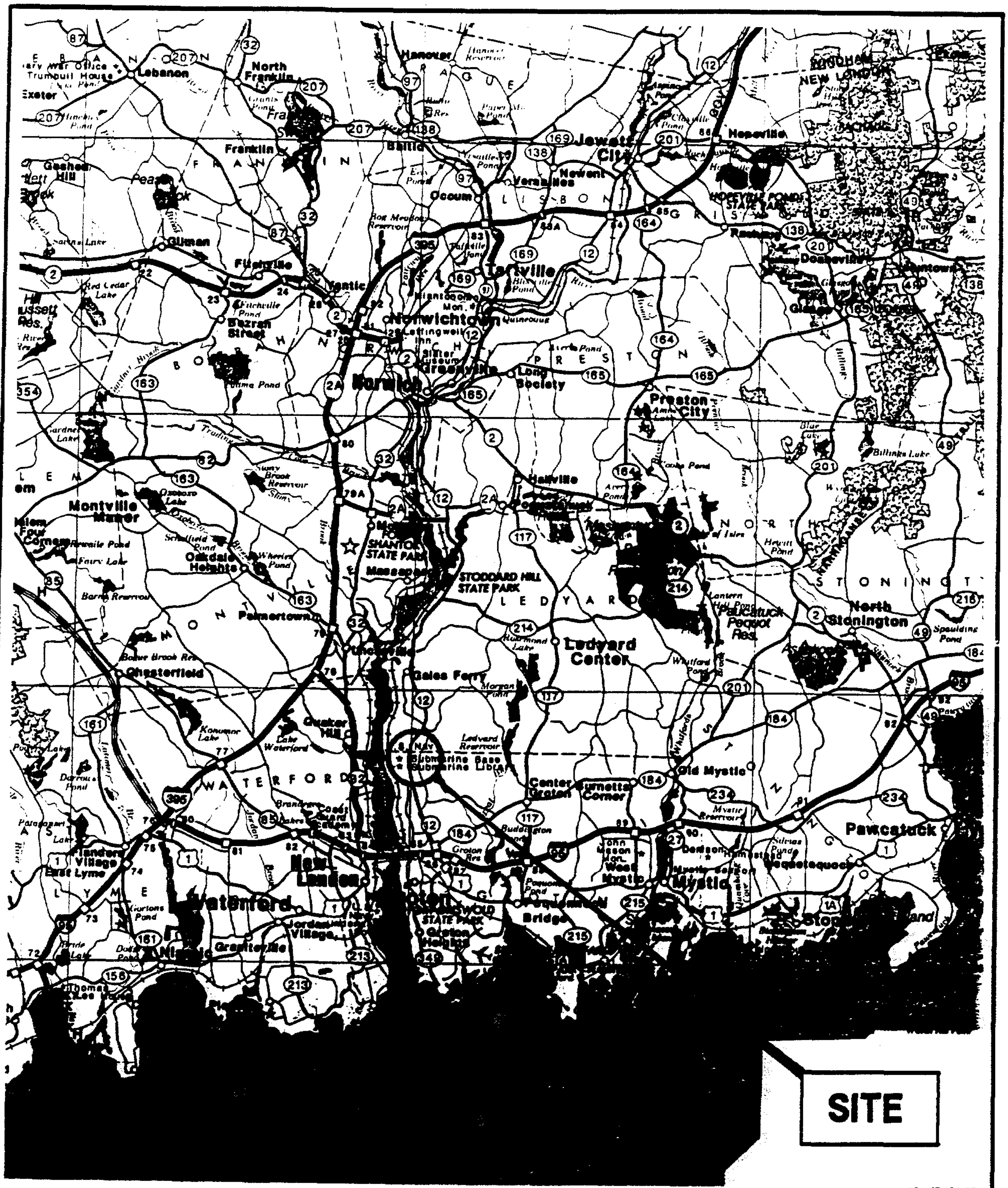
1.2 Site Background

This section of the report provides a description of the site location and area land use. A discussion of the area water quality classifications and water supply is also provided. This is followed by a general description of the Subase history, and a detailed description of each site investigated.

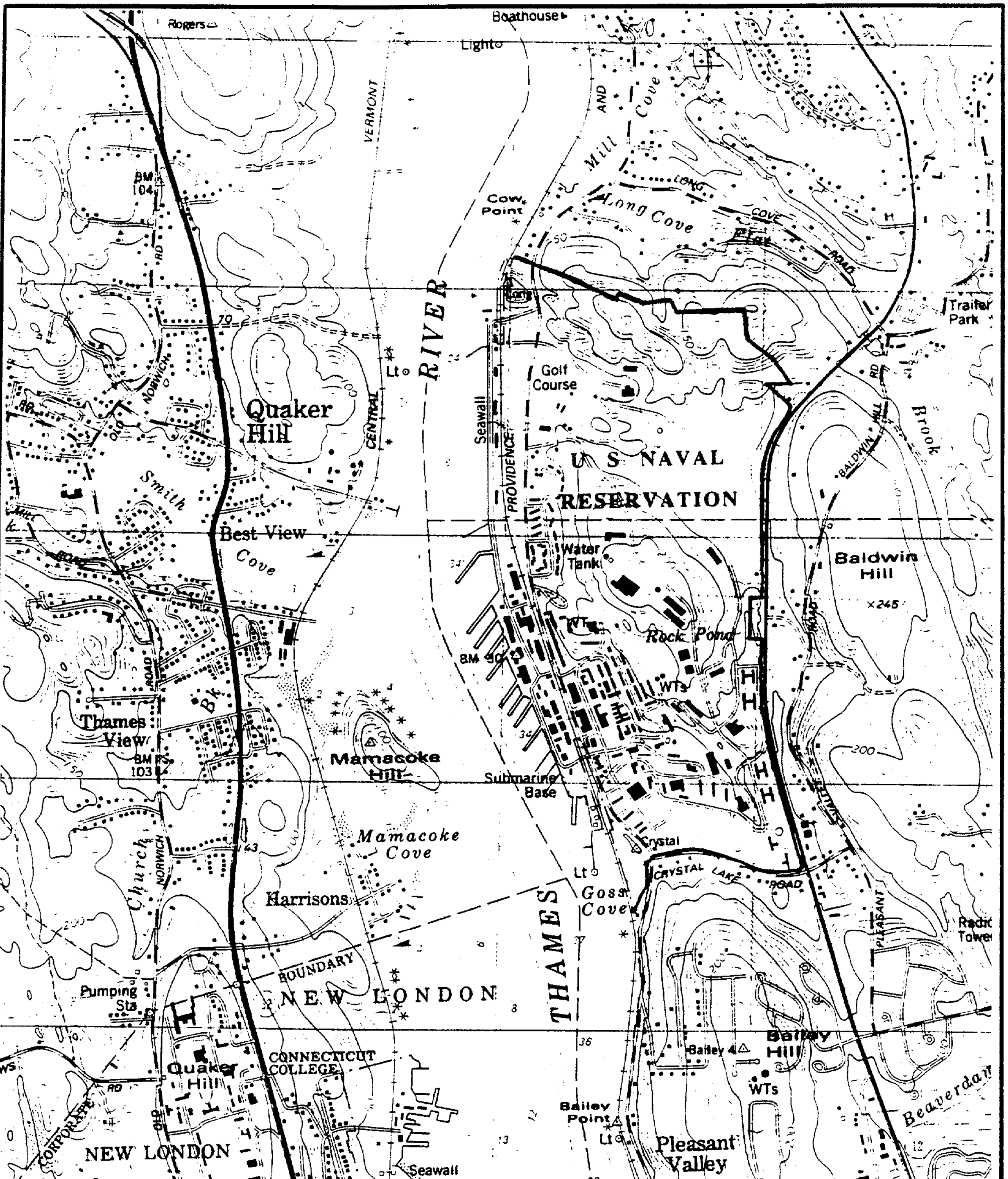
1.2.1 Site Location

The NSB-NLON consists of approximately 547 acres of land and associated buildings in southeastern Connecticut in the Towns of Ledyard and Groton. NSB-NLON is situated on the east bank of the Thames River approximately six miles north of Long Island Sound. Figures 1-1 and 1-2 show the site vicinity and the site location, respectively.

The site is bounded to the east by Connecticut Route 12, to the south by Crystal Lake Road, and to the west by the Thames River. The northern border is a low ridge that trends approximately east-southeast from the river to Baldwin Hill.



INSTALLATION RESTORATION STUDY NAVAL SUBMARINE BASE - NEW LONDON GROTON, CT	SOURCE: R.R. Donnelley & Sons Co. 1986 N 0 1 SCALE OF MILES	FIGURE 1-1 SITE VICINITY ATLANTIC ENVIRONMENTAL SERVICES, INC.



INSTALLATION RESTORATION STUDY NAVAL SUBMARINE BASE - NEW LONDON GROTON, CT	SOURCE: Uncasville, Ct. U.S.G.S. Topographic Map 1984 N 0 1000 2000' SCALE	FIGURE 1-2 SITE LOCATION ATLANTIC ENVIRONMENTAL SERVICES, INC.

1.2.2 Site and Area Land Use

NSB-NLON currently provides a base command for naval submarine activities in the Atlantic Ocean. Additionally, NSB-NLON includes housing for Navy personnel and their families, submarine training facilities, military offices, medical facilities, and facilities designed for the maintenance, repair, and overhaul of submarines.

Land use adjacent to the site is generally residential or commercial. Adjacent land use is shown on Figure 1-3. Residential development along Military Highway, Sleepy Hollow, Long Cove Road and Pinelock Drive borders the site to the north and extends north into the Gales Ferry section of Ledyard. Property along Route 12 to the east of the site consists of widely-spaced private homes and open, wooded land. Farther south on Route 12, development is mixed commercial and residential, and includes a church, automobile sales and repair facilities, convenience stores, restaurants, and a gas station. Private residences and an automobile service station are located along the south side of Crystal Lake Road; farther south is housing for Navy personnel.

1.2.3 Water Quality Classifications and Water Supply

1.2.3.1 Water Quality Classifications

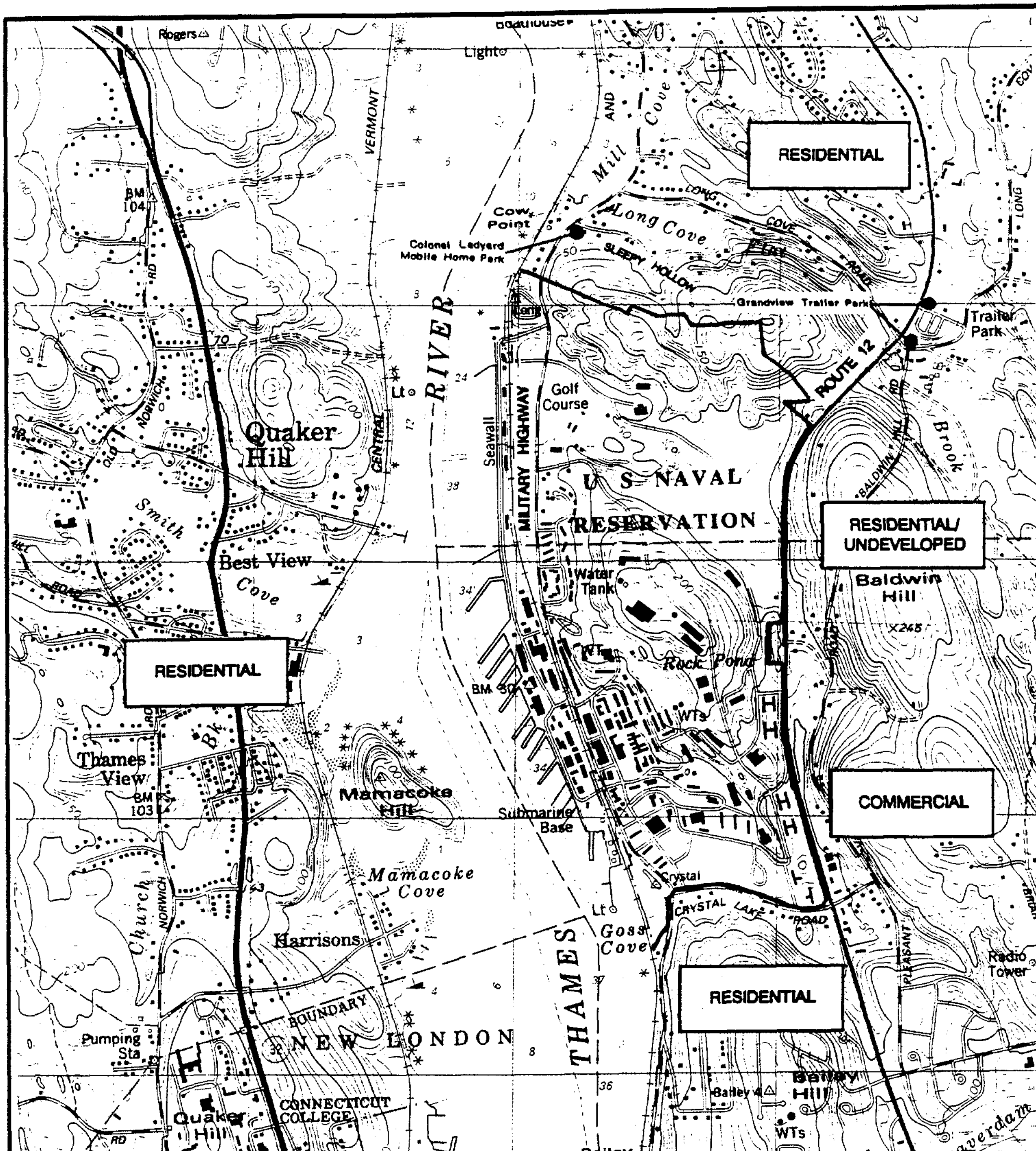
The State of Connecticut Department of Environmental Protection (CTDEP) has classified the Thames River quality as SC/SB. This classification indicates the following characteristics: good aesthetic value, suitable for fish, shellfish, and wildlife habitat; suitable for industrial cooling; and suitable for recreational boating and, in some places, bathing. This classification signifies that the Thames River is not meeting the water quality criteria goal of SB for one or more designated uses due to pollution (CTDEP, 1988).

The CTDEP has classified the ground waters beneath the central and southern portions of the site as GB/GA. A classification of GB/GA indicates that the ground water may not be suitable for direct human consumption without treatment due to waste discharges, spills, chemical leaks, or land use impacts. GB/GA waters may be useful for industrial process waters or cooling waters. The immediate goal, where appropriate, is to maintain the water at Class B condition; the long term goal is to restore the water to drinking water quality (GA).

The ground water beneath the north portion of NSB-NLON is classified by CTDEP as GA. Sites included on the north portion of NSB-NLON include the DRMO, and the Area A Landfill and adjacent sites. The GA classification signifies ground waters presumed suitable for direct human consumption without the need for treatment. The CTDEP's goal is to maintain drinking water quality.

1.2.3.2 Water Supply

The Groton Water Department supplies potable water to NSB-NLON. The primary source of the Groton water supply is reservoirs which are supplemented with wells. The water supplies are located within the Poquonock River Watershed, located east of NSB-NLON, which is not within the NSB-NLON watershed.



INSTALLATION RESTORATION STUDY NAVAL SUBMARINE BASE - NEW LONDON GROTON, CT	SOURCE: Uncasville, Ct. U.S.G.S. Topographic Map 1984 N 0 1000 2000' SCALE	FIGURE 1-3 AREA LAND USE ATLANTIC ENVIRONMENTAL SERVICES, INC.

Homes on Route 12 adjacent to the northeast portion of the site have individual onsite drinking water wells, as do homes north of NSB-NLON on Sleepy Hollow, Long Cove Road, and Military Highway. Two trailer parks near the site have wells classified as public water supply wells. The Colonel Ledyard Mobile Home Park, located on Sleepy Hollow adjacent to the North Gate has a well that supplies between 15 and 20 families. The Grandview Trailer Park, located at the intersection of Long Cove Road and Route 12, has two water supply wells. There are several irrigation wells onsite at the golf course which have not been used for several years. The public water supply well locations are shown on Figure 1-3.

1.2.4 General Site History

In 1867, the State of Connecticut donated a 112-acre parcel on the east bank of the Thames River to the Navy. The Navy did not use the property until 1868 when it was officially designated a Navy Yard. The site was then used to moor small craft and obsolete warships, and as a coaling station for the Atlantic fleet.

The Navy Department designated the site a Submarine Base in 1916. During World War I, facilities at the base were expanded extensively; six piers and 81 buildings were added. In 1917, a Submarine School was established and in 1918 the Submarine Medical Center was founded.

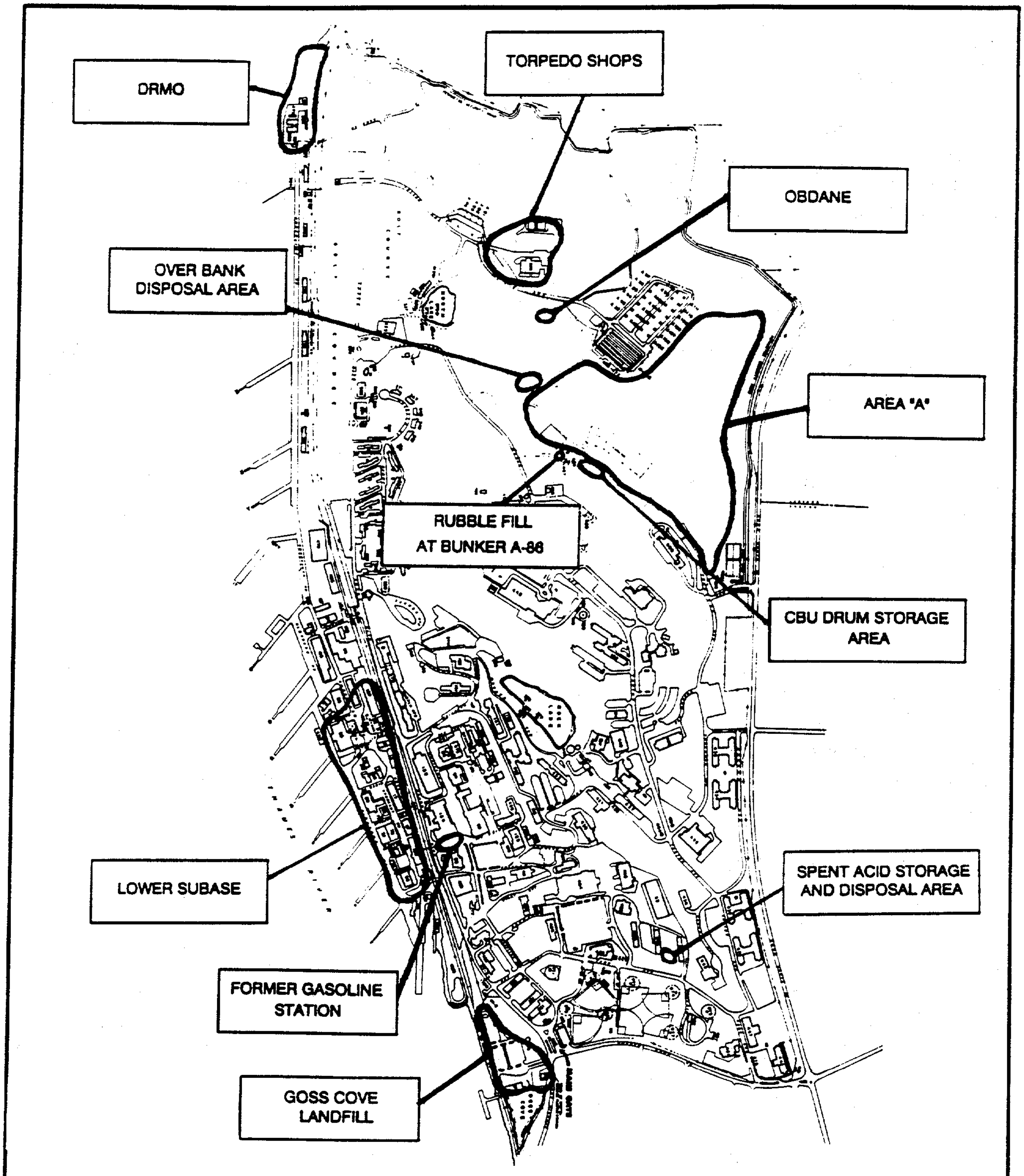
NSB-NLON experienced another period of growth during World War II. Between 1935 and 1945 the Navy built in excess of 180 buildings and acquired adjacent land to expand NSB-NLON from 112 to 497 acres of land.

The growth of NSB-NLON continued after World War II. The Medical Research Laboratory was established in 1946. In 1968 the status of the Submarine School was changed from an activity to a command and became the largest tenant on the base. The Naval Submarine Support Facility was established in 1974 and the Naval Undersea Medical Institute was established the following year. At present, NSB-NLON consists of over 300 buildings on 547 acres of land (U.S. Navy, 1988).

1.2.5 Site Descriptions

This section summarizes available information for each of the eleven sites investigated and includes details of past and future usage, findings of previous investigations (including chemical data where available), and observations made during site inspections. The sites are listed below and their locations are shown on Figure 1-4. Site numbers in parentheses refer to numbers assigned in a 1982 Initial Assessment Study (IAS) performed by Envirodyne Engineers, Inc. to identify and evaluate past hazardous waste disposal sites at NSB-NLON. The IAS study is discussed further in Section 1.2.6. Site numbers were used in this investigation primarily to identify analytical samples and are not repeated throughout the report.

Selected sites identified in the IAS report have been evaluated as part of this project. Two sites (Torpedo Shops and Former Gas Station) were added to the study. The Torpedo Shop was not recommended for further evaluation by the IAS report, however, the Navy felt that a Step I investigation was warranted. The Former Gasoline Station, not identified in the IAS report, was added as a Step I site.



INSTALLATION RESTORATION STUDY
NAVAL SUBMARINE BASE - NEW LONDON
GROTON, CT

SOURCE: Naval Submarine Base
Existing Conditions
April 1985
Loureiro Engineering Associates

FIGURE 1-4
INSTALLATION RESTORATION
SITES INVESTIGATED

ATLANTIC ENVIRONMENTAL SERVICES, INC.

Step I Sites

- Construction Battalion Unit (CBU) Drum Storage Area (Site 1)
- Rubble Fill at Bunker A-86 (Site 4)
- Torpedo Shops (Site 7)
- Goss Cove Landfill (Site 8)
- Over Bank Disposal Area Northeast (OBDANE) (Site 14)
- Spent Acid Storage and Disposal Area (Site 15)
- Former Gasoline Station (Site 18)

Step II Sites

- Area A (Site 2)
- Over Bank Disposal Area (Site 3)
- Defense Reutilization and Marketing Office (DRMO) (Site 6)
- Lower Subase (Site 13)

The site information which follows was developed from the IAS report, Atlantic's site inspection, and interviews with Navy personnel. Future land use and construction information was obtained from interviews with Mr. Joseph Simmons, Shore Facilities Planner.

1.2.5.1 CBU Drum Storage Area

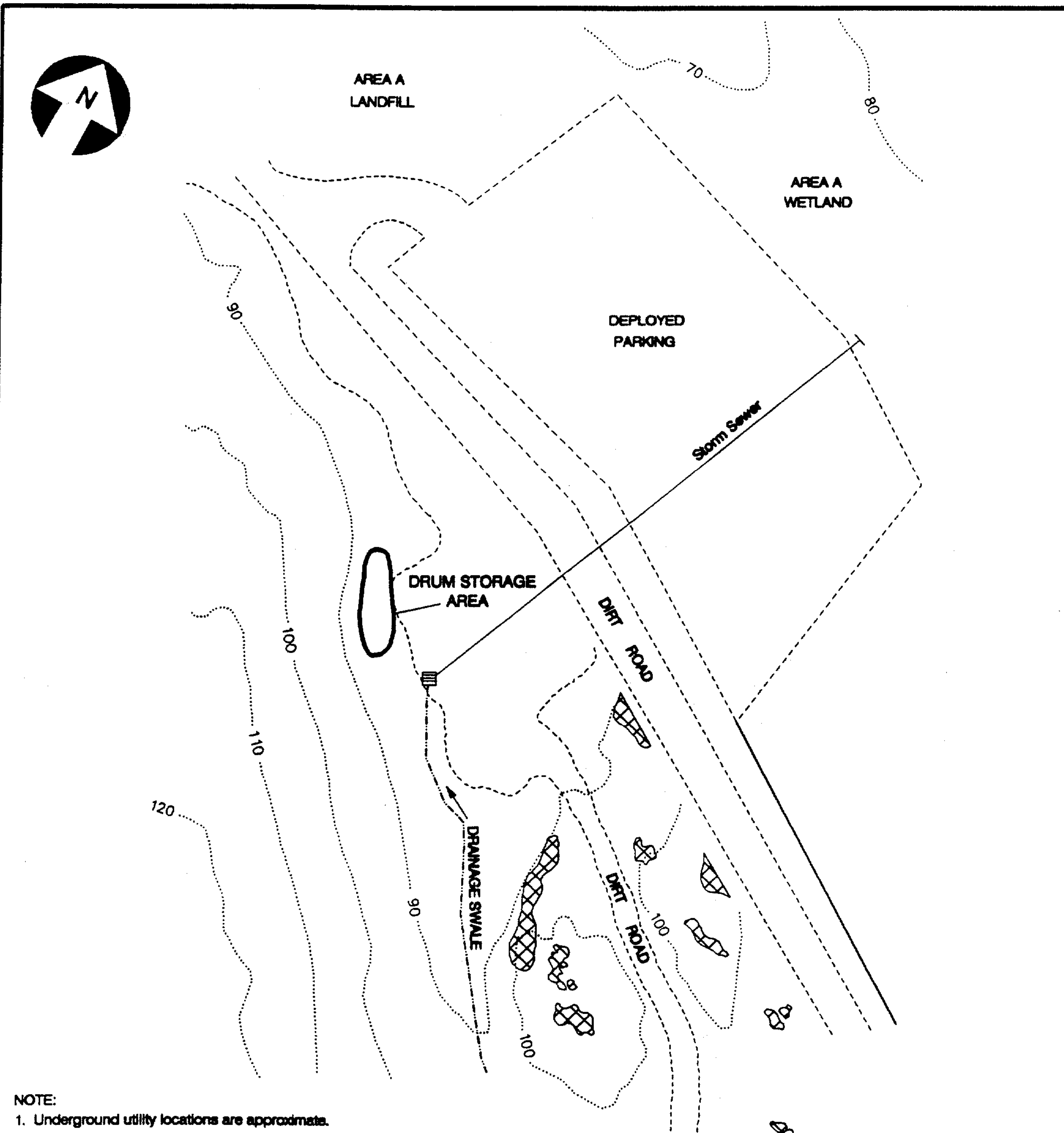
The Construction Battalion Unit (CBU) Drum Storage Area is located in the northern section of NSB-NLON adjacent to the deployed personnel parking lot and the Area A Landfill. Figure 1-5 shows site topography, drainage features, and utility information of this site. The site is situated on a flat, open area at the edge of a wooded hillside that slopes down toward the site at a 25 to 30 percent grade. The site is unpaved. Surface drainage from the site flows northeast across the unpaved deployed parking lot and into the Area A Wetland.

In 1982 the IAS identified twenty-six 55-gallon drums of waste oil, lube oil, and paint materials at the site. Some of the drums were leaking at that time. The IAS concluded that the site had not been used for several years.

Atlantic inspected the site on October 20, 1988 and observed two 55-gallon drums labeled as engine oil. No surface soil staining or stressed vegetation was evident. According to Mr. William Mansfield, the drums noted in the IAS report were removed and properly disposed of by the Navy; the two drums observed in 1988 subsequently have been removed.

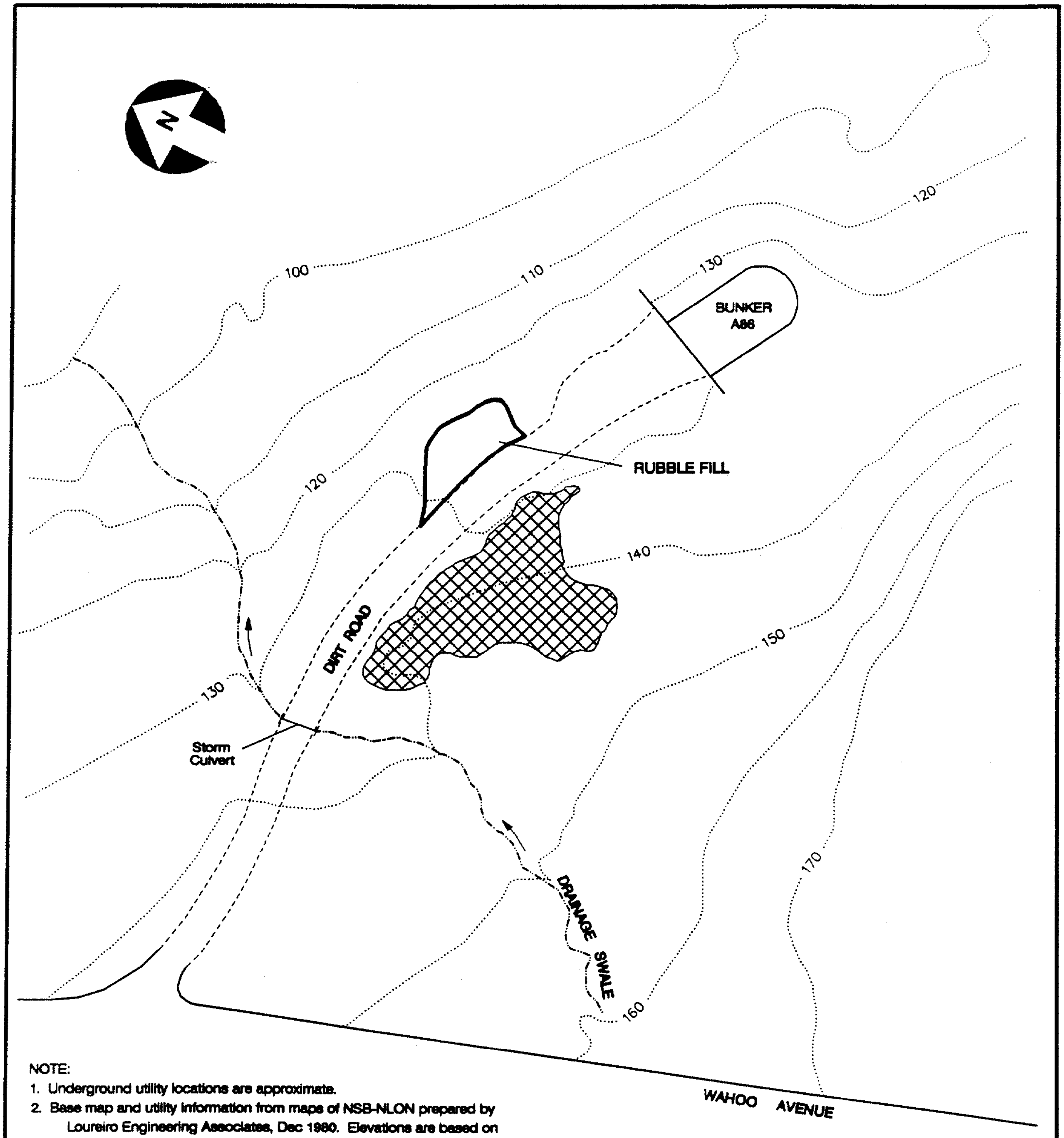
1.2.5.2 Rubble Fill at Bunker A-86

Bunker A-86 is located on a dirt road off Wahoo Avenue in the north central section of NSB-NLON. Area A landfill is adjacent to the north, and the Subase hazardous waste storage facility is adjacent to this site to the south. A site plan showing topography, drainage features, and utility information is shown as Figure 1-6. The rubble fill area is located to the north of the dirt road and to the west of the bunker. The site is on a wooded hillside that slopes down to the north-northeast at an approximately 30 percent grade. Surface drainage from this site also flows north-northeast toward the Area A landfill and wetland.



NOTE:
1. Underground utility locations are approximate.
2. Base map and utility information from maps of NSB-NLON prepared by Loureiro Engineering Associates, Dec 1980. Elevations are based on NSB-NLON datum which is 1.41 feet below NGVD.

INSTALLATION RESTORATION STUDY NAVAL SUBMARINE BASE - NEW LONDON GROTON, CT	LEGEND ·····95····· - Existing Grade (crosshatch) - Exposed Bedrock (symbol) - Catch Basin (shaded) - Building ——·——·—— - Watercourse Approximate Scale 0 20 40'	FIGURE 1-5 SITE PLAN CBU DRUM STORAGE AREA ATLANTIC ENVIRONMENTAL SERVICES, INC.



NOTE:
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INSTALLATION RESTORATION STUDY NAVAL SUBMARINE BASE - NEW LONDON GROTON, CT	LEGEND ·····95····· - Existing Grade Exposed Bedrock symbol - Exposed Bedrock Building symbol - Building - - - - - - - Watercourse Approximate Scale: 0 20 40'	FIGURE 1-6 SITE PLAN RUBBLE FILL AT BUNKER A86 ATLANTIC ENVIRONMENTAL SERVICES, INC.

The IAS report identified discarded construction materials including concrete, asphalt, an electric motor, tar buckets, wood, and gravel. The report concluded that material had not been disposed at this site for more than ten years before the date of the IAS inspection (1982).

Atlantic personnel inspected the site on October 20, 1988 and noted that the majority of the material present at that time was construction debris (wood and concrete products). Chemical containers found at the base of the fill during this inspection included an empty 5-gallon container of monothanolanine (labeled as a corrosive product), an empty 5-gallon container of thorite (labeled as non-shrinking compound for patching concrete) and a 55-gallon drum of lube oil that was approximately 10 percent full.

A parking lot is planned for the area south of Bunker A-86. Construction will include terracing and grading south of the bunker, but is not expected to disturb the subject site.

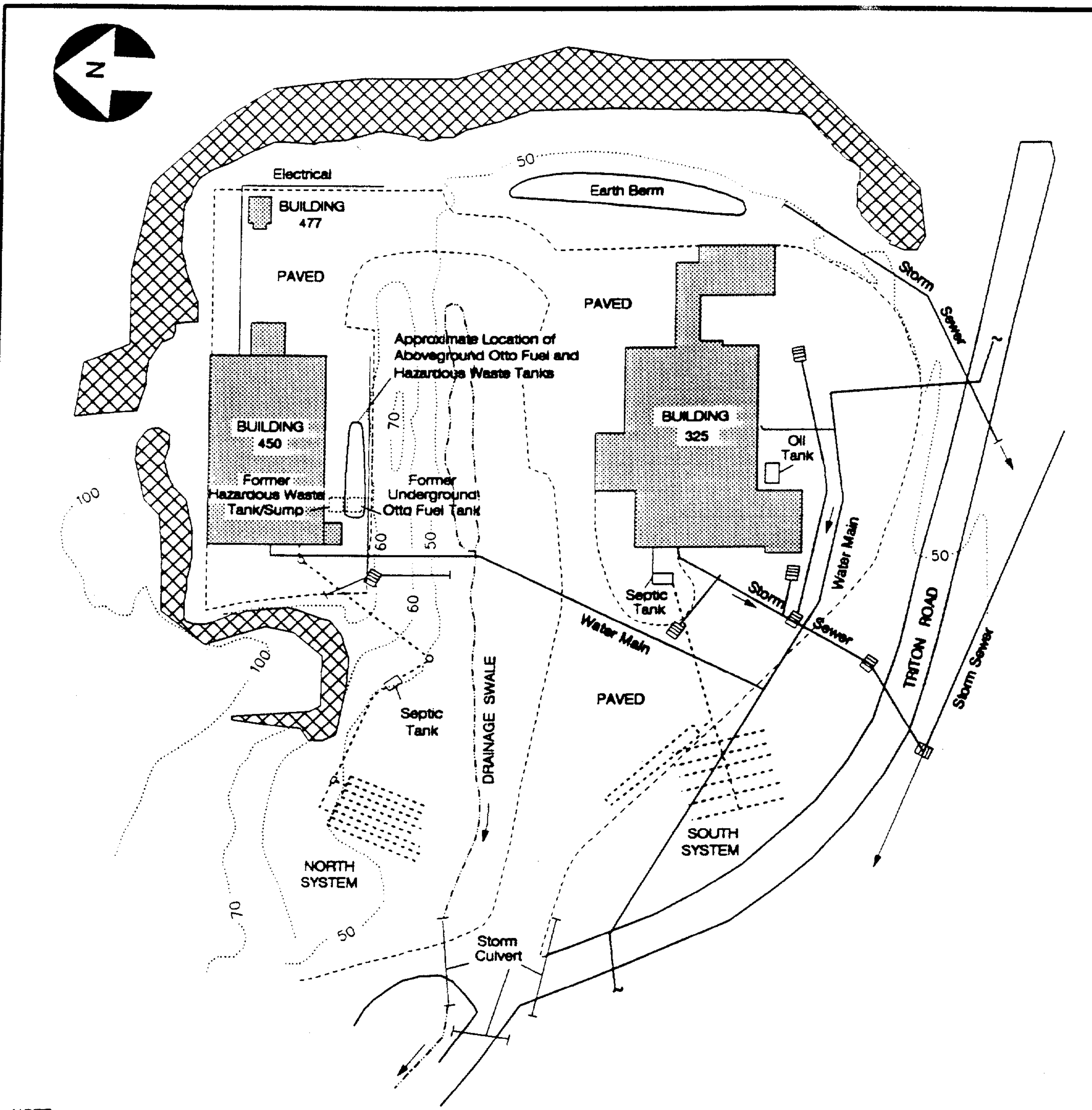
1.2.5.3 Torpedo Shops

The Torpedo Shops are located in the northern portion of NSB-NLON on the north side of Triton Avenue. Figure 1-7 shows topography, drainage features, and utility information. The site is bounded to the east and north by 60 foot high bedrock cliffs. The remainder of the site slopes down to the southwest. An earthen berm extends along the base of the eastern portion of the exposed rock face. Surface runoff from the site flows southwest to drainage swales and storm sewers located on the south side of Buildings 325 and 450. Runoff contained by the berm, as well as the storm sewer system, drains through culverts under Triton Avenue into the Area A downstream watercourses and eventually into the Thames River.

Building 325 is a torpedo overhaul facility. It was built in 1955 and had an onsite septic system until 1983, when all plumbing facilities were connected to sanitary sewers. The original septic field for Building 325 is located to the southwest of the building, adjacent to Triton Road. This leachfield became clogged in 1975 and was abandoned. A new leachfield was constructed next to the original distribution box and was used until sanitary sewers were installed in 1983. Fuels, solvents and petroleum products used in Building 325 may have been discharged to this septic system.

Atlantic personnel performed a visual inspection of Building 325 on March 20, 1989. According to interviews with onsite personnel, a variety of fuels, solvents and petroleum products have been used in the building. Otto fuel (a nitrated ester which produces hydrogen cyanide when burned), high octane alcohol (190 proof), and TH-Dimer (jet rocket fuel) were observed in maintenance areas. Solvents including mineral spirits, alcohol, and 1,1,1-trichloroethane and petroleum products such as motor oil and grease have been used in this building for weapons overhauls. A sink in one area was previously used for film development, and another sink was used for the overhaul of high alkaline batteries. This plumbing drained into the septic system onsite until 1983. The maintenance area has a shallow sump that is covered with a steel grating flush with the floor. The area surrounding this sump was previously a washdown/blowdown area for weapons; it is not known where this sump drains. An 8000-gallon underground fuel oil tank is located on the south side of this building.

A smaller attached building to the east was inspected. It had been used previously as an assembly shop for torpedoes and was a paint shop at the time of inspection. A storage closet in



NOTE:
1. Underground utility locations are approximate.
2. Base map and utility information from maps of NSB-NLON prepared by Loureiro Engineering Associates, Dec 1980. Elevations are based on NSB-NLON datum which is 1.41 feet below NGVD.

INSTALLATION RESTORATION STUDY
NAVAL SUBMARINE BASE - NEW LONDON
GROTON, CT

LEGEND

····95····· - Existing Grade	– – – – Former Septic System
- Exposed Bedrock	- Building
·–·–·–·–· - Watercourse	Approximate Scale 0 40 80'
- Catch Basin	

FIGURE 1-7
SITE PLAN
TORPEDO SHOPS

ATLANTIC ENVIRONMENTAL SERVICES, INC.

this building included containers of 1,1,1-trichloroethane and methyl ethyl ketone (MEK). Hazardous waste drums were stored outside on the east side of this building. The drums were labeled as containing propane, isobutane, MEK, xylot, methylene chloride, propellant, and zinc chromate.

An addition to the north side of Building 325 is under construction at present. Upon completion of the addition, the building will continue to be used as a torpedo shop.

Building 450 is the primary MK-48 torpedo overhaul/assembly facility. It was built in 1974 and was served by its own septic system until 1983, when it was connected to sanitary sewers. Such operations generate fuels, solvents, and petroleum products as wastes. An Otto fuel and seawater mixture is drained from the torpedoes which are then replenished with fresh fuel. The IAS study reported that Building 450 generates 2950 gallons per month of wastewater contaminated with Otto fuel. This building was constructed with a waste collection system which collected waste products from floor drains and discharged to a 1500± gallon underground waste tank/sump. The waste tank was pumped periodically and the contents were disposed of offsite. Otto fuel product was previously stored in a 4000-gallon underground tank south of Building 450. Onsite personnel report that solvents including 1,1,1-trichloroethane, trichloroethylene, toluene, mineral spirits, alcohol and bulk freon have been used at this facility. Petroleum products including TL-250 motor oil and hydraulic fluid have also been used in this building for torpedo maintenance. Building 477 was formerly used to store Otto fuel in drums. In the past, only domestic wastewater from toilets, lavatories, and showers in Building 450 was directed to the septic field.

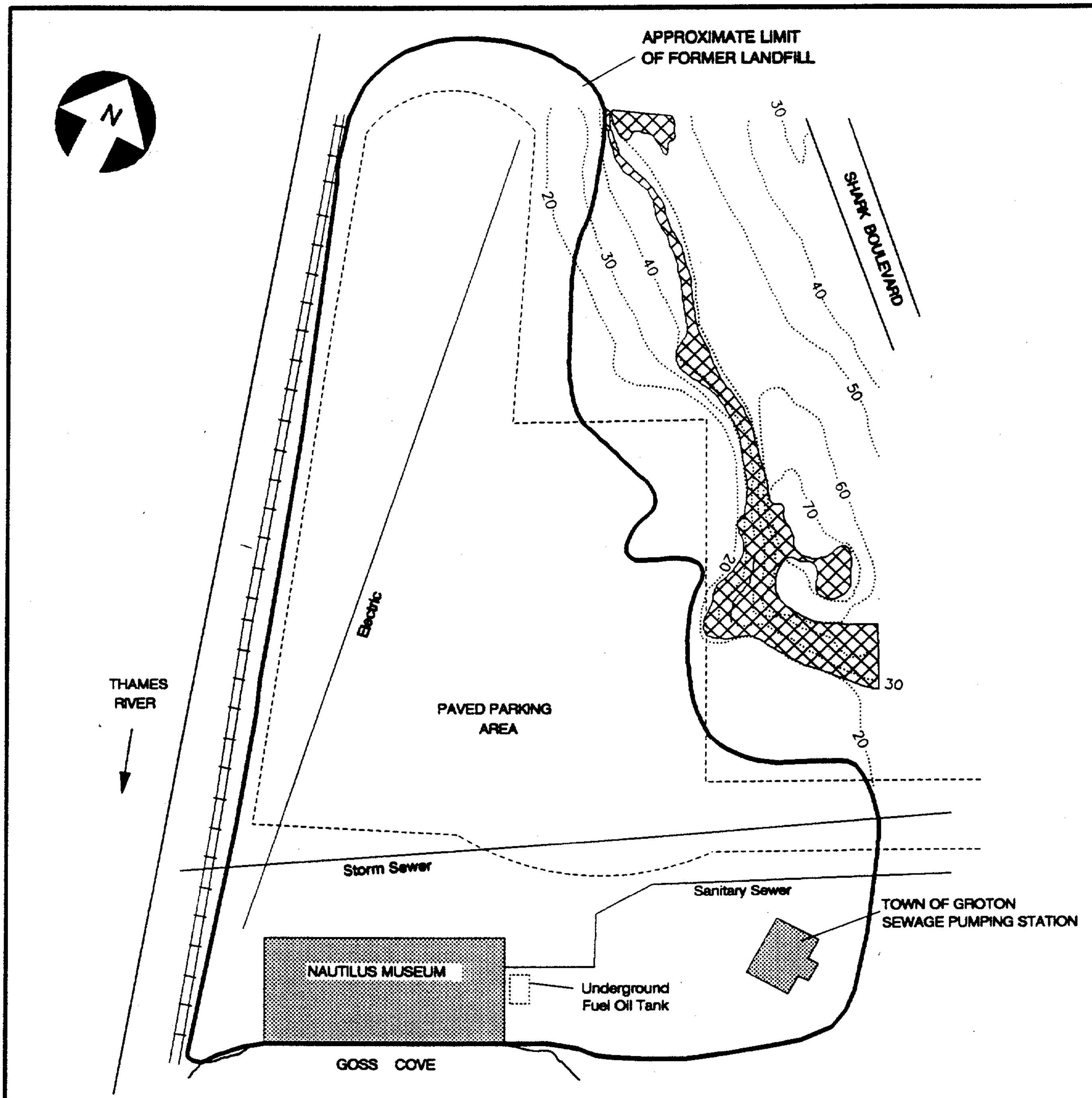
Atlantic personnel performed a site inspection of Building 450 on March 20, 1989. The former septic leachfield is located southwest of this building in a flat elevated area just east of Ammunition Bunker A-91. The hazardous waste sump was no longer in use and, reportedly, had been deactivated in 1987. It was replaced with three 1000-gallon above ground tanks to the south of the building. The floor drains were sealed and replaced with a new system for pumping waste products to the new tanks. A 4000-gallon above ground storage tank for Otto fuel is located to the south of the building, replacing the previous tank.

No construction is planned for the immediate future at Building 450.

1.2.5.4 Goss Cove Landfill

The Goss Cove Landfill site is located in the southwest portion of NSB-NLON, adjacent to the Thames River. It is west of the intersection of Crystal Lake Road and Military Highway, east of the Thames River and north of Goss Cove. Figure 1-8 is a site plan showing site development, topography, drainage features, and utility information. The Nautilus Museum and a paved parking lot are constructed directly over the site of the former landfill. The Nautilus Museum is a submarine museum operated by the Navy and open to the public.

The IAS report indicates that a landfill was operated onsite from 1946 until 1957. Incinerator ash and inert rubble were disposed at the site, in what was then the northern portion of Goss Cove. It is not known what other materials may have been disposed in the landfill. Mr. William Mansfield reported that several large compressed gas cylinders were uncovered during the excavation of a utility trench in the parking area north of the Nautilus Museum building. One of the tanks was leaking propane, one was filled with ammonia, and the others were empty.



NOTE:
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2. Base map and utility information from maps of NSB-NLON prepared by Loureiro Engineering Associates, Dec 1980. Elevations are based on NSB-NLON datum which is 1.41 feet below NGVD.

INSTALLATION RESTORATION STUDY NAVAL SUBMARINE BASE - NEW LONDON GROTON, CT	LEGEND ·····95····· - Existing Grade (crosshatch) - Exposed Bedrock	- Building Approximate Scale 0 20 40'	FIGURE 1-8 SITE PLAN GOSS COVE LANDFILL ATLANTIC ENVIRONMENTAL SERVICES, INC.

Atlantic personnel reviewed archive photographs for the Goss Cove area available at the Connecticut State Library. In the 1934 aerial photograph, the original limits of Goss Cove appear to be open water with no evidence of fill. The railroad tracks are shown at their present position between the cove and the Thames River. In 1951 aerial photographs, the fill extends south approximately to the location of the current access driveway to the museum. The 1965 aerial photographs show the landfill extending to the present limit of encroachment on Goss Cove. Aerial photographs from 1965, 1970, 1975, and 1980 show cars parked on the landfill surface. In the 1986 photographs, the Nautilus Museum is present on the southern limits of the landfill and a paved parking area extends over the remaining limit of the landfill to the north.

Atlantic personnel reviewed boring logs prepared for the construction of the Nautilus Museum. The boring logs note the presence of fill material consisting of cinders, metal, brick, glass, and sand and gravel, and extending to a depth of fifteen feet. Beneath the fill is a layer of organic silt approximately ten to fifteen feet thick; this material is likely the sediments from the bottom of the former cove. The silt is underlain by fine sand to depths ranging from 25 to 100 feet below the surface. The thickness of overburden increases from east to west.

Construction projects planned at the Goss Cove site include a new storm sewer under the parking lot, an addition onto the east side of the building, and a pumping station east of the building. The Town of Groton is opening a public park on Goss Cove, along Military Highway south of the site. There will be access to the Nautilus Museum from the park via a wooden walkway.

1.2.5.5 Over Bank Disposal Area Northeast (OBDANE)

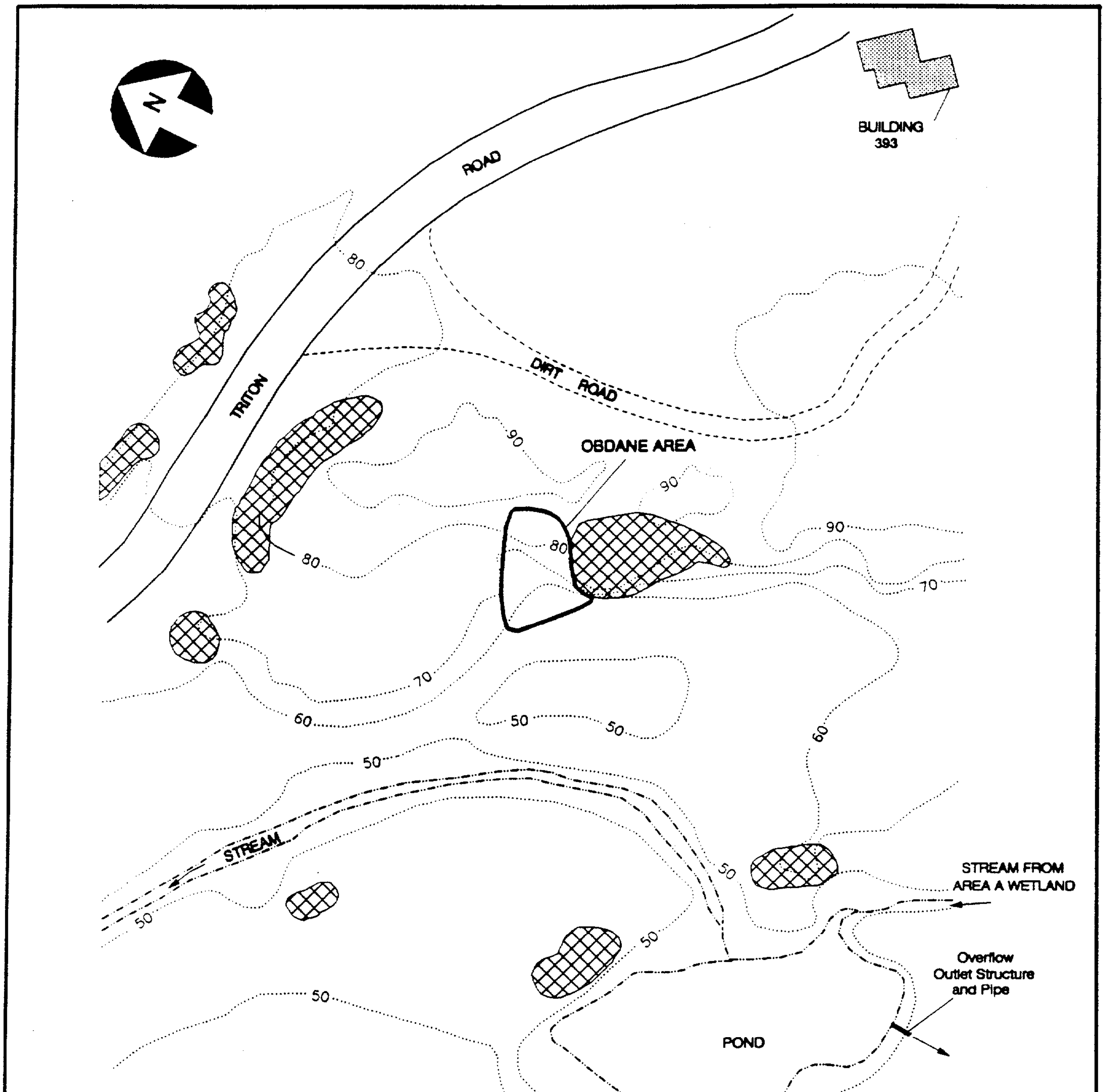
The Over Bank Disposal Area Northeast (OBDANE) site is located in a heavily wooded area on the edge of a ravine northwest of the Area A Landfill and south of the Torpedo Shops. A dirt road provides limited access to the site, which is wooded. Figure 1-9 is a site plan showing topography and drainage features. A nearly vertical 20 foot high bedrock face is located at the eastern edge of the site. The rest of the site slopes to the southwest. Surface runoff flows to the southwest into a stream which flows from the Area A wetland. The stream then flows along Triton Road and ultimately discharges into the Thames River at the southern end of the DRMO site.

The IAS report stated that the vegetation at the site indicated that no dumping had occurred within ten years of their investigation (1982). Atlantic personnel inspected the site on September 30, 1988 and verified the IAS report of the presence of several empty fiber drums. No visual staining or stressed vegetation was observed at this time.

No development of this area is planned at this time.

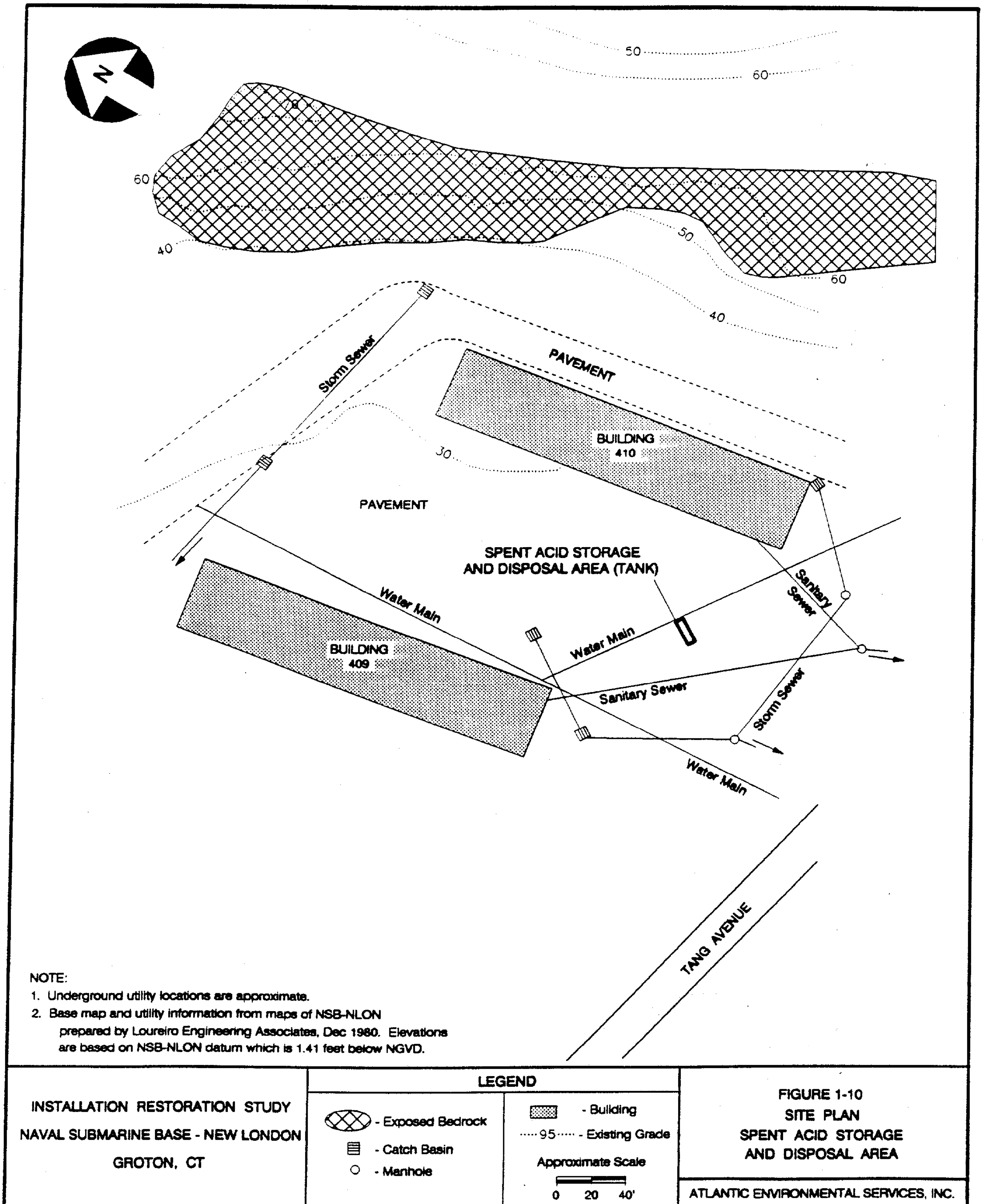
1.2.5.6 Spent Acid Storage and Disposal Area

This site is located in the southeastern section of NSB-NLON between the southern side of Buildings 409 and 410. Figure 1-10 is a site plan showing topography, drainage features and utility information. The site consists of a relatively flat area completely covered with concrete or bituminous pavement. A catch basin and storm sewers collect surface runoff which is directed to the south, ultimately to the Thames River at Goss Cove.



NOTE:
1. Underground utility locations are approximate.
2. Base map and utility information from maps of NSB-NLON prepared by Loureiro Engineering Associates, Dec 1980. Elevations are based on NSB-NLON datum which is 1.41 feet below NGVD.

INSTALLATION RESTORATION STUDY NAVAL SUBMARINE BASE - NEW LONDON GROTON, CT	LEGEND ····95···· - Existing Grade (crosshatch) - Exposed Bedrock (stipple) - Building -·-·-·- - Watercourse Approximate Scale 0 20 40'	FIGURE 1-9 SITE PLAN OBDANE ATLANTIC ENVIRONMENTAL SERVICES, INC.


N
50
60
70
60
40
50
60
40
Storm Sewer
PAVEMENT
BUILDING 410
30
PAVEMENT
SPENT ACID STORAGE AND DISPOSAL AREA (TANK)
Sanitary Sewer
Water Main
Water Main
BUILDING 409
Sanitary Sewer
Storm Sewer
Water Main
TANG AVENUE
NOTE:
1. Underground utility locations are approximate.
2. Base map and utility information from maps of NSB-NLON prepared by Loureiro Engineering Associates, Dec 1980. Elevations are based on NSB-NLON datum which is 1.41 feet below NGVD.
INSTALLATION RESTORATION STUDY
NAVAL SUBMARINE BASE - NEW LONDON
GROTON, CT
LEGEND
- Exposed Bedrock
- Catch Basin
- Manhole
- Building
95 - Existing Grade
Approximate Scale
0 20 40'
FIGURE 1-10
SITE PLAN
SPENT ACID STORAGE
AND DISPOSAL AREA
ATLANTIC ENVIRONMENTAL SERVICES, INC.

The IAS study reported that this area was used before and after World War II for the temporary storage of waste battery acid in a rubber-coated underground tank. The tank was reportedly 12 feet long by four feet wide by four feet high. The batteries were placed on a concrete pad next to the tank where some acids occasionally leaked, although no major spills were recorded. A review of a 1951 aerial photograph indicates that the area around the tank was not paved. Acid from the batteries was stored in the tank and, when full, it was pumped into a tank truck and disposed in the Area A Landfill.

Atlantic personnel inspected the site and found the outline of the top of the tank. The area is completely covered with concrete and only the lip of the tank is visible.

Future plans for the site area include the demolition of Buildings 409 and 410, and the construction of a warehouse over their present location.

1.2.5.7 Former Gasoline Station

The former gasoline station site is located in the roadway and parking area just south of Building 164 (Dealey Center) in the west central portion of the NSB-NLON. Figure 1-11 shows the site topography, drainage, utility information and the former gas station structures. The site is entirely covered with asphalt and slopes down to the southwest toward Shark Boulevard. Surface runoff drains into storm sewers located on the north and south sides of Grenadier Avenue and the east side of Shark Boulevard.

The gasoline station operated from 1940 to the early 1960s. When originally constructed in 1940, the gasoline station had only one garage bay and one pump island. The locations of the underground storage tanks and the method of sewage disposal are not known. In 1950, the site was renovated. Site plans show that the original gasoline island was removed and replaced by two islands located on the south side of the garage building. The original garage building was replaced by a smaller building with a lubrication bay attached to the northeast corner. A 250-gallon underground storage tank for waste oil was installed under the floor of the lubrication bay. Site plans show the fuel feed lines to the two 8000-gallon and one 10,000-gallon underground gasoline tanks located on the southeast section of the site. Navy personnel did not know if these were the original tanks installed in 1940.

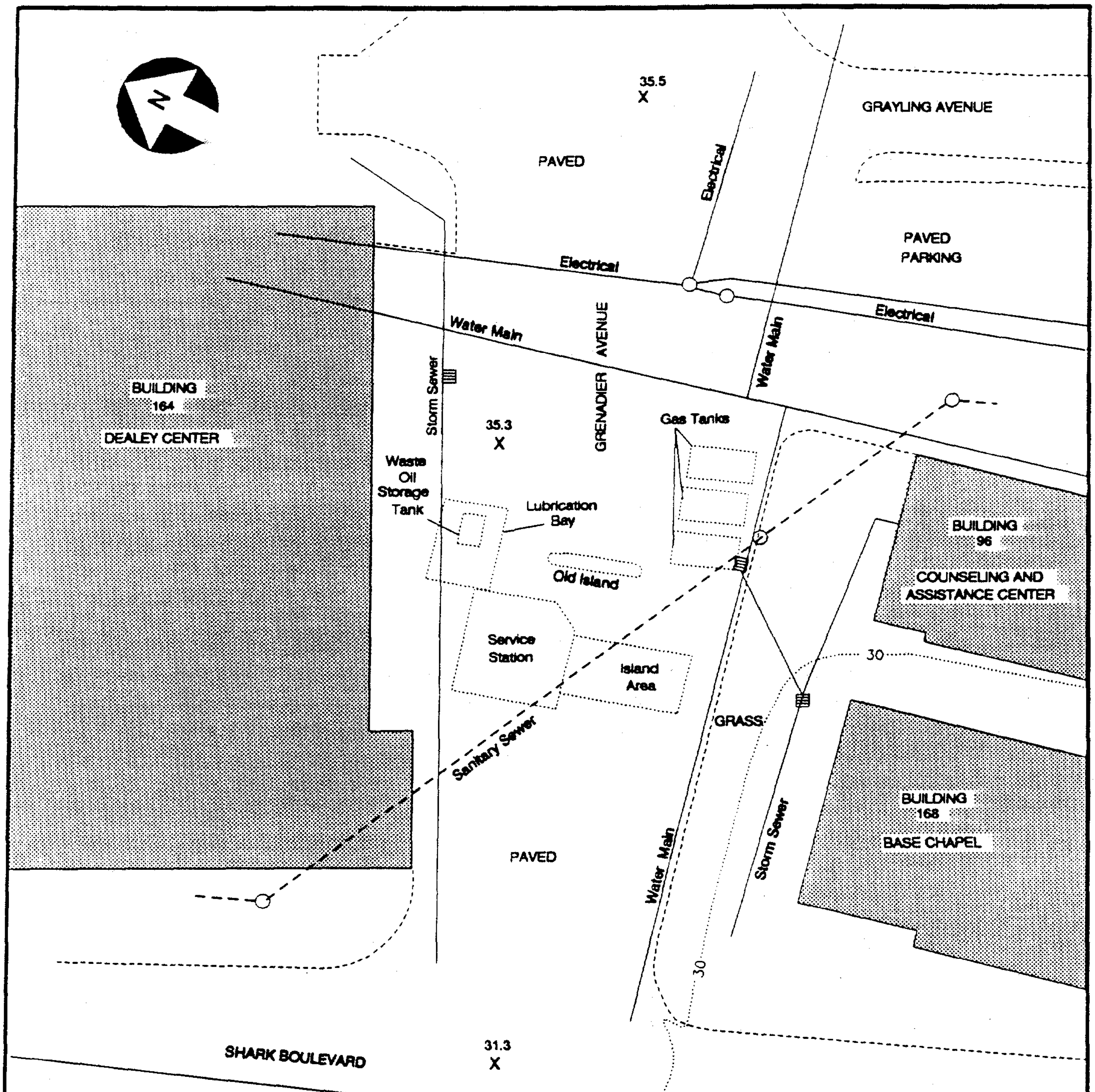
A 1960 site plan shows that the site was served by sanitary sewers at that time. The plan also shows a third gasoline island parallel to and south of the others. Aerial photographs indicate that the gasoline station was demolished between 1962 and 1964. It is not known if the gasoline tanks and associated piping or the waste oil tank were removed.

Atlantic personnel inspected this site on March 20, 1989. No evidence remained of the gasoline station or the underground tanks.

No construction on the site itself is planned, however, it is likely that Building 96 located south of the site will eventually be demolished.

1.2.5.8 Area A

The discussion of this site is divided into three areas: Area A Landfill; Area A Wetland;



NOTE:
1. Underground utility locations are approximate.
2. Base map and utility information from maps of NSB-NLON prepared by Loureiro Engineering Associates, Dec 1980. Elevations are based on NSB-NLON datum which is 1.41 feet below NGVD.

INSTALLATION RESTORATION STUDY NAVAL SUBMARINE BASE - NEW LONDON GROTON, CT	LEGEND ···95···· - Existing Grade .... - Former Structure ▤ - Catch Basin ○ - Manhole ▒ - Building 78.2 X - Spot Grade Approximate Scale 0 20 40'	FIGURE 1-11 SITE PLAN FORMER GASOLINE STATION ATLANTIC ENVIRONMENTAL SERVICES, INC.

and Area A Downstream Watercourses. Figure 1-12 is a site plan showing site development and drainage features. A figure showing topography of Area A is provided in Section 4.10.

Area A Landfill: The Area A Landfill is located in the northeastern and north-central section of the NSB-NLON. It is approximately seven acres in size. The depth of the landfill deposit is ten to 20 feet, based on test boring data. Access is via a dirt road off Wahoo Avenue. The Area A Landfill is a relatively flat area bordered by a steep, wooded hillside that rises to the south, a steep wooded ravine to the west, and the Area A Wetland to the north. Aerial photographs show that the landfill appears to extend east along the wetland to as far as the present position of the tennis courts. Runoff from the landfill drains as overland flow north into the Area A Wetland, which subsequently discharges to the Area A downstream watercourses and into the Thames River. A review of aerial photographs appears to indicate that the most filling occurred on the eastern and western limits of the landfill.

According to the IAS report, the landfill opened sometime before 1957. The base incinerator ceased operating in 1963, and from 1963 to 1973 all wastes were disposed in the landfill unburned. During this time, all non-salvageable materials generated by the submarines and base operations were disposed in the Area A Landfill.

The area fill method was reportedly used in landfill operations. New refuse was dumped from the face of previously deposited refuse and covered with earth. The cover material used on the landfill was gravel obtained from the Groton water supply reservoir.

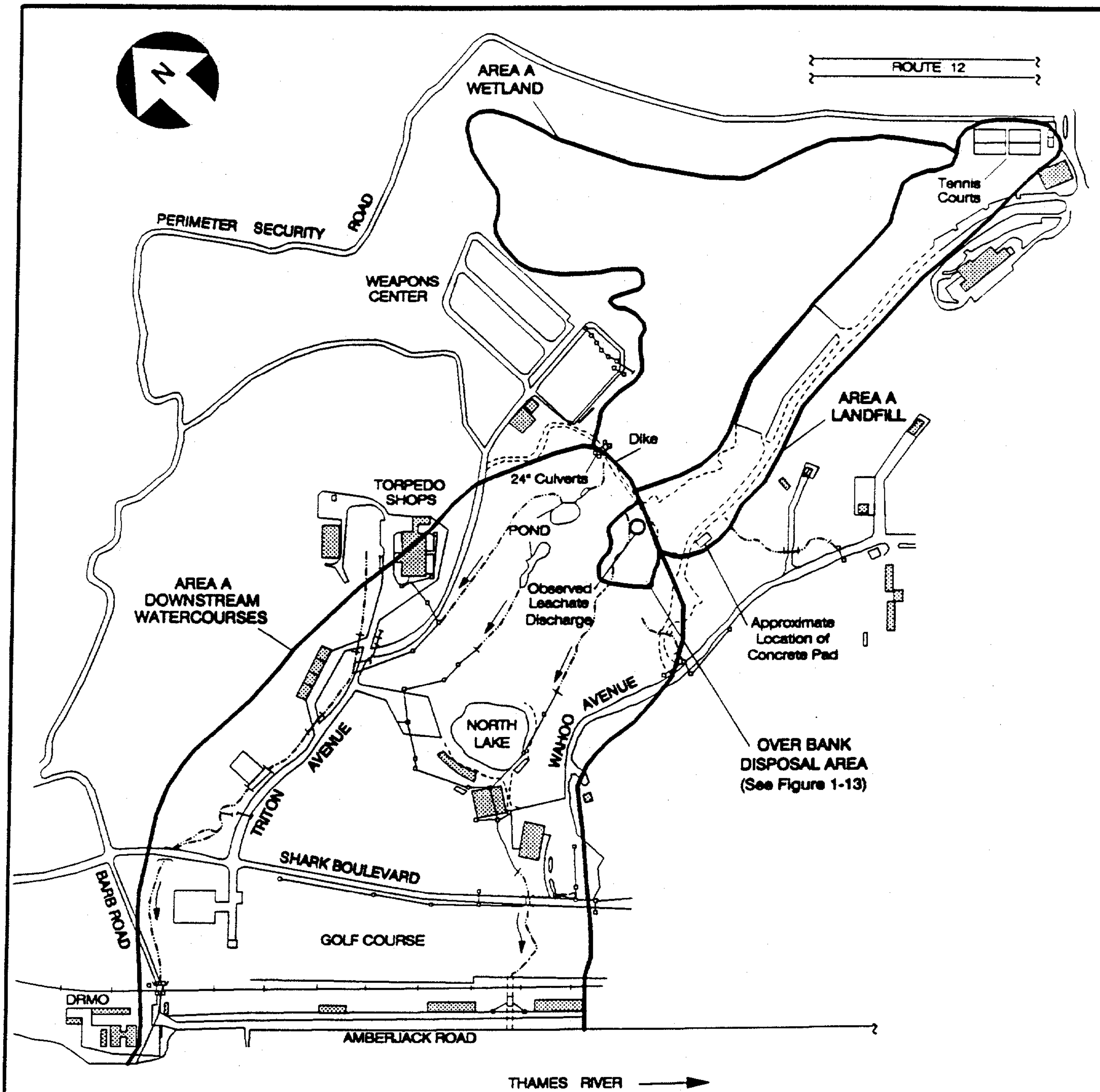
Landfilling operations ceased in 1973. After closure, a concrete pad was constructed in the southwest portion of the landfill for above ground storage of industrial wastes. At the time of the IAS survey, 42 steel drums, 87 transformers (mineral and PCB), and 60 to 80 electric switches were stored on the pad. Two transformers and several electrical switches were leaking. Past leakage of oil was also evident. Most drums were stacked on wooden pallets and those having PCB labels were covered and bound with plastic sheeting. All of these materials have since been properly disposed offsite.

The IAS report also noted that refuse, including steel drums, oxygen candles, wood scrap, metal scrap, concrete, and tires, was exposed at the edge of the landfill adjacent to the wetland. The IAS reported that petroleum compounds had recently been poured from containers and had flowed into the wetland at two locations (northwestern portions of landfill).

Atlantic personnel performed an inspection of the Area A Landfill on September 30, 1988. Orange leachate was observed along the toe of the slope of the landfill extending from the dike to the east end of the deployed parking lot. The slope of the landfill had been covered with fill and material in the landfill was not visible.

Sand bags and contractors' supplies and equipment were stored over the former landfill at the time of the inspection. Several transformers, removed underground storage tanks, crane weights, and other equipment were stored on the concrete pad in the southwest portion of the landfill. The remainder of the landfill is not paved.

The construction of a paved parking lot on the southeast end of the Area A Landfill was planned but has been delayed indefinitely.



NOTE:
1. Underground utility locations are approximate.
2. Base map and utility information from maps of NSB-NLON prepared by Loureiro Engineering Associates, Dec 1980. Elevations are based on NSB-NLON datum which is 1.41 feet below NGVD.

INSTALLATION RESTORATION STUDY NAVAL SUBMARINE BASE - NEW LONDON GROTON, CT	LEGEND - Storm Culvert - Watercourse	- Building Approximate Scale 0 200 400'	FIGURE 1-12 SITE PLAN AREA A ATLANTIC ENVIRONMENTAL SERVICES, INC.

Area A Wetland: The Area A Wetland abuts the north side of the landfill and is approximately 30 acres in size. The maximum wetland sediment thickness is approximately 35 feet, based on boring information. Until 1957, this portion of the site was undeveloped, wooded land. In 1957, dredge spoils from the Thames River were pumped to this area and contained within an earthen dike that extends from the Area A Landfill to the south side of the Weapons Storage Area. The dredged sediments, in combination with the elevated water table due to the damming of the stream, appear to have created this large wetland. There is a small pond located at the southeast end of the wetland and between one and three feet of standing water is present during all seasons. *Phragmites* is the predominant type of vegetation. Atlantic learned during the course of this study that, previously, pesticide "bricks" were placed on the wetland ice during winter and allowed to melt and discharge into the wetland for mosquito control.

Several construction projects are planned for the Weapons Storage Facility at the north end of the Area A Wetland. The facility was constructed partially on the dredged fill material and settlement has occurred in several areas. Routine maintenance and security improvements that are planned include grouting and waterproofing bunkers, repaving roads, and the installation of culverts and regrading associated with these activities. The Navy also plans to build more magazines and bunkers in this area within ten years.

Area A Downstream Watercourses: The Area A Downstream Watercourses drain the Area A Landfill and Wetland and ultimately flow into the Thames River. The Area A Downstream Watercourses include North Lake and several small streams which discharge from Area A and the Torpedo Shop and ultimately discharge to the Thames River.

The primary discharge point from the Area A Wetland is through four 24-inch metal culverts through the dike. This discharge forms a small stream which flows west for approximately 200 feet and into a small pond. Under normal flow conditions, this pond discharges to a small stream which flows north and then west toward Triton Avenue (past OBDANE site). The stream continues flowing west under Triton Avenue and Shark Boulevard and eventually discharges to the Thames River at the DRMO outfall. This pond also has a discharge structure on the south side. During periods of high flow and high water at the pond, water also flows out through this structure to a stream which flows south from the Over Bank Disposal Area site. A second pond to the south of the pond referenced above is formed by ground water inflow, and flows to the west around North Lake as shown on Figure 1-12.

Ground water also discharges from Area A to a small wetland at the base of the dike and the Over Bank Disposal Area site. A stream flows from this wetland west toward North Lake, a recreational swimming area for Navy personnel. Under normal flow conditions the stream enters a culvert which bypasses the pond and discharges to a stream below the outfall of the pond. This stream flows west under Shark Boulevard and through the golf course to the Thames River. There is a manhole adjacent to North Lake that connects to another pipe which was designed to discharge overflow water from North Lake. The invert elevation of this pipe is several inches higher than the main culvert, so that under normal flow conditions no water flows to the pond. Under substantial runoff conditions, however, it is likely that some water discharges to the pond from this stream. At the time of Atlantic's site inspection, the pond had been drained, yet some water remained in the pond, indicating that it receives ground water recharge.

Further development is not planned for this area and is not likely as most of the downstream watercourse area is within designated Explosive Safety Quantity Distance (ESQD) arcs of the Weapons Storage Area. Navy regulations prohibit construction of inhabited buildings or structures within these arcs and, while existing buildings operate under a waiver of these regulations, no further construction is planned.

1.2.5.9 Over Bank Disposal Area (OBDA)

The Over Bank Disposal Area (OBDA) is located on the slope of the dike below and adjacent to the Area A Landfill. It is located on the southwestern end of the dike where the slope approaches 45 degrees. A small wetland exists at the base of the dike. Figure 1-13 shows the site topography, drainage features and objects observed during Atlantic's site inspection.

This area was a disposal site after the earthen dike was constructed in 1957. In 1982, it was the finding of the IAS survey that the material had been there for many years. The IAS study reported that the materials were not covered and included thirty partially covered 200-gallon metal fuel tanks and scrap lumber.

Atlantic personnel inspected the site on September 30, 1988 and observed approximately thirty empty, unlabeled 200-gallon tanks, old creosote telephone poles, several empty unlabeled 55-gallon drums, and rolls of wire. Orange sediments were observed in the water discharging from the base of the dike embankment. The drainage from this wetland has been discussed in Section 1.2.5.8.

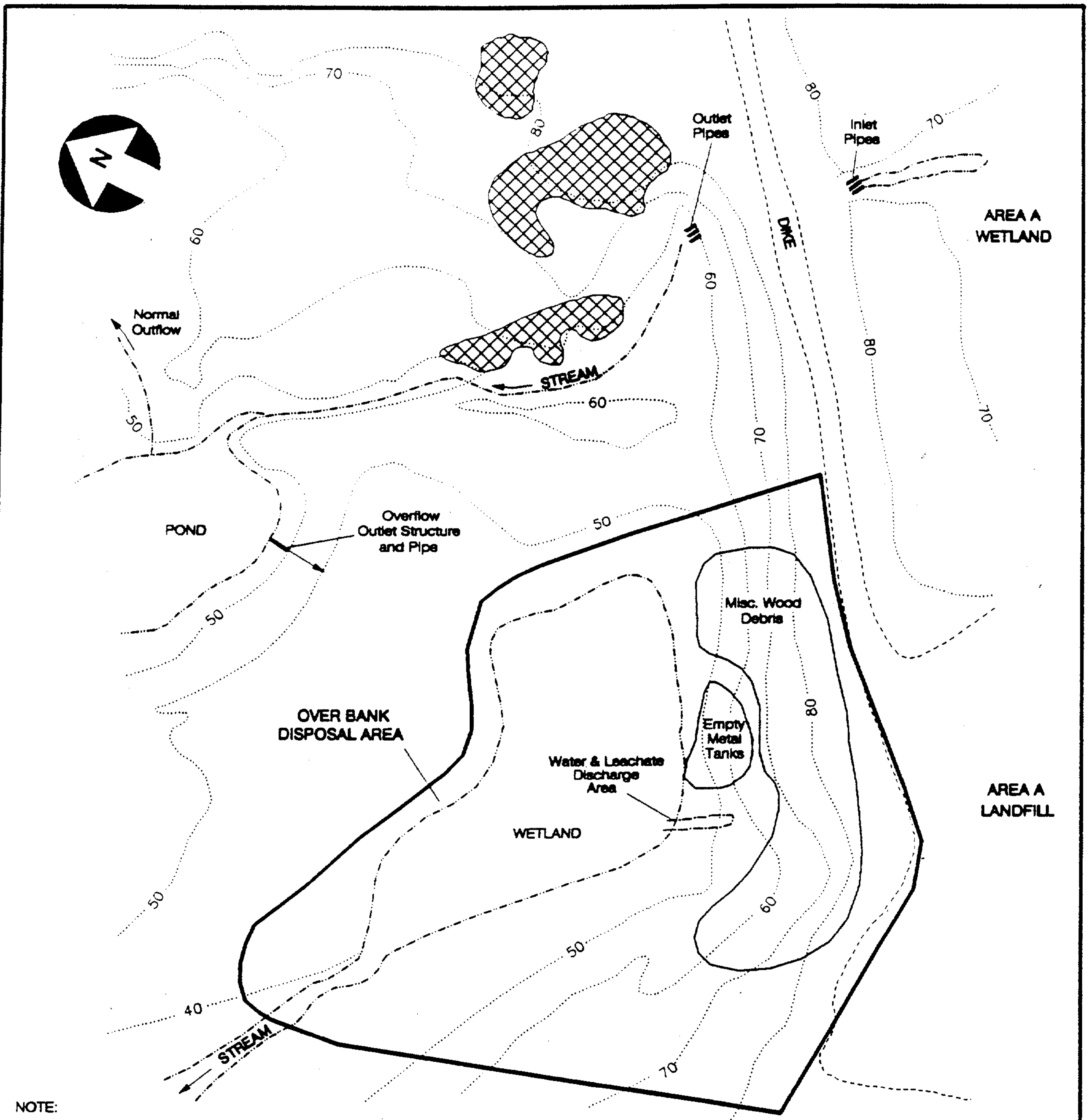
Background data and the topographic/hydrologic setting indicates that the OBDA and the Area A Landfill, Wetland, and Downstream Watercourses are closely related. Therefore, in subsequent sections of the report, data from and discussions of the OBDA are grouped with those of Area A.

1.2.5.10 Defense Reutilization and Marketing Office (DRMO)

The Defense Reutilization and Marketing Office (DRMO) site is adjacent to the Thames River in the northwestern section of NSB-NLON. The DRMO site is the storage and collection facility for items to be sold at auctions and sales held periodically throughout the year. Figure 1-14 shows the site topography, development conditions, and utilities. The land is relatively flat, low lying and prone to flooding. All drainage flows west to the Thames River. The southern half of the DRMO is covered with asphalt, most of which is deteriorated. The northern portion is unpaved.

The DRMO site was used as a major base landfill and burning ground from 1950 to 1969. The materials burned and landfilled included construction materials, combustible scrap, and other non-salvageable waste items. These materials were burned on the Thames River shoreline of what is now the DRMO. The residue was pushed to the shoreline and partially covered.

Atlantic personnel reviewed archive aerial photographs for the DRMO area. The 1934 photographs show fill in the southern portion of the existing site. Fill for the bulkheads and the docks south of the DRMO did not exist at this time. Aerial photographs from 1951 show the land in its present configuration, except for the northwest portion, which was not filled at that time.



NOTE:

1. Underground utility locations are approximate.
2. Base map and utility information from maps of NSB-NLON prepared by Loureiro Engineering Associates, Dec 1980. Elevations are based on NSB-NLON datum which is 1.41 feet below NGVD.

INSTALLATION RESTORATION STUDY
NAVAL SUBMARINE BASE - NEW LONDON
GROTON, CT

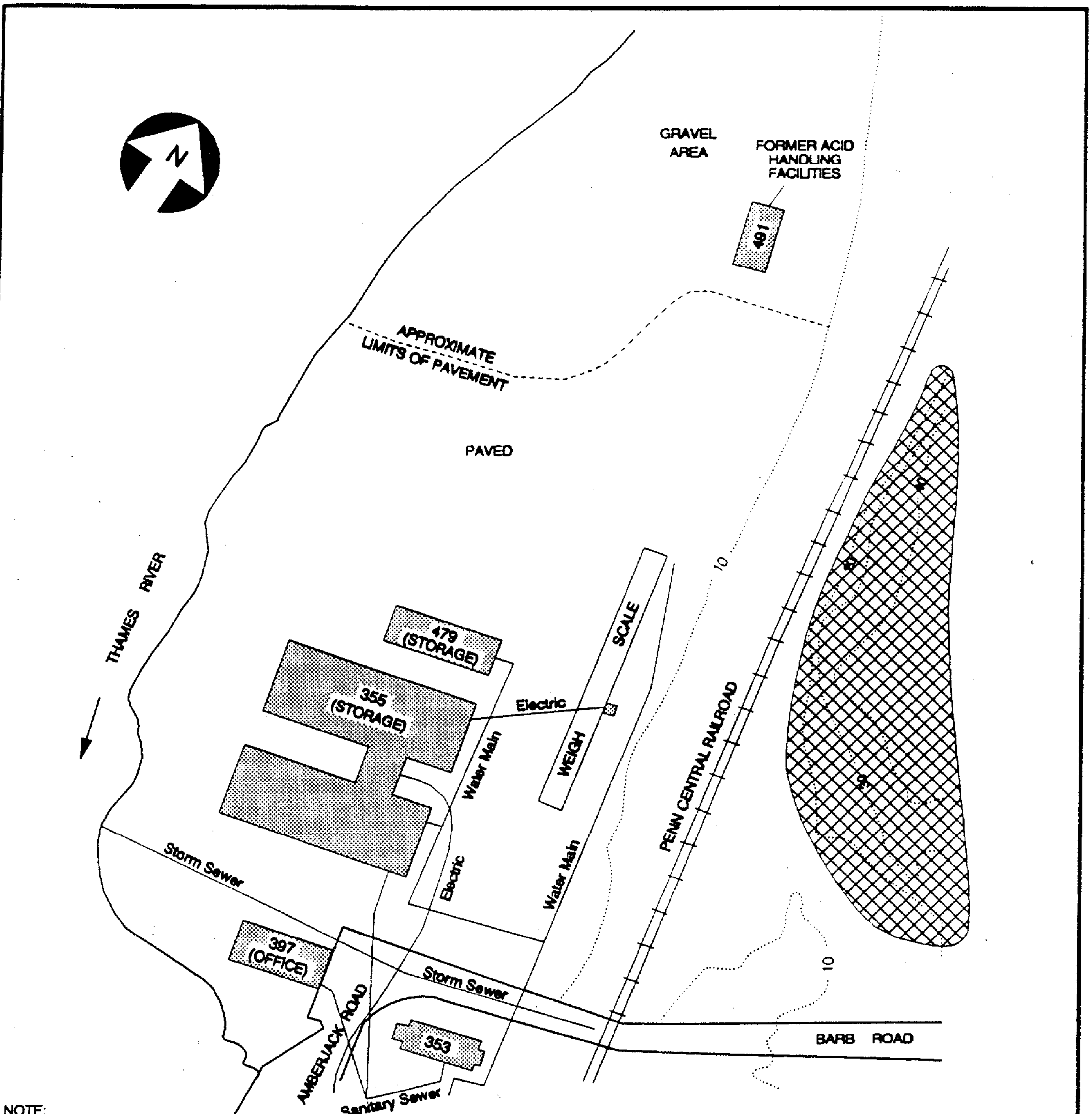
LEGEND

- ·····95····· - Existing Grade
- (crosshatch) - Exposed Bedrock
- (shaded) - Building
- - - - - Watercourse

Approximate Scale: 0 20 40'

FIGURE 1-13
SITE PLAN
OVER BANK DISPOSAL AREA

ATLANTIC ENVIRONMENTAL SERVICES, INC.



NOTE:
1. Underground utility locations are approximate.
2. Base map and utility information from maps of NSB-NLON prepared by Loureiro Engineering Associates, Dec 1980. Elevations are based on NSB-NLON datum which is 1.41 feet below NGVD.

INSTALLATION RESTORATION STUDY NAVAL SUBMARINE BASE - NEW LONDON GROTON, CT	LEGEND ······95······ - Existing Grade (crosshatch) - Exposed Bedrock (shaded) - Building Approximate Scale 0 20 40'	FIGURE 1-14 SITE PLAN DRMO ATLANTIC ENVIRONMENTAL SERVICES, INC.

Atlantic personnel inspected the site on September 30, 1988. Metal and wood products were stored throughout most of the site. A large scrap yard is located north of Building 479. Submarine batteries were stored in the southeast portion of the site adjacent to the railroad tracks; no leakage was observed. Buildings 479 and 355 are located within the paved area to the south and are used primarily for storage. Building 491, located in the unpaved area to the north, is used for miscellaneous storage, including batteries. Metal bailing operations are performed adjacent to Building 491 on a gravel surface. Based on an inspection of the building plans, Atlantic personnel identified the presence of a former battery acid handling facility at the north section of the site, within Building 491. An in-ground rubber-lined tank and associated pumping facilities were noted on the plans. DRMO personnel indicated that the tank actually may have been installed directly adjacent to the building to the east.

Future plans for this site include the construction of a Conforming Storage Facility for the temporary storage of hazardous wastes generated at NSB-NLON.

1.2.5.11 Lower Subase

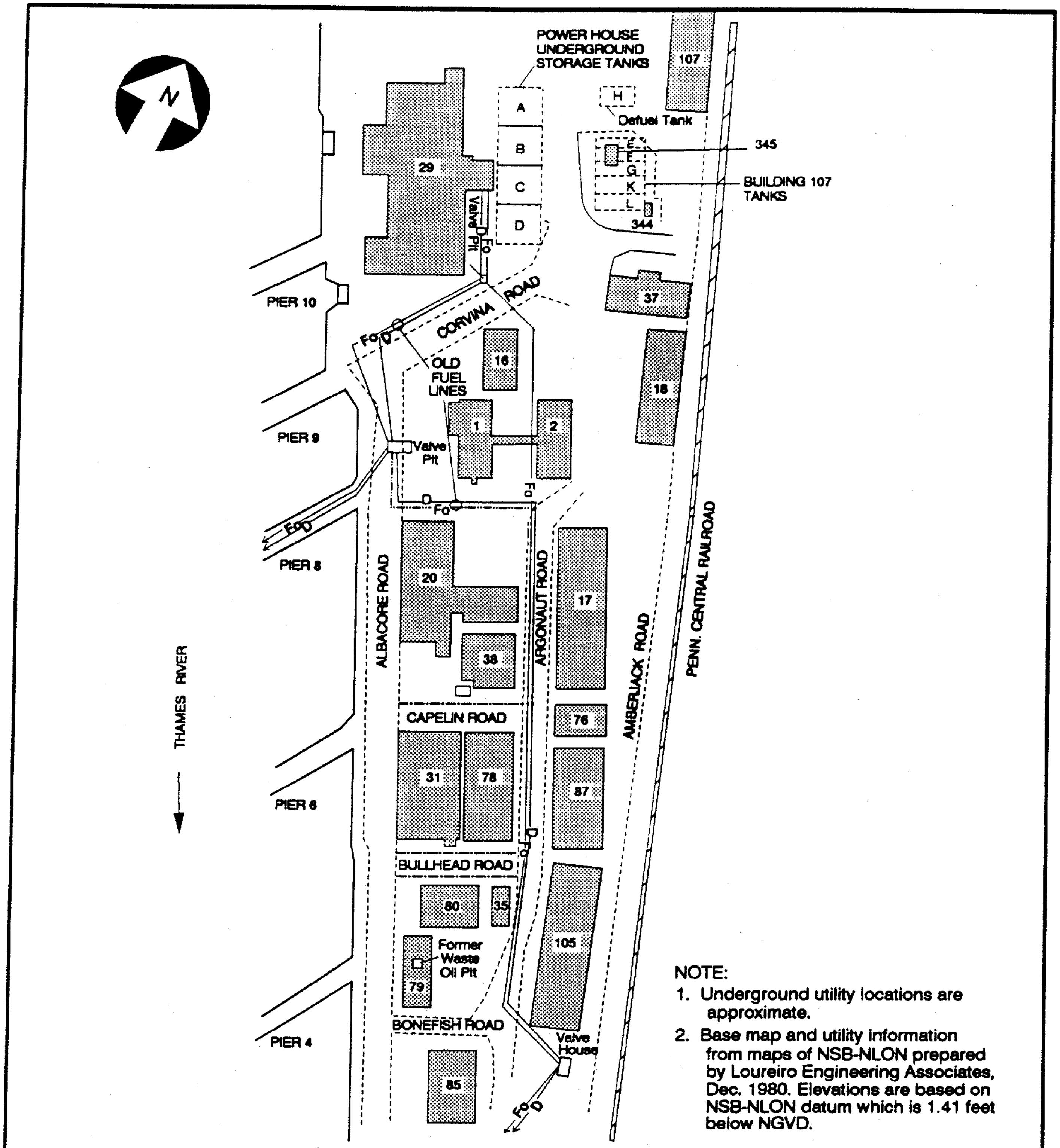
The extent of the Lower Subase site under investigation is shown on Figure 1-15. The site is bounded on the west by the Thames River and to the east by the Penn Central Railroad. This investigation extends to and includes Building 29 (Power Plant) to the north and Building 85 to the south.

The Lower Subase is the original Subase and, therefore, the history of its use dates from 1867. Most of the construction at the Lower Subase took place in the early 1900s with a major expansion between the years 1935 and 1940.

Based on previous investigations (detailed in subsequent sections), potential sources of fuel oil contamination on the Lower Subase have been identified. These sources are summarized below.

Building 79 Waste Oil Pit: Building 79 is located adjacent to one of the areas of contamination identified by the Navy Environmental Support Office (NESO) and Wehran Engineers reports (NESO, 1979 and Wehran, 1987, respectively). This area contained a railroad spur, and diesel train engines were serviced inside the building. The service area included a pit into which waste oil and solvents were reportedly drained during the cleaning and servicing of diesel engines. The pit is no longer in use and is filled with concrete. Available building maps show a subsurface drain pipe extending from the pit to outside the building foundation toward Albacore Road. The discharge location is not shown on the maps.

Power Plant Oil Tanks: These four underground tanks (A, B, C, D) were located adjacent to and east of the power house (Building 29). Tanks A and B contained No. 6 grade fuel oil which was pumped to them from the tank farms on the south end of NSB-NLON. Tank C contained diesel oil and Tank D contained waste oil from the bilge water oil recovery system at the power plant. The tanks have been in place since World War II. Mr. Mansfield reported that past oil leakage was apparent when the old tanks were cleaned, however, the old tanks were repaired and are now used as containment structures for three new tanks. The new tanks have a capacity of 150,000 gallons each and are constructed of steel.



INSTALLATION RESTORATION STUDY
NAVAL SUBMARINE BASE - NEW LONDON
GROTON, CT

LEGEND

— D — - Diesel Line
— Fo — - Fuel Oil Line
--- Fo --- - Out of Service Fuel Oil Line
- Building
Approximate Scale: 0 100 200'

FIGURE 1-15
SITE PLAN
LOWER SUBASE

ATLANTIC ENVIRONMENTAL SERVICES, INC.

Fuel Oil Storage Tanks at Building 107: Five concrete underground storage tanks were located southwest of Building 107 and were in use since World War II. Three of the tanks (E, F, and G) had a 125,000-gallon capacity each and were used to store diesel fuel. Tanks K and L were used to store lube oil and had a 25,000-gallon capacity each. A sixth tank, H, is located adjacent to and north of tank E. This tank has a 30,000 gallon capacity and was used as a reclamation tank for the other five tanks. Tanks E, F and G have been properly abandoned and new steel tanks have been installed at locations K and L. Tank H is presently out of service.

Fuel Oil Distribution System: Distribution systems are in place on the Lower Subase for No. 6 fuel oil and diesel fuel. The lines are used to convey fuel to the power house, to the tanks under the ball fields near the main gate, and to fuel ships at the piers. The No. 6 fuel and diesel lines along Argonaut Road were replaced in the late 1980s. The No. 6 fuel oil line is contained in concrete lined trenches shared with other utilities, including steam and condensate lines. Diesel fuel lines were buried directly. All diesel fuel lines have been replaced in the 1980s and all #6 oil lines will be abandoned in the future.

Atlantic personnel investigated Building 79 on September 30, 1988 and revisited the Lower Subase on November 7, 1988. Numerous manholes throughout the Lower Subase were inspected. Oil contamination was observed in one electric manhole north of Building 79 on Albacore Road. The oil appeared to be No. 6 fuel oil which entered the manhole through subgrade utility ducts. A detailed discussion of utility manhole inspections is provided in a subsequent section.

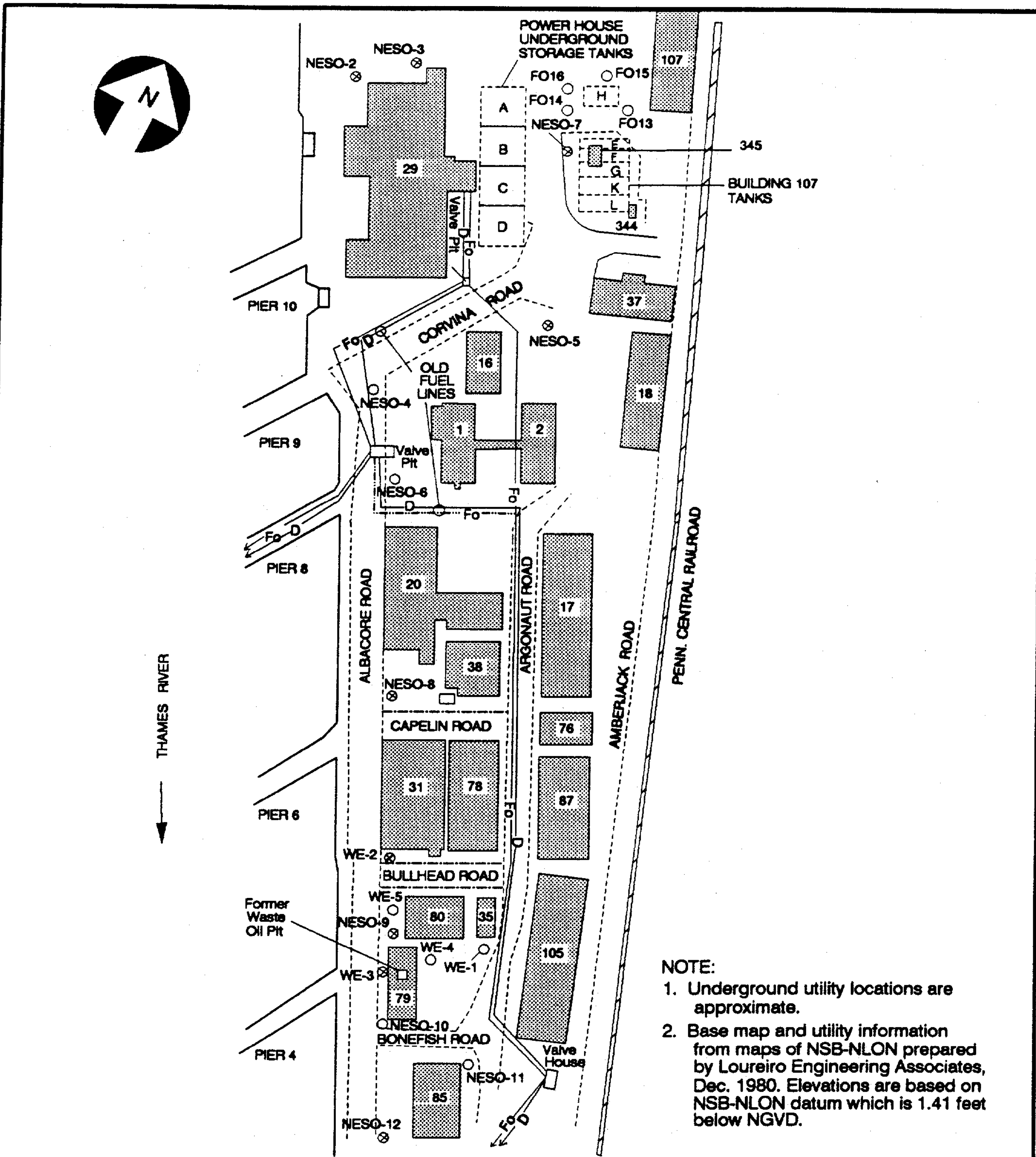
1.2.6 Previous Investigations

This subsection summarizes seven previous environmental studies conducted at the NSB-NLON. The information in these studies was used in developing the scope of work for this investigation and was considered in defining the nature and extent of onsite contamination. The seven investigations are listed below and are cited fully in the references to this section.

- NESO, Report of Lower Base, 1979
- Envirodyne, Initial Assessment Study, 1982
- Wehran, Lower Base, 1987
- Wehran, Verification Study - Area A, OBDA and DRMO, 1988
- GZA, Conforming Storage Facility Report - DRMO, 1988
- Fuss & O'Neill, Inc. Underground Storage Tanks - Lower Base, 1989
- U.S. Navy, North Lake Analytical Data, 1988-1990

1.2.6.1 NESO Report of Lower Base (1979)

In 1979 the Navy Environmental Support Office (NESO) conducted a study to determine the source and extent of oil contamination at the Lower Subase. The study was initiated to investigate oil found in soils along the riverfront and oil slicks reported in the pier area. NESO drilled a total of twelve soil borings and installed piezometers in each borehole to determine the amount of oil floating on the water table. Figure 1-16 shows the locations of borings installed in this investigation except for NESO-1, which is north of this investigation area near Pier 12. Soil samples from each boring were analyzed for oil content. A ground water sample was collected from each piezometer to check for the presence of oil and, where present, to check product thickness.



NOTE:

1. Underground utility locations are approximate.
2. Base map and utility information from maps of NSB-NLON prepared by Loureiro Engineering Associates, Dec. 1980. Elevations are based on NSB-NLON datum which is 1.41 feet below NGVD.

INSTALLATION RESTORATION STUDY NAVAL SUBMARINE BASE - NEW LONDON GROTON, CT	LEGEND ○ NESO-1 - NESO Well ○ WE-1 - Wehran Well ○ FO13 - Fuss & O'Neill Well ⊗ - Destroyed Well --- Fo --- - Out of Service Fuel Oil Line ▒ - Building — D — - Diesel Line — Fo — - Fuel Oil Line Approximate Scale 0 100 200'	FIGURE 1-16 PREVIOUS SAMPLING LOCATIONS LOWER SUBASE ATLANTIC ENVIRONMENTAL SERVICES, INC.

The study identified contamination near the powerhouse tanks extending toward the Thames River, to a lesser degree around the tanks south of Building 107, and northwest of Building 79. The oil found in the vicinity of Building 79 was identified as a lubricating oil.

The NESO report recommended the abandonment of the building waste oil pit (it was filled with concrete) and the installation of a recovery well system near Building 79. A recovery well system was installed near Building 79 in 1985 (approximate) and operated for a period of several months. It was determined to be ineffective and was abandoned.

1.2.6.2 Initial Assessment Study Report (1982)

In 1982, Envirodyne Engineers, Inc. (Envirodyne) performed an Initial Assessment Study (IAS) of NSB-NLON as part of the Navy Assessments and Control of Installation Pollutants (NACIP). The purpose of this study was to identify and evaluate past hazardous waste disposal practices and to assess the potential for environmental contamination. The Envirodyne study recommended further investigation and testing at the following three sites: Area A Landfill; Over Bank Disposal Area; and DPDO (now DRMO) site. As previously discussed, all potential waste disposal sites identified in the IAS have been included as part of this Installation Restoration study.

1.2.6.3 Site Investigation Report - Subsurface Oil Contamination - Lower Subase (1987)

In 1987, Wehran Engineers and Scientists (Wehran) completed an investigation of the subsurface oil contamination at the Lower Subase. The objective of the study was to determine the horizontal extent and interrelation among the heavy oils detected in earlier studies. Soil from test borings, sludge from manholes and ground water from monitoring wells was tested to determine type of oil, degree of weathering and general levels of contamination. The Wehran report conclusions and recommendations were as follows.

Three separate oil contaminated areas seem to be present.

1) *The concrete utility trench is contaminated with a #6 fuel oil that is less than one year old (Argonaut Road).*

2) *The manholes, soils and ground water in the vicinity of Building 79 are contaminated with a #6 fuel oil that is greater than one year old and trace levels of waste oil.*

3) *The manholes, soil, and ground water in the vicinity of Buildings 29 and 345 are contaminated with #5 and #6 oils.*

Recommendations for these three sites include:

1) *the inspection of the #6 fuel line and the subsequent cleaning of the trench;*

2) *oil mopping of the sludge oil in the manholes and/or excavation of the oil laden soils; and*

3) *an additional study of the operations and distribution of oil in Building 29, including further study of the adjacent contaminated manholes.*

Recommendation #1 was completed with the replacement of the #6 and diesel lines from the valve house at the entrance to the Lower Subase along Argonaut Road to the Power House. The fuel lines along Corvina Road to the piers have also been replaced recently.

1.2.6.4 Verification Study - Area A, OBDA and DRMO (1988)

In December of 1984, Wehran began a verification study of Area A, OBDA, and the DRMO. The purpose of the study was to determine whether toxic and hazardous materials identified in the IAS study were present onsite, and to further assess the potential impact of the contamination on human health and the environment. Wehran sampled and analyzed surface water, sediment and soils. The results of the investigation are summarized below.

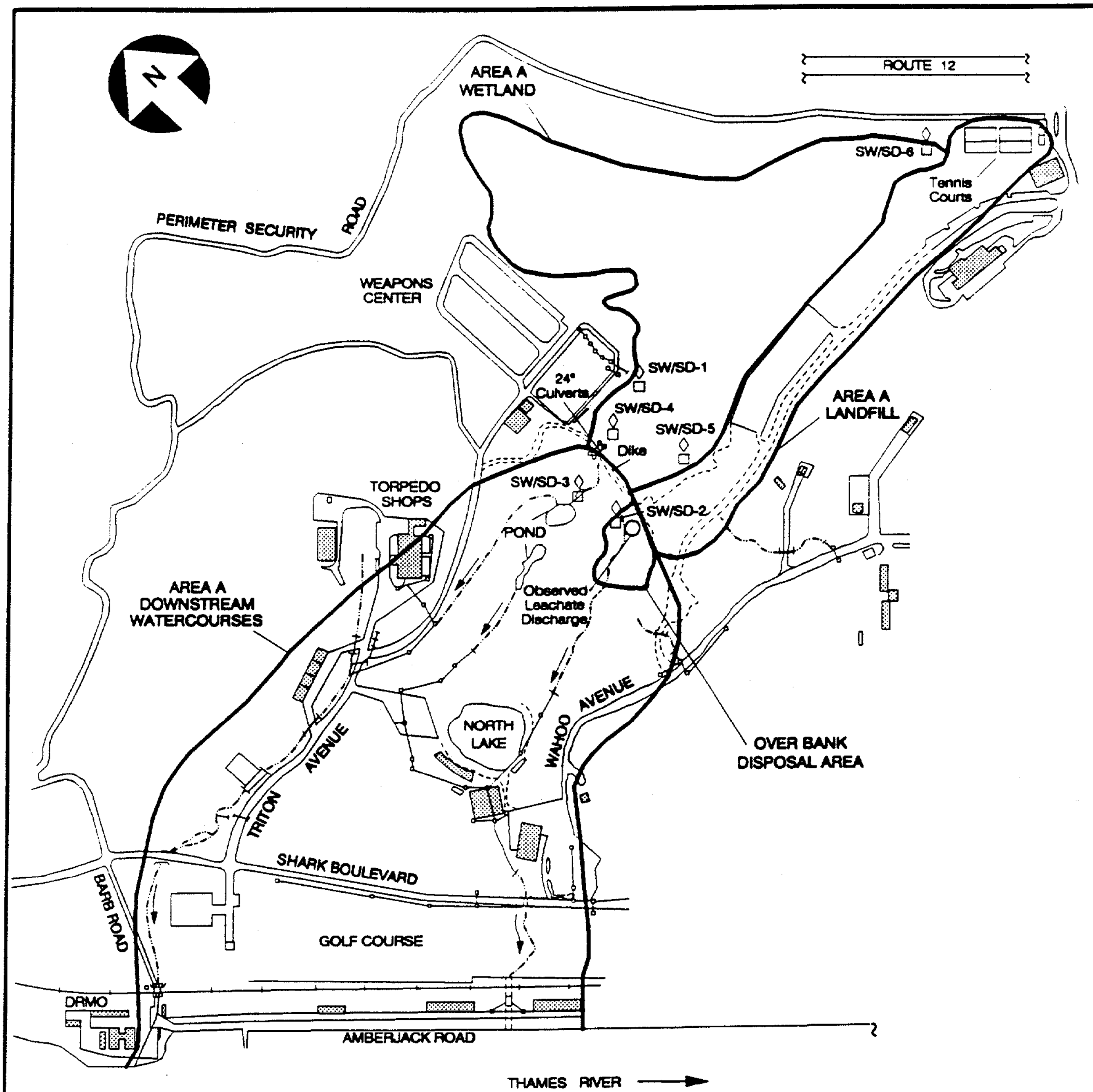
Area A and OBDA: The Verification Study of the Area A and OBDA consisted of three rounds of surface water and sediment sampling and analysis at six locations in the vicinity of the Area A Wetland and Downstream Watercourses, as shown in Figure 1-17. One of the six locations, SW-2, was in the wetland at the base of the Over Bank Disposal Area. Sampling was performed between December 1984 and April 1985. The first round of samples was analyzed for volatile organic compounds (VOCs) and semi-volatile organics (SVOs), which include polynuclear aromatic hydrocarbons (PAHs), pesticides, polychlorinated biphenyls (PCBs), and inorganic compounds. The samples from the second and third rounds were analyzed only for VOCs and inorganics. The results are summarized on Tables 1-1 and 1-2.

Analyses of surface water samples showed the highest concentration of VOC contamination (methylene chloride 0.31 ppm) in the vicinity of the landfill (SW-5) and in the surface water discharging from the landfill (SW-2, SW-3). SVOs were detected in the surface water of the Area A Wetland (SW-1) and Downstream Watercourses (SW-2). Metals were detected in all six surface water samples. Sample SW-6, located upstream of the wetland, had the lowest level of metals, while all other sample locations had generally consistent levels.

Analytical results from sediment samples showed VOCs (methylene chloride and toluene) at all sampling locations. SVOs were detected at SW-1 on the far side of the wetland adjacent to the Weapons Storage Area. Pesticides including DDT, DDE, and DDD, were detected in all six samples. The sample closest to the landfill (SW-5) had the lowest concentrations of contaminants. Samples SW-2 and SW-3, located in the downstream area below the dike, contained the highest concentrations of pesticides.

Ten metals and cyanide were detected in sediment samples collected from Area A. Antimony, arsenic, cadmium, chromium, mercury, copper, lead, nickel, zinc, and thallium were detected. Elevated levels of cyanide were detected in the sediment at SW-1 which is near the Weapons Storage Area.

DRMO: The Verification Study at the DRMO was conducted in December 1984. Sample locations are shown on Figure 1-18. Three soil borings were drilled in the landfill material. Soil samples were collected continuously to a depth of ten feet. The samples were composited (0 to 10



NOTE:

1. Underground utility locations are approximate.
2. Base map and utility information from maps of NSB-NLON prepared by Loureiro Engineering Associates, Dec 1980. Elevations are based on NSB-NLON datum which is 1.41 feet below NGVD.

INSTALLATION RESTORATION STUDY NAVAL SUBMARINE BASE - NEW LONDON GROTON, CT	LEGEND ◊ SW-1 - Surface Water Sample 1984, Wehran □ SD-1 - Sediment Sample 1984, Wehran - Storm Culvert - Building - Watercourse Approximate Scale 0 200 400'	FIGURE 1-17 PREVIOUS SAMPLING LOCATIONS AREA A ATLANTIC ENVIRONMENTAL SERVICES, INC.

TABLE 1-1
AREA A AND OBDA VERIFICATION STUDY (1988)
SUMMARY OF SURFACE WATER ANALYTICAL DATA

PARAMETER	SAMPLE I.D.	SW-1	SW-2	SW-3	SW-4	SW-5	SW-6
VOLATILE ORGANICS (ppm)							
Methylene chloride		ND	0.27	0.19	ND	0.31	ND
SEMI-VOLATILE ORGANICS (ppm)							
Bis(2-ethyl hexyl) phthalate		0.118	0.44	ND	ND	ND	ND
Butyl benzyl phthalate		0.115	ND	ND	ND	ND	ND
Di-n-octyl-phthalate		0.245	0.032	ND	ND	ND	ND
INORGANICS (ppm)							
Antimony		0.4	0.4	0.2	0.2	0.2	ND
Arsenic		ND	ND	ND	0.004	ND	ND
Cadmium		ND	ND	ND	0.03	ND	ND
Copper		0.03	0.12	0.02	0.02	0.02	ND
Nickel		0.08	0.04	0.03	ND	0.03	ND
Zinc		0.1	0.152	0.1	0.08	0.05	0.05
Cyanide (total)		0.175	ND	ND	ND	ND	ND
Phenols (total)		ND	0.096	0.132	0.188	0.194	0.092

1. All results shown are the greatest concentrations for the three sampling rounds. ND - Not detected
2. Samples collected from December, 1984 to April, 1985.
3. Source of analytical data (Wehran, 1988).

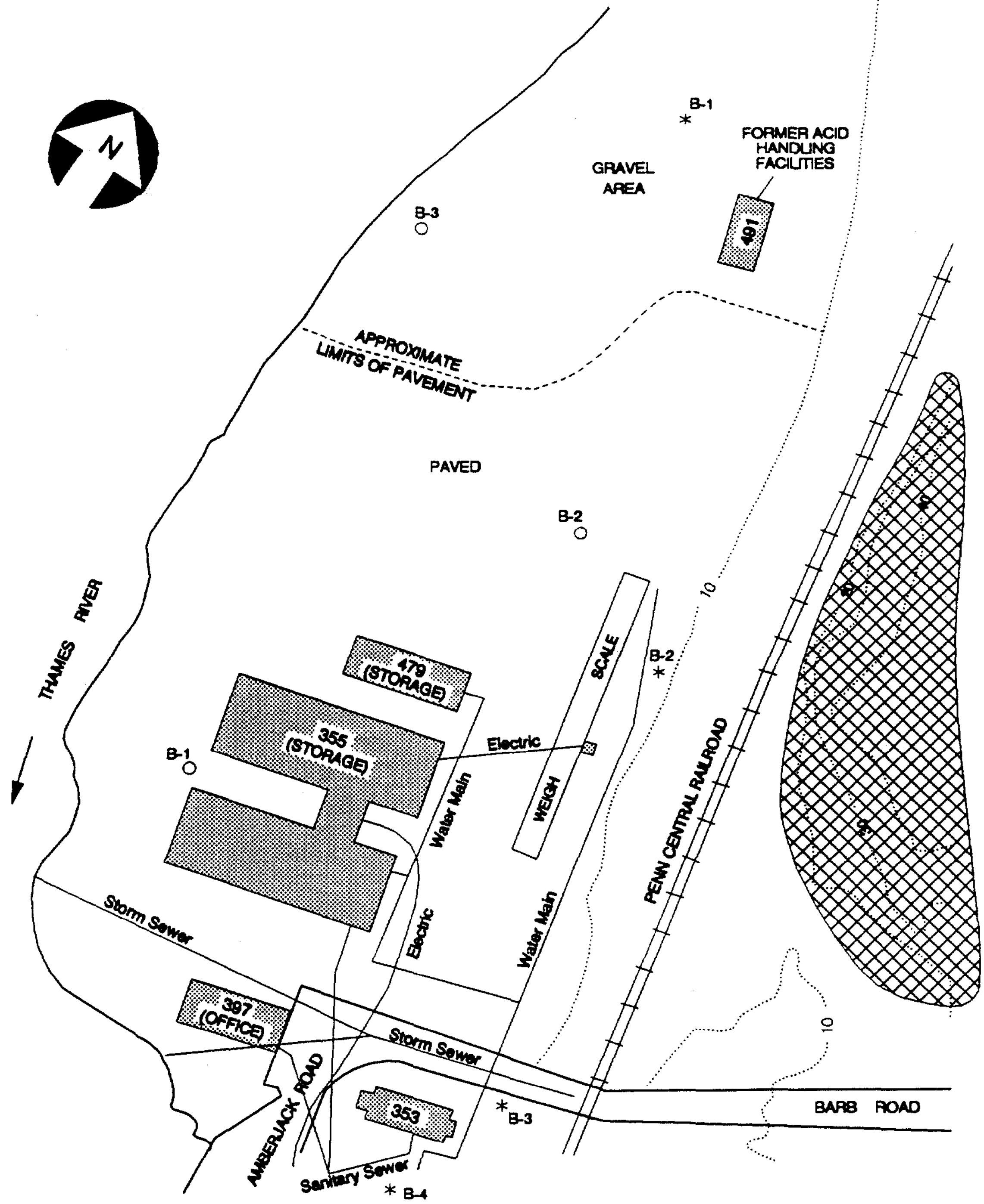
TABLE 1-2
AREA A AND OBDA VERIFICATION STUDY (1988)
SUMMARY OF SEDIMENT ANALYTICAL DATA

PARAMETER	SAMPLE I.D.	SW-1	SW-2	SW-3	SW-4	SW-5	SW-6
VOLATILE ORGANICS (ppm)							
Benzene		ND	0.24	ND	ND	ND	ND
Chloroform		ND	ND	ND	0.01	ND	ND
Methylene chloride		0.29	0.15	0.018	0.016	0.031	0.027
Toluene		0.016	0.016	0.1	0.092	0.058	0.036
SEMI-VOLATILE ORGANICS (ppm)							
Benzo(a)anthracene		1.2	ND	ND	ND	ND	ND
Benzo(b)fluoranthene		0.95	ND	ND	ND	ND	ND
Benzo(k)fluoranthene		0.95	ND	ND	ND	ND	ND
Benzo(g,h,i)perylene		0.55	ND	ND	ND	ND	ND
Benzo(a)pyrene		0.75	ND	ND	ND	ND	ND
Chrysene		0.55	ND	ND	ND	ND	ND
Fluoranthene		1.85	ND	ND	ND	ND	ND
Phenanthrene		0.75	ND	ND	ND	ND	ND
Pyrene		1.35	ND	ND	ND	ND	ND
PESTICIDES/PCBs (ppm)							
4,4 DDD		ND	79	91	17	0.01	12
4,4 DDE		0.0048	7.4	2.5	1.3	0.093	0.82
4,4 DDT		0.022	59	4.8	17.6	ND	17
INORGANICS (ppm)							
Antimony		18.3	36.2	18.4	12	10.4	12.7
Arsenic		3.21	1.96	3.68	2.94	2.92	1.33
Beryllium		0.44	0.68	2.62	0.48	0.31	0.51
Cadmium		0.8	1.81	2.5	0.64	0.49	0.49
Chromium		20.4	7.5	12	9.84	9.37	6.6
Copper		30.8	11.3	33.2	20	26.3	13.9
Lead		104	38.7	5960	1486	39.2	24.6
Mercury		ND	ND	0.28	ND	ND	0.06
Nickel		18.32	32.14	22.5	13.2	15	13.5

TABLE 1-2 (continued)
AREA A AND OBDA VERIFICATION STUDY (1988)
SUMMARY OF SEDIMENT ANALYTICAL DATA

PARAMETER	SAMPLE I.D.	SW-1	SW-2	SW-3	SW-4	SW-5	SW-6
INORGANICS (ppm)							
Selenium		ND	ND	ND	ND	ND	ND
Silver		ND	ND	ND	ND	ND	ND
Thallium		5.86	2.35	4.47	3.24	2.48	3.25
Zinc		57.2	90.5	169	53.8	56.5	30.4
Cyanide (total)		2.53	0.36	0.79	0.63	1.52	0.11
Phenols (total)		ND	ND	ND	ND	ND	ND

1. All results shown are the greatest concentrations for the three sampling rounds.
2. Samples collected from December, 1984 to April, 1985.
3. Source of analytical data (Wehran, 1988).



NOTE:
1. Underground utility locations are approximate.
2. Base map and utility information from maps of NSB-NLON prepared by Loureiro Engineering Associates, Dec 1980. Elevations are based on NSB-NLON datum which is 1.41 feet below NGVD.

INSTALLATION RESTORATION STUDY
NAVAL SUBMARINE BASE - NEW LONDON
GROTON, CT

LEGEND
- Exposed Bedrock
○ B-1 - Test Boring 1984, Wehran
* B-1 - Test Boring 1988, GZA
····· 95 ····· - Existing Grade
- Building
Approximate Scale 0 20 40'

FIGURE 1-18
PREVIOUS SAMPLING LOCATIONS
DRMO

ATLANTIC ENVIRONMENTAL SERVICES, INC.

feet) from each boring and analyzed for VOCs, SVOs, pesticides/PCBs, and inorganics. The results are presented in Table 1-3.

VOCS and SVOs were detected primarily at samples B-1 and B-3. Elevated levels of some metals (e.g., lead) were also detected at B-3.

1.2.6.5 Conforming Storage Facility Report - DRMO (1988)

In November of 1988, Goldberg-Zoino & Associates, Inc. (GZA) conducted a study at the DRMO site in preparation for the siting of a Conforming Storage Facility (hazardous waste storage) at the northern portion of the DRMO site. GZA installed four test borings and collected four composite samples for analysis as part of the field investigation for this study. Sample locations are also shown on Figure 1-18. The samples were analyzed for USEPA priority pollutants including VOCs, SVOs, pesticides/PCBs, inorganics, total cyanide and total phenols.

Semi-volatile compounds were detected in samples BH-3 and BH-4. Pesticides (DDE) and PCBs (Arochlor 1254) were detected in sample BH-1. Cyanide was detected in sample BH-3. No VOCs or Phenols were found in excess of laboratory detection limits. Results are summarized in Table 1-4.

1.2.6.6 Hydrogeologic Investigation, Underground Storage Tanks - Lower Subase (1989)

In 1989 Fuss & O'Neill, Inc. conducted a hydrogeologic investigation of two underground storage tank sites on the NSB-NLON, one of which is located within the study area on the Lower Subase. The study was initiated due to subsurface soil contamination encountered during construction activities in the area. The Fuss & O'Neill investigation at the Lower Subase focused on a 30,000-gallon concrete oil reclamation tank designated as tank H and located west of Building 107 (Figure 1-16). Tank H was used as an oil reclamation tank for the five underground storage tanks located adjacent to it to the south.

Four monitoring wells were installed around tank H and locations are shown on Figure 1-16. Well depths were approximately ten feet. Soil samples were collected during the drilling and field screened for volatile organics (organic vapor analyzer). Ground water samples were collected and analyzed for volatile aromatic hydrocarbons and also scanned for petroleum products (U.S. Coast Guard Method CG-D-52-77).

Soil samples collected from ten to 12 foot depths as FO-13, FO-14, FO-15 and FO-16 had organic vapor readings of 22, 800, 40, and 410 ppm (methane equivalence), respectively. Ground water analytical results are summarized in Table 1-5. No floating petroleum product was identified in the wells.

1.2.6.7 North Lake Analytical Data

Since 1988, soil and water samples from North Lake have been tested by the Navy for a variety of parameters to determine if the lake is safe for recreational use. Sampling has been conducted at the lake due to its proximity to the Area A disposal site. However, it is noted that the lake is filled each season with municipal water.

TABLE 1-3
DRMO VERIFICATION STUDY (1988)
SUMMARY OF SUBSURFACE SOIL ANALYTICAL DATA

PARAMETER	SAMPLE ID:	B-1	B-2	B-3
	DEPTH (ft):	0-10	0-10	0-10
VOLATILE ORGANICS (ppm)				
Chloroform		ND	ND	0.016
1,1-Dichloroethene		0.03	ND	0.026
1,2-Dichloroethene		0.011	ND	0.039
Methylene chloride		0.036	ND	0.057
Toluene		0.096	0.041	0.076
1,1,1-Trichloroethane		0.013	ND	ND
Trichloroethylene		ND	0.03	0.011
SEMI-VOLATILE ORGANICS (ppm)				
Acenaphthene		1.85	ND	ND
Anthracene		5	ND	1.6
Benzo(a)anthracene		5.35	ND	5.6
Benzo(b)fluoranthene		2.35	ND	3.55
Benzo(k)fluoranthene		3.3	ND	1.95
Benzo(g,h,i)perylene		1.3	ND	1.65
Benzo(a)pyrene		2.65	ND	2.35
Chrysene		4.85	ND	4.65
Fluoranthene		11	ND	12.3
Fluorene		8.8	ND	ND
Indeno(1,2,3-cd)pyrene		0.7	ND	1.25
Naphthalene		ND	ND	1.05
Phenanthrene		18.2	ND	7.25
Pyrene		9.3	ND	9.2
INORGANICS (ppm)				
Antimony		12.8	7.5	13
Arsenic		1.73	1.5	1.87
Beryllium		0.25	0.3	0.5
Cadmium		0.49	0.45	4.4
Chromium		10.7	9.44	26.4

TABLE 1-3 (continued)
DRMO VERIFICATION STUDY (1988)
SUMMARY OF SUBSURFACE SOIL ANALYTICAL DATA

PARAMETER	SAMPLE ID:	B-1	B-2	B-3
	DEPTH (ft):	0-10	0-10	0-10
INORGANICS (ppm)				
Copper		43.4	38.9	1000
Lead		30.6	45.8	750
Nickel		9.87	10.2	130
Silver		ND	0.35	2.1
Thallium		4.44	2.99	4
Zinc		103	8.19	1050
Cyanide (total)		0.07	0.07	0.1

1. Source of analytical data (Wehran, 1988)

TABLE 1-4
DRMO CONFORMING STORAGE FACILITY REPORT (1988)
SUMMARY OF SUBSURFACE SOIL ANALYTICAL DATA

PARAMETER	SAMPLE ID:	BH-1	BH-2	BH-3	BH-4
	DEPTH (ft):	Composite	Composite	Composite	Composite
VOLATILE ORGANICS (ppb)					
Volatile Organics		ND	ND	ND	ND
SEMI-VOLATILE ORGANICS (ppb)					
Phenanthrene		ND	ND	1400	2100
Fluoranthene		ND	ND	1400	4000
Pyrene		ND	ND	1300	2700
Chrysene		ND	ND	920	1200
Benzo(b)Fluoranthene		ND	ND	ND	920
PESTICIDES/PCBs (ppb)					
4,4 DDE		41	ND	ND	ND
PCB (Arochlor 1254)		570	ND	ND	ND
INORGANICS (ppm)					
Arsenic		2.7	1.4	3.2	3.3
Beryllium		2.4	0.2	0.36	4.2
Cadmium		0.98	ND	ND	ND
Total Chromium		27	18	18	18
Copper		460	25	72	66
Lead		340	17	120	64
Nickel		83	11	11	20
Silver		1.3	1	0.98	0.82
Zinc		1900	62	69	190
Cyanide		ND	ND	0.69	ND

1. Source of analytical data (Wehran, 1988)

TABLE 1-5
LOWER SUBASE
HYDROGEOLOGIC INVESTIGATION, UNDERGROUND STORAGE TANK H
SUMMARY OF GROUND WATER ANALYTICAL DATA

PARAMETER	SAMPLE I.D.	FO-13	FO-14	FO-15	FO-16
Fuel Oil (ppm)		97	1100	750	21
Toluene (ppb)		11	ND	ND	ND
Xylenes (ppb)		9.6	ND	ND	ND

1. Source of analytical data (Fuss & O'Neill, 1989).

Both soil and water were tested for priority pollutants in the spring of 1988 and 1990. Low levels of metals, including mercury, were measured in the sand. Low to moderate levels (10-3000 ppb) of phthalates were intermittently detected in the lake water. The lake was retested monthly in the spring and summer of 1990. Low levels of phthalates were detected once during this period. Mercury was also detected in beach sand in one April 1990 sample, but was not detected in lake water or other soils collected during the spring of 1990. Sampling was conducted in the fall of 1990 to determine the extent of mercury in beach sand; no mercury was detected. Navy laboratory data for North Lake are summarized in Table 1-6.

1.3 Report Organization

The following subsection provides a brief overview of the remaining sections of the report. Report organization follows USEPA CERCLA guidance (USEPA, 1988).

1.3.1 Site Investigation

Section 2.0 provides details and procedures used to conduct the site investigation and laboratory analytical program. Procedures and sampling plan summaries are provided for the radiation, geophysical and soil gas surveys; soils investigation, ground water investigation, ecological investigation, and a summary of the quality assurance/quality control program is also included. Tables are provided listing samples collected and analyses performed for all samples by site and media.

1.3.2 Physical Characteristics of the Study Area

Section 3.0 describes the general physical features of the site and surrounding area. This section includes discussions of the regional and site specific bedrock and surficial geology, soils, ground and surface water hydrology, climatology and demography. Site specific geologic cross-sections and ground water contour maps are provided as applicable.

1.3.3 Nature and Extent of Contamination

Section 4.0 presents the radiation, geophysics, and soil gas survey results for applicable sites. Laboratory analytical data is also presented in tabular and graphical form for surface soils, subsurface soils, sediment, ground water, and surface water. Biota sampling results are presented

TABLE 1–6
NORTH LAKE
SUMMARY OF SURFACE WATER AND SEDIMENT/BEACH SAND ANALYTICAL DATA (ORGANICS AND INORGANICS)

PARAMETER	SAMPLE DATE: / SAMPLE MATRIX:	April 1988 Water	March 1990 Water	May 1990 Water	July 1990 Water	April 1988 Soil (North Lake)	April 1988 Soil (East Gate)	March 1990 Soil	April 1990 Soil	May 1990 Soil	August 1990 Soil
VOLATILE ORGANICS (ppb)											
		ND	ND	ND	NA	ND	NA	ND	ND	NA	NA
SEMI-VOLATILE ORGANICS (ppb)											
Phthalates											
Bis(2-ethylhexyl)phthalate		13	ND	NA	NA	ND	NA	ND	NA	NA	NA
Di-n-butylphthalate		ND	ND	NA	NA	ND	NA	3289	NA	NA	NA
PHTHALATE ESTERS (ppb)											
Bis(2-ethylhexyl)phthalate[1]		NA	NA	NA	6	NA	NA	NA	NA	ND	ND
PESTICIDES/PCBs (ppb)											
		ND	ND	NA	NA	ND	NA	ND	NA	NA	NA
TAL INORGANICS (ppm)											
Antimony		ND	ND	NA	NA	ND	NA	ND	NA	NA	NA
Arsenic		ND	ND	NA	NA	30	NA	3.9	NA	NA	NA
Beryllium		ND	ND	NA	NA	ND	NA	ND	NA	NA	NA
Cadmium		ND	ND	NA	ND	ND	NA	1.6	0.72	0.85	ND
Chromium		ND	ND	NA	ND	6.3	NA	5.7	NA	5.1	5
Copper		0.1	ND	NA	ND	3.1	NA	8.9	ND	5.1	ND
Iron		NA	NA	NA	NA	NA	NA	NA	2522	NA	NA
Lead		ND	ND	NA	ND	13	NA	15	ND	15	ND
Mercury		ND	ND	NA	NA	ND	NA	ND	32	ND	1.1
Nickel		ND	ND	NA	ND	3.1	NA	4	NA	46	ND
Selenium		ND	ND	NA	NA	ND	NA	ND	NA	NA	ND
Silver		ND	0.02	NA	NA	ND	NA	ND	NA	NA	ND
Thallium		ND	ND	NA	NA	0.56	NA	ND	NA	NA	ND
Zinc		ND	0.042	NA	ND	6.3	NA	15	9.9	13	15
Cyanide		NA	ND	NA	NA	NA	NA	ND	NA	NA	NA
EP TOXICITY METALS (ppm)											
Arsenic		NA	NA	NA	NA	0.01	0.019	NA	NA	NA	NA
Chromium		NA	NA	NA	NA	ND	ND	NA	NA	NA	NA
Lead		NA	NA	NA	NA	ND	ND	NA	NA	NA	NA
Thallium		NA	NA	NA	NA	ND	ND	NA	NA	NA	NA
Copper		NA	NA	NA	NA	0.2	0.1	NA	NA	NA	NA
Nickel		NA	NA	NA	NA	ND	ND	NA	NA	NA	NA
Zinc		NA	NA	NA	NA	0.18	0.25	NA	NA	NA	NA

TABLE 1–6 (continued)
NORTH LAKE (OCTOBER 1990)
SUMMARY OF SEDIMENT/BEACH SAND ANALYTICAL DATA (INORGANICS)

PARAMETER	SAMPLE ID[2]:	8A	8B	9A	9B	10A	10B	11A	11B	12A	12B
TCLP METALS (ppm)											
Arsenic		ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Barium		0.729	0.544	0.231	0.119	0.748	0.253	0.197	0.322	0.26	0.739
Cadmium		ND	ND	ND	0.057	ND	ND	ND	ND	ND	0.018
Chromium		0.05	ND	ND	ND	ND	ND	ND	ND	ND	ND
Lead		0.14	ND	ND	ND	ND	ND	0.08	ND	ND	ND
Mercury		ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Selenium		ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Silver		ND	ND	ND	ND	ND	ND	ND	ND	ND	ND

SOURCE: Analytical Data provided by U.S. Navy

NOTES

1) Some samples not analyzed for all SVOs, just phthalate esters.
2) Discrete sample locations from beach area.
3) ND indicates not detected; NA indicates not analyzed.

and discussed in Section 6.0. Results are compared with site specific applicable or relevant and appropriate requirements (ARARs), and to be considered (TBC) values, which are also discussed in this section of the report.

1.3.4 Contaminant Fate and Transport

Fate and transport data for the classes of chemicals identified are discussed in Section 5.0. These include volatile organic compounds (VOCs), semi-volatile organics (SVOs), pesticides/PCBs, and inorganics. General potential routes of contaminant migration are discussed as well as an evaluation of site specific contaminant migration potential.

1.3.5 Health and Ecological Risk Assessment

A health risk assessment for Step I and II sites is provided in Section 6.0. An ecological risk assessment for Step I and II sites is provided in Section 7.0 For Step I sites, these assessments are qualitative in nature and are used as part of the determination of whether to proceed to the Step II phase. The quantitative health and environmental risk assessments for Step II sites include contaminant identification, exposure assessment, toxicity assessment and risk characterization.

1.3.6 Summary and Conclusions

Section 8.0 discusses the summary and conclusions of the investigations and evaluations at each site. Included are overviews of site history, nature and extent of contamination, and health and environmental risk assessment. Based on this information, for Step I sites, a recommendation is provided for proceeding to Step II, or for no further action. A no further action recommendation is based on identification of no significant contamination and no health or environmental risk. Recommendations to proceed from Step I to Step II are based on identification of contaminants above applicable standards, and where health and/or environmental risk are of concern. Four Step II site recommendations are provided to proceed to the Feasibility Study phase, and to collect additional data as appropriate.

2.0 SITE INVESTIGATION

This section provides details and procedures used to conduct the site investigation and laboratory analytical program. Procedures and sampling plan summaries are provided for the radiation, geophysical, and soil gas surveys, soils investigation, ground water investigation, surface water investigation, ecological investigation, and a summary of the quality assurance/quality control program. Tables are provided listing samples collected and analyses performed for all samples by media. Figures illustrating sample locations at each site are provided in Section 4.0 of this report.

All field work was conducted in accordance with The Installation Restoration Study Final Plan of Action, prepared by Atlantic, dated April 1989, as modified by USEPA and CTDEP comments, and approved by the Navy. All survey and analytical results are provided in Section 4.0. Hydrogeologic data results (e.g., conductivity, water table maps) are provided in Section 3.0.

2.1 General Discussion

A sample designation format was developed for this project. Each sample was given a sample identification number in the field. An example of a soil sample number is the following: **081590 - 2LMW17 (4-8)**. Each sample identification number is comprised of the elements described below. Examples are provided in **bold**.

- Date: The date the sample was collected is included in six digit form, **081590**;

- Site Number: The site at which a sample was collected is identified by the site numbers used in the IR Work Plan and as noted in Section 1.2.5. Exceptions include offsite sampling points which are designated OS and Area A samples which include an additional letter describing location (i.e., L for Landfill, W for Wetland and D for Downstream Watercourses; **2L = Site 2, Landfill**);

- Sample Description: Denoted by the following abbreviations:

  SS - Surface Soil
  TB - Test Boring (no well installed)
  MW - Monitoring well (used for both soil and ground water samples)
  SD - Sediment
  SW - Surface Water
  W - Offsite Residential Well
  SG - Soil Gas

- Sample Number: Individual sample numbers start at 1 for each medium at each site and are numbered consecutively. Note that monitoring wells for all Area A and Over Bank Disposal Area sites are grouped together and numbered from 1 to 18;

- Sample Depth: Soil sampling interval is indicated parenthetically in feet below ground surface, **(4-8)**;

- **Other Abbreviations Used:**

  S - for shallow surface soils - 0 to 0.5 feet, **14SS1S;**

  S - for overburden monitoring wells, **6MW5S;**

  D - for deep surface soils - 1 to 1.5 feet, **4SS1D;** and

  D - for bedrock monitoring wells, **6MW5D.**

2.2 Laboratory Analysis Program

The laboratory analysis program was conducted by NET Atlantic, Inc., Cambridge Division of Bedford, Massachusetts. The work was completed in accordance with the Quality Assurance Project Plan prepared by NET and dated January 27, 1989 as amended, which complied with the Navy's NEESA document 20.2-047B, *Sampling and Chemical Analysis Quality Assurance Requirements for the Navy Installation Restoration Program.*

All applicable organic analysis was performed in accordance with *Organic Analysis for Multi-Media, Multi-Concentration, Statement of Work, Revision 2/88, U.S. Contract Laboratory Program, USEPA, 1988.* All applicable inorganic analysis was performed in accordance with the *Contract Laboratory Program Inorganic Analysis for Multi-Media, Multi-Concentration, Statement of Work, Revision 2/88, U.S. Contract Laboratory Program, USEPA, 1988.* TCLP extractions were performed on some soil and sediment samples in accordance with the procedures specified in the March 29, 1990 Federal Register. Metals analyzed in the extract by this procedure included arsenic, barium, cadmium, chromium, lead, mercury, selenium, and silver. Also, selected pesticide and PCB sample extracts were analyzed by TCLP. The TCLP extraction test, established by USEPA, was designed to simulate the leaching of chemicals from a material disposed in a waste disposal area.

Tables 2-1, 2-2 and 2-3 summarize the target compound list (TCL) parameters and contract required quantitation limits (CRQLs) for volatile organic compounds (VOCs), semi-volatile organics (SVOs), PCBs/pesticides. Table 2-4 summarizes the target analyte list (TAL) parameters and contract required detection limits (CRDLs) for inorganics. Tentatively identified compounds (TIC) were identified on the laboratory analysis reports for VOC and SVO compounds. TICs are considered in the Health and Environmental Risk Assessment.

Actual detection limits for VOCs and SVOs in an aqueous sample are 1 ppb, and values reported between this level and the CRQLs are estimated. Also, in soil samples, the detection limits may be below the CRQLs due to laboratory instrument capabilities.

2.3 Surveying and Mapping

Methodologies and references used for surveying and for mapping are described below.

2.3.1 Surveying

Surveying for the project was provided by Associated Surveys of Branford, Connecticut.

TABLE 2-1
TARGET COMPOUND LIST VOLATILE ORGANICS

COMPOUND	CAS NUMBER	CONTRACT REQUIRED QUANTITATION LIMITS (CRQL) WATER (ppb)	SOIL/SEDIMENT (ppb)
Chloromethane	74-87-3	10	10
Bromomethane	74-83-9	10	10
Vinyl Chloride	75-01-4	10	10
Chloroethane	75-00-3	10	10
Methylene Chloride	75-09-2	5	5
Acetone	67-64-1	10	10
Carbon Disulfide	75-15-0	5	5
1,1-Dichloroethene	75-35-4	5	5
1,1-Dichloroethane	75-34-3	5	5
1,2-Dichloroethene (total)	540-59-0	5	5
Chloroform	67-66-3	5	5
1,2-Dichloroethane	107-06-2	5	5
2-Butanone	78-93-2	10	10
1,1,1-Trichloroethane	71-55-6	5	5
Carbon Tetrachloride	56-23-5	5	5
Vinyl Acetate	108-05-4	10	10
Bromodichloromethane	75-27-4	5	5
1,2-Dichloropropane	78-87-5	5	5
cis-1,3-Dichloropropene	10061-01-5	5	5
Trichloroethene	79-01-6	5	5
Dibromochloromethane	124-48-1	5	5
1,1,2-Trichloroethane	79-00-5	5	5
Benzene	71-43-2	5	5
trans-1,3-Dichloropropene	10061-02-6	5	5
Bromoform	75-25-2	5	5
4-Methyl-2-pentanone	108-88-2	10	10
2-Hexanone	591-78-6	10	10
Tetrachloroethene	127-18-4	5	5
1,1,2,2-Tetrachloroethane	79-34-5	5	5
Toluene	108-88-2	5	5
Chlorobenzene	108-90-7	5	5
Ethyl Benzene	100-41-4	5	5
Styrene	100-42-5	5	5
Xylenes (total)	133-02-7	5	5

1. Laboratory analysis procedures per USEPA, 1988. Organic Analysis for Multi-Media, Multi-Concentration, Statement of Work, Revision 2/88. US Contract Laboratory Program. EPA/CLP, Washington, D.C.
2. Medium Concentration Soil/Sediment CRQLs for Volatile Compounds are 125 times the individual Low Concentration Soil/Sediment CRQL. The CRQL is the CLP Contract Required Quantitation Limit.
3. Specific detection limits are highly matrix dependent. The Quantitation Limits listed herein are provided for guidance and may not always be achievable.
4. Quantitation Limits listed for soil/sediment are based on wet weight. The Quantitation Limits calculated by the laboratory for soil/sediment, calculated on a dry weight basis as required by the contract, will be higher.
5. CAS number is chemical abstract service number.

TABLE 2-2
TARGET COMPOUND LIST SEMI-VOLATILE ORGANICS

COMPOUND	CAS NUMBER	CONTRACT REQUIRED QUANTITATION LIMITS (CRQL)	
		WATER (ppb)	SOIL/SEDIMENT (ppb)
Phenol	108-95-2	10	330
bis(2-chloroethyl)ether	111-4-4	10	330
2-Chlorophenol	95-57-8	10	330
1,3-Dichlorobenzene	541-73-1	10	330
1,4-Dichlorobenzene	106-46-7	10	330
Benzyl Alcohol	100-51-6	10	330
1,2-Dichlorobenzene	95-50-1	10	330
2-Methylphenol	95-48-7	10	330
bis(2-chloroisopropyl)ether	39638-32-9	10	330
4-Methylphenol	106-44-5	10	330
N-nitroso-di-n-propylamine	621-64-7	10	330
Hexachloroethane	67-72-1	10	330
Nitrobenzene	98-95-3	10	330
Isophorone	78-59-1	10	330
2-Nitrophenol	88-75-5	10	330
2,4-Dimethylphenol	105-67-9	10	330
Benzoic Acid	65-85-0	50	1,600
bis(2-chloroethoxy)methane	111-91-1	10	330
2,4-Dichlorophenol	120-83-2	10	330
1,2,4-Trichlorobenzene	120-82-1	10	330
Naphthalene	91-20-3	10	330
4-Chloroaniline	106-47-8	10	330
Hexachlorobutadiene	87-68-3	10	330
4-Chloro-3-methylphenol	59-50-7	10	330
2-Methylnaphthalene	91-57-6	10	330
Hexachlorocyclopentadiene	77-47-4	10	330
2,4,6-Trichlorophenol	88-06-2	10	330
2,4,5-Trichlorophenol	95-95-4	50	1,600
2-Chloronaphthalene	91-58-7	10	330
2-Nitroaniline	88-74-4	50	1,600
Dimethyl Phthalate	131-11-3	10	330
Acenaphthylene	208-96-8	10	330
2,6-Dinitrotoluene	606-20-2	10	330
3-Nitroaniline	99-09-2	50	1,600
Acenaphthene	83-32-9	10	330
2,4-Dinitrophenol	51-28-5	50	1,600
4-Nitrophenol	100-02-7	50	1,600
Dibenzofuran	132-64-9	10	330
2,4-Dinitrotoluene	121-14-2	10	330
Diethylphthalate	84-66-2	10	330

1. Laboratory analysis procedures per USEPA, 1988. Organic Analysis for Multi-Media, Multi-Concentration, Statement of Work, Revision 2/88. US Contract Laboratory Program. EPA/CLP, Washington, D.C.
2. Medium Concentration Soil/Sediment CRQLs for Semi-Volatile Organics are 60 times the individual Low Concentration Soil/Sediment CRQL. The CRQL is the CLP Contract Required Quantitation Limit.
The CRQL is the CLP Contract Required Quantitation Limit.
3. Specific detection limits are highly matrix dependent. The Quantitation Limits listed herein are provided for guidance and may not always be achievable.
4. Quantitation Limits listed for soil/sediment are based on wet weight. The Quantitation Limits calculated by the laboratory for soil/sediment, calculated on a dry weight basis as required by the contract, will be higher.
5. CAS number is chemical abstract service number.

TABLE 2-2 (continued)
TARGET COMPOUND LIST SEMI-VOLATILE ORGANICS

COMPOUND	CAS NUMBER	CONTRACT REQUIRED QUANTITATION LIMITS (CRQL)	
		WATER (ppb)	SOIL/SEDIMENT (ppb)
4-Chlorophenyl-phenylether	7005-72-3	10	330
Fluorene	86-73-7	10	330
4-Nitroaniline	100-10-6	50	1,600
4,6-Dinitro-2-methylphenol	534-52-1	50	1,600
N-nitrosodiphenylamine	86-30-6	10	330
4-Bromophenyl-phenylether	101-55-3	10	330
Hexachlorobenzene	118-74-1	10	330
Pentachlorophenol	87-86-5	50	1,600
Phenanthrene	85-01-8	10	330
Anthracene	120-12-7	10	330
Di-n-butylphthalate	86-74-2	10	330
Fluoranthene	206-44-0	10	330
Pyrene	129-00-0	10	330
Butylbenzylphthalate	85-68-7	10	330
3,3-Dichlorobenzidine	91-94-1	20	660
Benzo(a)anthracene	56-55-3	10	330
Chrysene	218-01-9	10	330
bis(2-Ethylhexyl)phthalate	117-81-7	10	330
Di-n-octylphthalate	117-84-0	10	330
Benzo(b)fluoranthene	205-99-2	10	330
Benzo(k)fluoranthene	207-08-9	10	330
Benzo(a)pyrene	50-32-8	10	330
Indeno(1,2,3-cd)pyrene	193-39-5	10	330
Dibenzo(a,h)anthracene	53-70-3	10	330
Benzo(g,h,i)perylene	191-24-2	10	330

1. Laboratory analysis procedures per USEPA, 1988. Organic Analysis for Multi-Media, Multi-Concentration, Statement of Work, Revision 2/88. US Contract Laboratory Program. EPA/CLP, Washington, D.C.
2. Medium Concentration Soil/Sediment CRQLs for Semi-Volatile Organics are 60 times the individual Low Concentration Soil/Sediment CRQL. The CRQL is the CLP Contract Required Quantitation Limit.
   The CRQL is the CLP Contract Required Quantitation Limit.
3. Specific detection limits are highly matrix dependent. The Quantitation Limits listed herein are provided for guidance and may not always be achievable.
4. Quantitation Limits listed for soil/sediment are based on wet weight. The Quantitation Limits calculated by the laboratory for soil/sediment, calculated on a dry weight basis as required by the contract, will be higher.
5. CAS number is chemical abstract service number.

TABLE 2-3
TARGET COMPOUND LIST PESTICIDES/PCBs

COMPOUND	CAS NUMBER	CONTRACT REQUIRED QUANTITATION LIMITS (CRQL)	
		WATER (ppb)	SOIL/SEDIMENT (ppb)
alpha-BHC	319-84-6	0.05	8.0
beta-BHC	319-85-7	0.05	8.0
delta-BHC	319-86-8	0.05	8.0
Lindane	58-89-9	0.05	8.0
Heptachlor	76-44-8	0.05	8.0
Aldrin	309-00-2	0.05	8.0
Heptachlor Epoxide	1024-57-3	0.05	8.0
Endosulfan I	959-98-8	0.05	8.0
Dieldrin	60-57-1	0.10	16.0
4,4'DDE	72-55-9	0.10	16.0
Endrin	72-20-8	0.10	16.0
Endosulfan II	33213-65-9	0.10	16.0
4,4'DDD	72-54-8	0.10	16.0
Endosulfan Sulfate	1031-07-8	0.10	16.0
4,4'DDT	50-29-3	0.10	16.0
Methoxychlor	72-43-5	0.05	80.0
Endrin Ketone	53494-70-5	0.10	16.0
alpha-chlordane	5103-71-9	0.05	80.0
gamma-chlordane	5103-74-2	0.05	80.0
Toxaphene	8001-35-2	1.0	160.0
PCB Aroclor-1016	12674-11-2	0.05	80.0
PCB Aroclor-1221	11104-28-2	0.05	80.0
PCB Aroclor-1232	11141-16-5	0.05	80.0
PCB Aroclor-1242	53469-21-9	0.05	80.0
PCB Aroclor-1248	12672-29-6	0.05	80.0
PCB Aroclor-1254	11097-69-1	1.0	160.0
PCB Aroclor-1260	11096-82-5	1.0	160.0

1. Laboratory analysis procedures per USEPA, 1988. Organic Analysis for Multi-Media, Multi-Concentration, Statement of Work, Revision 2/88. US Contract Laboratory Program. EPA/CLP, Washington, D.C.
2. Medium Concentration Soil/Sediment CRQLs for Pesticide/PCB TCL Compounds are 15 times the individual Low Concentration Soil/ Sediment CRQL. The CRQL is the CLP Contract Required Quantitation Limit.
   The CRQL is the CLP Contract Required Quantitation Limit.
3. Specific detection limits are highly matrix dependent. The Quantitation Limits listed herein are provided for guidance and may not always be achievable.
4. Quantitation Limits listed for soil/sediment are based on wet weight. The Quantitation Limits calculated by the laboratory for soil/sediment, calculated on a dry weight basis as required by the contract, will be higher.
5. CAS number is chemical abstract service number.

TABLE 2-4
TARGET ANALYTE LIST - INORGANICS

COMPOUND	CONTRACT REQUIRED DETECTION LIMIT (CRDL) WATER (ppb)
Aluminum	200
Antimony	60
Arsenic	10
Barium	200
Beryllium	5
Cadmium	5
Calcium	5,000
Chromium	10
Cobalt	50
Copper	25
Iron	100
Lead	5
Magnesium	5,000
Manganese	15
Mercury	0.2
Nickel	40
Potassium	5,000
Selenium	5
Silver	10
Sodium	5,000
Thallium	10
Vanadium	50
Zinc	20
Boron	200
Cyanide	10

1. Laboratory analysis procedure per Contract Laboratory Program Inorganic Analysis for Multi-Media, Multi-Concentration, Statement of Work, Revision 2/88, U.S. Contract Laboratory Program, USEPA, 1988.
2. Boron is not a TAL Compound under CLP and, therefore, value reported is not a CRDL.

Elevations and coordinates were established for all monitoring wells and test borings, and the majority of surface soil and sediment samples. Fifty foot grid points were painted or staked in the field for the soil gas, geophysical and/or radiation surveys at Area A Landfill, DRMO, Goss Cove and the Former Gasoline Station sites. Some deviations in the grid spacing were required for the site specific conflicts.

All elevations are based on differential leveling runs between known vertical control points and objects requiring elevations. All vertical control was double run to confirm final elevations. Elevations are accurate to Class V-2. The datum used is as shown on a map entitled, Base Traverse and Monuments, NAVFAC Drawing No. 2,037,619; Code Ident. No. 80091; Size: F; Contr. No. N62472-78-C-3422(ES) Sheet 1 of 2 prepared for the Department of the Navy by Kieltyka, Woodis & Pike Land Surveyors. The elevations are in the Subase datum, which is 1.41$\pm$ feet below the USGS NGVD datum.

All coordinates are based on field methods that conform to the standards of a Class A-2 survey. The Connecticut State Plane Coordinate System was used based on the above mentioned map.

2.3.2 Mapping

Map information (e.g., topography, buildings) was developed based on maps of NSB-NLON, prepared by Loureiro Engineering Associates, December 1980. These maps are 1 inch = 40 feet and have a two foot contour interval.

Site plans and field sampling plans were developed from the above referenced maps using Freelance™, a graphics software package. The approximate scale of these figures is so noted.

For Step II sites, AutoCAD™, a computer aided design software package, was used to develop site plans, sampling plans, ground water contour maps, and other data presentation plans. The maps were digitized from the Loureiro Engineering Associates maps. Scales are noted on the plans; contour intervals are two feet except as noted on the plans.

2.4 Radiation Survey

Radiation Safety Associates, Inc. (RSA) of Hebron, Connecticut performed a radiological survey of three areas at NSB-NLON. The three sites surveyed were the Area A Landfill, Goss Cove Landfill, and DRMO. The purpose of these surveys was to determine if any radioactive material had been disposed of at the former landfills, or if any radioactive contamination now exists at any of these locations. Surveys were carried out on June 27, July 10, and August 8, 9, and 17, 1990. The complete radiation survey report is provided as a separate bound report.

2.4.1 Instrumentation

The gamma radiation surveys were performed using a solid-state, one inch by one inch sodium iodide detector in a Model 19 Micro-R meter, manufactured by Ludlum Measurements of Sweetwater, Texas. This instrument is sensitive only to gamma radiation and reads in units of micro Roentgens per hour (μR/hour) or millionths of a Roentgen per hour. This is a very sensitive detector in general use for environmental surveys. This was the primary instrument used for the radiological survey of the sites.

Beta radiation surveys were performed using a two inch diameter (approximately 20 square centimeters) Geiger-Mueller, thin entry window, pancake type, Ludlum Model 44-9 detector. This was connected to a Ludlum Model 18 count rate meter. This detection system is sensitive to beta and gamma radiation, but will also detect alpha particles which have energies over 3 MeV.

Alpha radiation surveys were performed using a four inch diameter (approximately 80 square centimeters) Model 43-1 detector with a Model 18 count rate meter, both manufactured by Ludlum Measurements. This detector is sensitive only to alpha radiation, and does not respond to beta or gamma radiation. During surveys, the detector was held within one centimeter of the surface being surveyed. This is necessary due to the very short range of alpha particles in air (approximately seven centimeters).

Low energy gamma measurements were taken using a one inch diameter Model 44-3 detector with a Model 18 count rate meter, both manufactured by Ludlum Measurements. This detector is sensitive to low-energy gamma radiation, which may not be detected with the Micro-R meter. It does not respond to the higher energy gamma rays which the Micro-R meter detects.

2.4.2 Methodology

Surveyed grids (50 feet on center) were established at the sites where radiation surveys were conducted. The gamma radiation survey consisted of walking along each grid line and also halfway between each grid line, recording gamma levels at each grid point, and at the approximate midpoint. Measurements at each survey point consisted of one gamma reading at waist level and another in contact with the ground. Additionally, a continuous survey was performed while walking between each survey point. Background gamma radiation levels were taken outside the perimeters of each area surveyed and at other randomly selected locations around NSB-NLON. Any gamma measurement in the survey areas found to be significantly in excess of background gamma levels was investigated further by attempting to determine the specific origin of that radiation, and by performing alpha and beta radiation surveys in those areas.

Survey results are discussed in Section 4.0.

2.5 Geophysical Investigation

Weston Geophysical of Westboro, Massachusetts performed the geophysical investigations for the project. Geophysical investigations were conducted at five sites (Spent Acid Storage and Disposal Area, Former Gasoline Station, Area A Landfill, DRMO, and Goss Cove Landfill) to assist in characterization of subsurface conditions at those areas. Ground penetrating radar (GPR), magnetometry, and electromagnetic (EM) terrain conductivity methods were employed during these surveys.

The objectives of the geophysical surveys were identification of buried, man-made features such as storage tanks or possibly drums, and delineation of contaminant plumes. The former landfills (Goss Cove, Area A, and DRMO) were surveyed due to the potential for past disposal of metal objects in those areas. Potentially identified buried objects were then avoided in subsequent drilling activities. The Former Gasoline Station site was surveyed to assess the potential of remaining underground storage tanks. The survey at the Spent Acid Storage and Disposal Area was conducted in an attempt to locate the battery acid storage tank. Field work was accomplished between June 13-15 and 25-27, 1990. The complete geophysical report is provided as a separate bound report.

The following geophysical survey techniques were used at the investigated sites.

Magnetometry - Magnetometry surveying was performed at the Area A Landfill, DRMO, and Goss Cove Landfill to identify buried ferrous metal objects. Data were acquired using a Geometrics model G-856 digital proton precession magnetometer at intervals of ten feet along each grid line. Upon completion of surveying at each area, data were downloaded to a portable computer to facilitate processing and preparation of magnetic contour maps.

Electromagnetic Terrain Conductivity - Conductivity profiling was accomplished at the Area A Landfill, DRMO Area, and Goss Cove Landfill to screen for electrically conductive subsurface contamination and to confirm results of the magnetometry surveys. Electromagnetic (EM) conductivity data were obtained using a Geonics Model EM-31 equipped with a digital datalogger. The datalogger enabled transferring EM data to a portable computer for contouring.

Ground Penetrating Radar - Ground penetrating radar (GPR) data were obtained at sites specified for geophysical investigation to identify stratigraphy or subsurface objects such as storage tanks. GPR data were acquired using GSSI model SIR-8 instrumentation coupled with a 500 megahertz antenna and a graphic recorder. Hardcopy prints produced by the graphic recorder were evaluated for stratigraphic information as well as evidence of trenches, backfill material, or buried objects.

Survey results are discussed in Section 4.0.

2.6 Soil Gas Survey

Soil gas surveys were conducted at Torpedo Shops, Goss Cove Landfill, Former Gasoline Station, Area A Landfill, DRMO, and Lower Subase. The purpose of the soil gas survey is to detect and estimate the lateral extent and relative concentration of subsurface VOCs. This is accomplished by collecting and analyzing soil vapors for selected constituents that result from volatilization of subsurface VOCs. Atlantic Technical Procedure 1052, as described herein, was followed in performing the soil gas surveys.

2.6.1 Sample Collection and Analysis

The soil gas survey was conducted using a Photovac Model 10S50 portable gas chromatograph (GC) with a capillary column and a photoionization detector. The daily GC conditions were as follows: oven temperature 40°C; column flow of 10 mls/minute-ultra zero air; gain of 50; and analysis time of 1500 seconds maximum.

The sample chromatograms were compared to the following standards, as appropriate:

- benzene in air standard, 1 ppm; and

- headspace standard of the following volatile organics mixed in water: benzene at 17 ppb; toluene at 17 ppb; ethyl benzene at 72 ppb; xylenes (o, m, and p) at 34 ppb each; 1,2,4-trimethyl benzene at 400 ppb; and 1,1 dichloroethene, trichloroethene, and tetrachloroethene at 30 ppb each.

A plunger bar was used to drive a one-half inch diameter hole approximately four feet into the ground. A properly decontaminated five foot long one-quarter inch O.D. stainless steel tube was used to collect the sample. To prevent soil from entering the tube, a length of polycarbonate line was inserted into the stainless steel tube and held in place. After the stainless steel tube was in place in the ground, the polycarbonate line was removed, allowing vapors to be drawn into the stainless steel tube. Clay was placed around the tube at the soil surface creating a seal that prevented surface air from mixing with soil vapors. A three-way Swagelok fitting was placed on the open end of the steel tube at the ground surface. One end of the fitting was connected to a teflon tube leading to a small personal sampler air pump. A teflon coated septum was secured over the remaining opening of the fitting. The sampler pump was turned on for three to five minutes at a flow rate of approximately 180 ml/minute. The soil gas sample was collected by inserting a properly decontaminated syringe through the septum and withdrawing 300 microliters of air. The sampling apparatus was removed and flushed with ambient air to remove any contamination. The sample was then directly injected into the portable field GC.

The peaks in the soil gas samples were identified by retention time comparisons to the known standard previously mentioned. Standards were run at the beginning, middle, and end of each day, and whenever a question of shifting retention times occurred. The following quality control samples were run at the frequencies listed:

- Duplicates - one per day minimum;

- Background Samples - system blanks which were run at the beginning and end of each day;

- Calibration Standards - beginning and end of each day, and whenever a question of shifting retention times arose; and

- Calibration Blanks - one in ten samples and whenever a question of possible cross-contamination arose.

2.6.2 Data Utilization

Each chromatogram produced during the soil gas survey was interpreted with respect to peak identification and relative quantitation. The peaks generated by each sample were identified by retention time comparison to the known standards.

The relative quantitation of the soil gas data took all soil gas peaks into account. The Photovac GC measures peak areas in units of volt-seconds. The higher VOC concentration, the higher number of volt-seconds it will produce. The following guidelines were established in order to classify ranges of concentration at the sites.

QUANTITATION OF SOIL GAS DATA

ASSIGNED SAMPLE CONCENTRATION	RANGE OF CONCENTRATIONS/ PEAK AREAS (VOLT-SECONDS)
None Detected	< 0.3
Trace	0.3 - 2.0
Low	2.1 - 50
Moderate	51 - 300
High	< 300

The soil gas data tables for each site investigated are included in Appendix A. The tables list the retention times, peak areas (volt-seconds), and assigned sample concentration classifications (e.g., moderate) for each soil gas component detected at the various sites. The sample concentration classification assigned for each sample are based upon the dominant peak from each sample, denoted as the indicator peak. Based on previous experience with soil gas surveys, moderate to high detections are most likely to be indicative of contamination.

2.7 Soils Investigation

This section describes the objectives, methodologies, and scope of work for sampling and analysis of test borings, surface soils and sediments.

2.7.1 Test Borings

The objectives of the test boring program were to characterize physical properties and classifications of subsurface soils, to identify areas of soil contamination, to estimate the lateral and vertical extent of soil contamination (Step II sites), and to identify soil contaminants present.

A total of 108 test borings/monitoring wells were drilled at seven of the Step I and Step II sites at NSB-NLON. The drilling was performed from August to November of 1990 by Empire Soils Investigations, Inc. (Empire) of Edison, New Jersey. Atlantic personnel inspected the drilling, logged and screened soil samples, and collected samples for analysis.

At most sites, soil borings were extended to auger refusal or a maximum depth of twenty feet. Exceptions to this procedure included locations in Area A and the DRMO where nested monitoring wells (overburden/bedrock) were to be installed and borings were extended to bedrock at the nested well locations; the Area A Wetland and Goss Cove Landfill where borings extended to the underlying native material; and the Lower Subase where borings were extended approximately ten feet below the ground water table.

The borings were advanced with 4¼ inch hollow stem augers. Samples were collected continuously with a two inch diameter, two foot long split-spoon sampler. Atlantic personnel logged physical characteristics such as color, density, lithology, and moisture as well as any visual evidence of contamination (i.e., staining or sheen) according to Atlantic Procedure 1030. Each sample was screened with an HNu PI 101 Organic Vapor Analyzer, a Ludlum Model 3 Radiation Meter, and a Neotronics Trigas explosive gas meter. Select samples were also screened for pH in the field.

Atlantic personnel selected a total of 118 subsurface soil samples from 78 of the borings/monitoring wells for laboratory analysis. Other samples were collected and evaluated for the visual presence of contamination (Lower Base) and for pH screening (Area A Landfill).

Selection criteria, as specified in the Plan of Action, included the results of field screening, visual indication of contamination, proximity to the water table, or within known disposal areas (landfill materials, leaching field areas). Some or all of the following parameters were analyzed for: VOCs, SVOs, inorganics, pesticides, PCBs, total petroleum hydrocarbons (TPH), and fluorescence oil identification. Selected soil samples were also analyzed for metals, pesticides, or PCBs by Toxicity Characteristic Leachate Procedure (TCLP). Specific analyses performed and soil sampling intervals are provided for each site on Tables 2-5 (Step I sites), 2-6 (Area A), 2-7 (DRMO), and 2-8 (Lower Subase).

Test boring logs are provided in Appendix B. The test boring logs provide the physical characteristics and soil classification, density information, observations of visual contamination, and radiation/organic vapor screening results.

2.7.2 Surface Soils

The surface soil sampling program was designed to screen for contamination within the upper 18 inches of soil. Surface soils represent one of the principal sources of human health risk due to the possibility of direct contact, ingestion and/or inhalation of soils by onsite workers, maintenance or construction crews, and site visitors. Surface soil sampling locations were selected on the basis of proximity to known fill areas and visual evidence of contamination such as staining.

A total of 24 surface soil samples were collected from four Step I sites and two Step II sites. Protocols for sampling surface soils were followed as specified in Atlantic Procedure 1020. Both discrete and composite samples were collected. Composite samples were not analyzed for VOCs per comments received from the USEPA; discrete samples were selected for VOC analysis based on organic vapor screening results. Atlantic personnel collected the samples with a four inch, stainless steel hand-auger and stainless steel spoons. Composite samples were mixed in a stainless steel bowl. Each sample was logged by Atlantic personnel and screened with an HNu PI 101 Organic Vapor Analyzer, a Ludlum Model 3 Radiation Meter, and a Neotronics Trigas explosive gas meter.

Tables 2-5 through 2-8 include a site by site listing of surface soil samples and laboratory analytical parameters.

2.7.3 Sediments

The objective of sediment sampling was to determine if measurable quantities of contaminants from the site are present in sediments on and near the site. Downstream sediment sampling from Area A to the Thames River was also conducted to evaluate the potential transport of contaminants.

TABLE 2-5
STEP I SITES
SUMMARY OF SOIL SAMPLING PROGRAM

SAMPLE ID[2,3]	SAMPLE DEPTH (ft)	COMMENTS	LABORATORY ANALYSES[1] VOC	SVO	INORGANICS	PESTICIDES	PCBs	TCLP METALS	TCLP PESTICIDES	TCLP PCBs	TPH	FLUORESCENCE	pH
CBU DRUM STORAGE AREA													
112890-1SS4C	0 - 0.5	Composite of 1SS1S, 1SS2S and 1SS3S[6]		•	•	•[4]	•[4]						
112890-1SS1S	0 - 0.5		•					•		•	•		
112890-1SS1D	1 - 1.5	HNu Reading - 5.4 ppm	•								•		
112890-1SS2S	0 - 0.5							•		•	•		
112890-1SS2D	1 - 1.5		•								•		
112890-1SS3S	0 - 0.5							•		•	•		
112890-1SS3D	1 - 1.5	HNu Reading - 11.8 ppm	•								•		
RUBBLE FILL AT BUNKER A-86													
112890-4SS1S	0 - 0.5							•		•			
112890-4SS2S	0 - 0.5		•					•		•			
112890-4SS1D	1 - 1.5		•										
112890-4SS2D	1 - 1.5		•										
112890-4SS3C	0 - 0.5	Composite of 4SS1S and 4SS2S[6]		•	•	•[4]	•[4]						
TORPEDO SHOPS													
080990-7TB1	2 - 4	Within Leaching Zone	•	•	•	•	•	•					
080990-7TB2	2 - 4	Within Leaching Zone	•	•	•	•	•	•					
081390-7TB3[5]	4 - 6	Within Leaching Zone	•	•	•	•	•	•					
081490-7TB4	4 - 6	Within Leaching Zone	•	•	•	•	•	•					
081090-7TB5	6 - 8	At Water Table	•	•	•	•	•	•					
081490-7TB6	6 - 8	At Water Table	•	•	•	•	•	•					
081390-7MW1	0 - 2	At Bedrock Surface	•	•	•	•	•	•					
080990-7MW2	2 - 4	Within Leaching Zone	•	•	•	•	•	•					
081490-7MW3	6 - 8	Within Leaching Zone	•	•	•	•	•	•					
GOSS COVE LANDFILL													
103090-8TB1	4 - 6	HNu Reading - 14 ppm	•	•	•	•	•	•					
103090-8TB2	6 - 8	HNu Reading - 20 ppm; Visual Discoloration	•	•	•	•	•	•					
103090-8TB3[5]	10 - 12	HNu Reading - 7 ppm	•	•	•	•	•	•					
103090-8MW1	6 - 8		•	•	•	•	•	•					
110690-8MW2	10 - 12	HNu Reading - 35 ppm	•	•	•	•	•	•					
110690-8MW3	8 - 10	HNu Reading - 200 ppm	•	•	•	•	•	•					
110690-8MW4[5]	4 - 6	HNu Reading - 11 ppm	•	•	•	•	•	•					
OVER BANK DISPOSAL AREA, NORTHEAST													
112890-14SS3C	0 - 0.5	Composite of 14SS1S and 14SS2S[6]		•	•	•[4]	•[4]						
112890-14SS1S	0 - 0.5							•					
112890-14SS1D	1 - 1.5	HNu Reading - 50 ppm	•										
112890-14SS2S	0 - 0.5	HNu Reading - 1 ppm	•					•					
112890-14SS2D	1 - 1.5		•										

TABLE 2–5 (continued)
STEP I SITES
SUMMARY OF SOIL SAMPLING PROGRAM

			LABORATORY ANALYSES[1]										
SAMPLE ID[2,3]	SAMPLE DEPTH (ft)	COMMENTS	VOC	SVO	INORGANICS	PESTICIDES	PCBs	TCLP METALS	TCLP PESTICIDES	TCLP PCBs	TPH	FLUORESCENCE	pH
SPENT ACID STORAGE AND DISPOSAL AREA													
113090–15SS1	1 – 2							•					
101890–15TB1	0 – 4							•					5.08
101890–15TB1	4 – 8	HNu Reading – 11 ppm						•					6.26
102390–15TB2	0 – 4							•					4.57
102390–15TB2	4 – 8							•					4.22
102490–15TB3	0 – 4							•					7.54
102490–15TB3	4 – 8		•	•	•	•	•	•					5.86
FORMER GASOLINE STATION													
110190–18TB1	8 – 10	HNu Reading – 7.5 ppm	•		•			•					
110190–18TB2	12 – 14	HNu Reading – 7.5 ppm	•		•			•					
110190–18TB3	14 – 16	HNu Reading – 15 ppm; Visual Discoloration	•		•			•					
110190–18TB4	16 – 18		•		•			•					
110190–18TB5	10 – 12	HNu Reading – 8.5 ppm	•		•			•					

NOTES

1) VOC – Volatile Organic Compounds
SVO – Semi–Volatile Organic Compounds
Inorganics – Metals and Cyanide
PCBs – Polychlorinated Biphenyls
TCLP – Toxicity Characteristic Leachate Procedure
TPH – Total Petroleum Hydrocarbons
pH – field pH measurement to assess potential battery acid residuals

2) SS – Surface Soil, TB – Test Boring, MW – Monitoring Well

3) Laboratory Sample Identification Numbers also included sample depth in parentheses following the Sample ID listed above (e.g. 081690–2LTB2 (2–8)).

4) Original sample data rejected during validation; location was resampled at a later date for parameters indicated.

5) Location changed from that shown in Plan of Action (April 1989). Actual location shown on Figure in Section 4.0.

6) Sample submitted for VOC analysis was not composited.

TABLE 2-6
AREA A
SUMMARY OF SOIL SAMPLING PROGRAM

			LABORATORY ANALYSES[1]										
SAMPLE ID[2,3]	SAMPLE DEPTH (ft)	COMMENTS	VOC	SVO	INOR-GANICS	PESTI-CIDES	PCBs	TCLP METALS	TCLP PESTICIDES	TCLP PCBs	TPH	FLUORE-SCENCE	pH[7]
LANDFILL													
112890-2LSS1	0 - 0.5		•[4]	•	•	•[4]	•[4]	•	•				
112890-2LSS2	0 - 0.5		•	•	•	•[4]	•[4]	•	•				
081690-2LTB2[5]	2 - 8	HNu Reading - 4-21 ppm	•	•	•	•	•	•	•				
092590-2LTB1[5]	0 - 2	Screen for Acid											6.05
092590-2LTB1[5]	2 - 4	Screen for Acid											6.0
092590-2LTB1[5]	4 - 6	No Recovery, Screen for Acid											NA
092590-2LTB1[5]	6 - 8	Screen for Acid											6.53
092590-2LTB1[5]	8 - 10	Screen for Acid											6.55
092590-2LTB1[5]	10 - 12	No Recovery, Screen for Acid											NA
092590-2LTB1[5]	12 - 14	Screen for Acid											7.02
092590-2LTB1[5]	14 - 16	Screen for Acid											7.07
092590-2LTB1[5]	16 - 18	No Recovery, Screen for Acid											NA
092590-2LTB1[5]	18 - 20	Screen for Acid											7.90
081690-2LTB2[5]	0 - 2	Screen for Acid											5.82
081690-2LTB2[5]	2 - 4	Screen for Acid											5.99
081690-2LTB2[5]	4 - 6	Screen for Acid											6.13
081690-2LTB2[5]	6 - 8	Screen for Acid											6.20
081690-2LTB2[5]	8 - 10	Screen for Acid											6.37
081690-2LTB2[5]	10 - 12	Screen for Acid											NA
081690-2LTB2[5]	12 - 14	Screen for Acid											6.59
081690-2LTB2[5]	14 - 16	No Recovery, Screen for Acid											NA
081690-2LTB2[5]	16 - 18	No Recovery, Screen for Acid											NA
081690-2LTB2[5]	18 - 20	Screen for Acid											NA
081690-2LTB2[5]	20 - 22	Screen for Acid											NA
081690-2LTB2[5]	22 - 24	Screen for Acid											7.39
092590-2LTB3	0 - 2	Screen for Acid											6.74
092590-2LTB3	2 - 4	Screen for Acid											7.25
092590-2LTB3	4 - 6	Screen for Acid											7.26
092590-2LTB3	6 - 8	Screen for Acid											7.19
092590-2LTB3	8 - 10	Screen for Acid											7.55
092590-2LTB3	10 - 12	No Recovery, Screen for Acid											NA
092590-2LTB3	12 - 14	Screen for Acid											7.87
092590-2LTB3	14 - 16	No Recovery, Screen for Acid											NA
092590-2LTB3	16 - 18	No Recovery, Screen for Acid											NA
092090-2LTB4	0 - 2	Screen for Acid											6.95
092090-2LTB4	2 - 4	Screen for Acid											8.02
092090-2LTB4	4 - 6	Screen for Acid											9.0

TABLE 2–6 (continued)
AREA A
SUMMARY OF SOIL SAMPLING PROGRAM

			LABORATORY ANALYSES[1]										
SAMPLE ID[2,3]	SAMPLE DEPTH (ft)	COMMENTS	VOC	SVO	INOR–GANICS	PESTI–CIDES	PCBs	TCLP METALS	TCLP PESTICIDES	TCLP PCBs	TPH	FLUORE–SCENCE	pH[7] pH
092090–2LTB4	6 – 8	Screen for Acid											10.19
092090–2LTB4	8 – 10	Screen for Acid											11.0
092090–2LTB4	10 – 12	Screen for Acid											11.0
092090–2LTB4	12 – 14	Screen for Acid											8.97
092090–2LTB4	14 – 16	Screen for Acid											8.1
092190–2LTB5	0 – 2	Screen for Acid											7.31
092190–2LTB5	2 – 4	No Recovery, Screen for Acid											NA
092190–2LTB5	4 – 6	Screen for Acid											9.31
092190–2LTB5	6 – 8	Screen for Acid											8.93
092190–2LTB5	8 – 10	Screen for Acid											8.99
080890–2LTB6	0 – 2	Screen for Acid											7.4
080890–2LTB6	2 – 4	Screen for Acid											8.0
080890–2LTB6	5 – 7	Screen for Acid											8.08
080890–2LTB6	7 – 9	No Recovery, Screen for Acid											NA
080890–2LTB6	9 – 11	Screen for Acid											7.60
080890–2LTB6	11 – 13	Screen for Acid											7.02
080890–2LTB6	13 – 15	Screen for Acid											7.67
080890–2LTB6	15 – 17	Screen for Acid											7.01
080890–2LTB6	17 – 19	Screen for Acid											7.17
080890–2LTB6	19 – 21	Screen for Acid											7.29
080790–2LTB7	0 – 2	Screen for Acid											7.5
080790–2LTB7	2 – 4	Screen for Acid											5.6
080790–2LTB7	4 – 6	Screen for Acid											6.1
080790–2LTB7	6 – 8	Screen for Acid											6.1
080790–2LTB7	8 – 10	Screen for Acid											5.9
080790–2LTB7	10 – 12	Screen for Acid											6.4
080790–2LTB7	12 – 13	Screen for Acid											6.1
081590–2LMW7	7 – 10	Within Landfill Material	●	●	●	●	●	●	●				
080290–2LMW8	6 – 10	Oily Appearance	●	●	●	●	●	●	●				
081790–2LMW9	0 – 4	HNu Reading – 6.5 ppm	●	●	●	●	●	●	●				
081690–2LMW9	2 – 8	At Water Table	●	●	●	●	●	●	●				
082290–2LMW13	2 – 4		●	●	●	●	●	●	●				
082290–2LMW13	6 – 8	Within Landfill Material	●	●	●	●	●	●	●				
080290–2LMW14S	5 – 7	Within Landfill Material	●	●	●	●	●	●	●				
081590–2LMW17	0 – 2	Within Landfill Material	●	●	●	●	●	●	●				
081590–2LMW17	4 – 8	Within Landfill Material	●	●	●	●	●	●	●				
080790–2LMW18S	0 – 2	Within Landfill Material	●	●	●	●	●	●	●				
080790–2LMW18S	2 – 6	HNu Reading – 3.2 ppm	●	●	●	●	●	●	●				

TABLE 2-6 (continued)
AREA A
SUMMARY OF SOIL SAMPLING PROGRAM

			LABORATORY ANALYSES[1]										
SAMPLE ID[2,3]	SAMPLE DEPTH (ft)	COMMENTS	VOC	SVO	INOR-GANICS	PESTI-CIDES	PCBs	TCLP METALS	TCLP PESTICIDES	TCLP PCBs	TPH	FLUORE-SCENCE	pH[7]
					WETLAND								
090590-2WTB1	8 - 10	Within Dredge Spoil	•	•	•	•	•	•	•				
090590-2WTB1	10 - 12	Within Dredge Spoil	•	•	•	•	•	•	•				
090590-2WTB1	15 - 17	HNu Reading - 12 ppm	•	•	•	•	•	•	•				
090590-2WTB1	20 - 22	HNu Reading - 17 ppm	•	•	•	•	•	•	•				
090690-2WTB2	0 - 2	Within Dredge Spoil	•	•	•	•	•	•	•				
090690-2WTB2	4 - 6	Within Dredge Spoil	•	•	•	•	•	•	•				
090690-2WTB2	10 - 12	Within Dredge Spoil	•	•	•	•	•	•	•				
090690-2WTB2	15 - 17	HNu Reading - 3 ppm	•	•	•	•	•	•	•				
090690-2WTB2	20 - 22	HNu Reading - 19 ppm	•	•	•	•	•	•	•				
083190-2WTB3	4 - 6	Within Dredge Spoil	•	•	•	•	•	•	•				
083190-2WTB3	10 - 12	HNu Reading - 14 ppm	•	•	•	•	•	•	•				
083190-2WTB3	15 - 17	Within Dredge Spoil	•	•	•	•	•	•	•				
083190-2WTB3	20 - 22	Within Dredge Spoil	•	•	•	•	•	•	•				
090690-2WTB4	0 - 2		•	•	•	•	•	•	•				
090690-2WTB6	0 - 2	Within Dredge Spoil	•	•	•	•	•	•	•				
090690-2WTB6	4 - 6	Within Dredge Spoil	•	•	•	•	•	•	•				
090690-2WTB6	15 - 17	Within Dredge Spoil	•	•	•	•	•	•	•				
090690-2WTB6	20 - 22	Within Dredge Spoil	•	•	•	•	•	•	•				
090590-2WTB7	0 - 2	Within Dredge Spoil	•	•	•	•	•	•	•				
090590-2WTB7	4 - 6	At Water Table	•	•	•	•	•	•	•				
090590-2WTB7	10 - 12	Within Dredge Spoil	•	•	•	•	•	•	•				
083090-2WTB8	1 - 3		•	•	•	•	•	•	•				
083090-2WTB8	6 - 8	Within Dredge Spoil	•	•	•	•	•	•	•				
083090-2WTB8	10 - 12	Within Dredge Spoil	•	•	•	•	•	•	•				
082390-2WMW2	0 - 2		•	•	•	•	•	•	•				
082190-2WMW3	10 - 12	At Water Table	•	•	•	•	•	•	•				
082190-2WMW3	16 - 18	Within Dredge Spoil	•	•	•	•	•	•	•				
092690-2WMW4	0 - 2		•	•	•	•	•	•	•				
090490-2WMW5	0 - 2	Within Dredge Spoil	•	•	•	•	•	•	•				
090490-2WMW5	4 - 6	Within Dredge Spoil	•	•	•	•	•	•	•				
090490-2WMW5	10 - 12	Within Dredge Spoil	•	•	•	•	•	•	•				
090490-2WMW5	13 - 13.2	Within Dredge Spoil	•	•	•	•	•	•	•				
100390-2WMW6	2 - 4	Within Dredge Spoil	•	•	•	•	•	•	•				

TABLE 2–6 (continued)
AREA A
SUMMARY OF SOIL SAMPLING PROGRAM

SAMPLE ID[2,3]	SAMPLE DEPTH (ft)	COMMENTS	LABORATORY ANALYSES[1] VOC	SVO	INOR-GANICS	PESTI-CIDES	PCBs	TCLP METALS	TCLP PESTICIDES	TCLP PCBs	TPH	FLUORE-SCENCE	pH[7]
DOWNSTREAM													
092090–2DMW10S	3 – 5		•	•	•	•	•	•					
082890–2DMW11S	2 – 4		•	•	•	•	•	•					
091990–2DMW15	2 – 4		•	•	•	•	•	•					
091890–2DMW16	2 – 4		•	•	•	•	•	•					
OVER BANK DISPOSAL AREA													
082890–3MW12S	0 – 3		•	•	•	•	•	•	•				

NOTES

1) VOC – Volatile Organic Compounds
   SVO – Semi–Volatile Organic Compounds
   Inorganics – Metals and Cyanide
   PCBs – Polychlorinated Biphenyls
   TCLP – Toxicity Characteristic Leachate Procedure
   TPH – Total Petroleum Hydrocarbons
   pH – Field pH measurement to assess potential battery acid residuals
2) SS – Surface Soil, TB – Test Boring, MW – Monitoring Well
3) Laboratory Sample Identification Numbers also included sample depth in parentheses following the Sample ID listed above (e.g. 081690–2LTB2 (2–8)).
4) Original sample data rejected during validation; location was resampled at a later date for parameters indicated.
5) Location changed from that shown in Plan of Action (April 1989). Actual location shown on Figure in Section 4.0.
6) NA – Not Analyzed
7) pH analysis to screen for presence of battery acid.

TABLE 2–7
DRMO
SUMMARY OF SOIL SAMPLING PROGRAM

SAMPLE ID[2,3]	SAMPLE DEPTH (ft)	COMMENTS	LABORATORY ANALYSES[1] VOC	SVO	INOR-GANICS	PESTI-CIDES	PCBs	TCLP METALS	TCLP PESTICIDES	TCLP PCBs	TPH	FLUORE-SCENCE	pH
					DRMO								
112790–6SS1C	0 – 0.5	Composite Sample	●	●	●	●	●	●					
112790–6SS2C	0 – 0.5	Composite Sample	●	●	●	●	●	●					
112790–6SS3	0 – 0.5		●	●	●	●	●	●					
112790–6SS4	0 – 0.5		●	●	●	●	●	●					
101190–6TB1	0 – 2		●	●	●	●	●	●					
101190–6TB1	2 – 4		●	●	●	●	●	●					
100490–6TB2	0 – 2		●	●	●	●	●	●					
100490–6TB2	2 – 4	At Water Table	●	●	●	●	●	●					
100490–6TB3	0 – 2	HNu Reading – 170 ppm	●	●	●	●	●	●					
100490–6TB3	6 – 8	HNu Reading – 160 ppm	●	●	●	●	●	●					
100490–6TB4	0 – 2	Within Landfill Material	●	●	●	●	●	●					
100490–6TB4	6 – 8	Oily Appearance	●	●	●	●	●	●					
100390–6TB5	0 – 2	Within Landfill Material	●	●	●	●	●	●					
100390–6TB5	2 – 6	Within Landfill Material	●	●	●	●	●	●					
092790–6TB6	0 – 2	Within Landfill Material	●	●	●	●	●	●					
092790–6TB6	2 – 4		●	●	●	●	●	●					
092690–6TB7	0 – 2	Within Landfill Material	●	●	●	●	●	●					
092690–6TB7	2 – 4	Within Landfill Material	●	●	●	●	●	●					
101190–6MW1	0 – 2		●	●	●	●	●	●					
101190–6MW1	4 – 6	Discoloration	●	●	●	●	●	●					
100990–6MW2	0 – 2	HNu Reading – 400 ppm	●	●	●	●	●	●					
100990–6MW2	2 – 4	At Water Table	●	●	●	●	●	●					
100290–6MW3	0 – 2	Within Landfill Material	●	●	●	●	●	●					
100290–6MW3	2 – 4	At Water Table	●	●	●	●	●	●					
092790–6MW4	0 – 2	Within Landfill Material	●	●	●	●	●	●					
092790–6MW4	2 – 4	Within Landfill Material	●	●	●	●	●	●					
101590–6MW5S	0 – 2		●	●	●	●	●	●					
101590–6MW5S	8 – 10	At Water Table	●	●	●	●	●	●					

NOTES

1) VOC – Volatile Organic Compounds
SVO – Semi–Volatile Organic Compounds
Inorganics – Metals and Cyanide
PCBs – Polychlorinated Biphenyls
TCLP – Toxicity Characteristic Leachate Procedure
TPH – Total Petroleum Hydrocarbons

2) SS – Surface Soil, TB – Test Boring, MW – Monitoring Well

3) Laboratory Sample Identification Numbers also included sample depth in parentheses following the Sample ID listed above (e.g. 081690–2LTB2 (2–8)).

4) Sample submitted for VOC analysis was not composited.

TABLE 2–8
LOWER SUBASE
SUMMARY OF SOIL SAMPLING PROGRAM

					LABORATORY ANALYSES[1]								
SAMPLE ID[2,3]	SAMPLE DEPTH (ft)	COMMENTS	VOC	SVO	INOR–GANICS	PESTI–CIDES	PCBs	TCLP METALS	TCLP PESTICIDES	TCLP PCBs	TPH	FLUORE–SCENCE	pH
13TB1[4,5]	0 – 2												
13TB1	2 – 4												
13TB1	4 – 6	No Recovery											
13TB1	6 – 8	HNu Reading – 55 ppm											
13TB1	8 – 10												
13TB1	10 – 12												
13TB1	12 – 14												
13TB1	14 – 16												
13TB1	16 – 18												
13TB1	18 – 20												
13TB2	0–2												
13TB2	2 – 4												
13TB2	4 – 6	HNu Reading – 10 ppm											
13TB2	6 – 8												
13TB2	8 – 10	HNu Reading – 3 ppm											
13TB2	10 – 12	HNu Reading – 5.5 ppm											
13TB2	12 – 14	No Recovery											
13TB2	14 – 16	Discoloration											
13TB2	16 – 18												
13TB2	18 – 20												
13TB3	0–2												
13TB3	2 – 4	HNu Reading – 3.8 ppm											
13TB3	4 – 6	Discoloration; HNu Reading – 9.4 ppm											
13TB3	6 – 8	Discoloration; HNu Reading – 8.5 ppm											
13TB3	8 – 10	No Recovery											
13TB3	10 – 12	No Recovery											
13TB3	12 – 14	Discoloration; HNu – 4.0 ppm											
13TB3	14 – 16	Discoloration; HNu – 6.5 ppm											
13TB3	16 – 18	Discoloration; HNu – 4.0 ppm											
13TB3	18 – 20	HNu – 2.5 ppm											
13TB4	0–2												
13TB4	2 – 4												
13TB4	4 – 6	HNu Reading – 4.9 ppm											
13TB4	6 – 8	No Recovery											
13TB4	8 – 10	HNu Reading – 1.2 ppm											
13TB4	10 – 12												
13TB4	12 – 14												
13TB4	14 – 16												

TABLE 2–8 (continued)
LOWER SUBASE
SUMMARY OF SOIL SAMPLING PROGRAM

SAMPLE ID[2,3]	SAMPLE DEPTH (ft)	COMMENTS	LABORATORY ANALYSES[1] VOC	SVO	INOR–GANICS	PESTI–CIDES	PCBs	TCLP METALS	TCLP PESTICIDES	TCLP PCBs	TPH	FLUORE–SCENCE	pH
13TB4	16 – 18	Oil Sheen											
13TB4	18 – 20												
13TB5	0–2												
13TB5	2 – 4	No Recovery											
13TB5	4 – 6												
13TB5	6 – 8	No Recovery											
13TB5	8 – 10												
13TB5	10 – 12												
13TB5	12 – 14	Oil Sheen; HNu Reading – 1.5 ppm											
13TB5	14 – 16	Oil Sheen; HNu Reading – 9.0 ppm											
13TB5	16 – 18	Oil Sheen; HNu Reading – 3.0 ppm											
13TB5	18 – 20	Oil Sheen; HNu Reading – 9.5 ppm											
110590–13MW1	12 – 14	HNu Reading – 30 ppm	●		●			●			●	●	
110590–13MW2	10 – 12	Visual Contamination, HNu Reading – 100 ppm	●		●			●			●	●	
110790–13MW3	12 – 14	Discoloration, HNu Reading – 90 ppm	●		●			●			●	●	
110790–13MW4	6 – 8	HNu Reading – 15 ppm	●		●			●			●	●	
110890–13MW5	10 – 12	HNu Reading – 8.5 ppm	●		●			●			●	●	
111390–13MW6	14 – 16	HNu Reading – 500 ppm	●		●			●			●	●	
110790–13MW7	8 – 10	Discoloration, HNu Reading – 24 ppm	●		●			●			●	●	
110790–13MW8	8 – 10	Discoloration, HNu Reading – 100 ppm	●		●			●			●	●	
110790–13MW9	6 – 8	HNu Reading – 15 ppm	●		●			●			●	●	
110790–13MW10	6 – 8	HNu Reading – 13 ppm	●		●			●			●	●	
110890–13MW11	2 – 4	HNu Reading – 12 ppm	●		●			●			●	●	
110890–13MW12	8 – 10	HNu Reading – 22 ppm	●		●			●			●	●	
111390–13MW13	8 – 10	HNu Reading – 4 ppm	●		●			●			●	●	
111390–13MW14	12 – 14	HNu Reading – 450 ppm	●		●			●			●	●	
111290–13MW15	12 – 14	Discoloration, HNu Reading – 16 ppm	●		●			●			●	●	
111290–13MW16	10 – 12	Discoloration	●		●			●			●	●	
111290–13MW17	8 – 10	HNu Reading – 13.5 ppm	●		●			●			●	●	

NOTES

1) VOC – Volatile Organic Compounds
   SVO – Semi–Volatile Organic Compounds
   Inorganics – Metals and Cyanide
   PCBs – Polychlorinated Biphenyls
   TCLP – Toxicity Characteristic Leachate Procedure
   TPH – Total Petroleum Hydrocarbons
2) SS – Surface Soil, TB – Test Boring, MW – Monitoring Well
3) Laboratory Sample Identification Numbers also included sample depth in parentheses following the Sample ID listed above (e.g. 081690–2LTB2 (2–8)).
4) Test boring installed, organic vapor measurements and visual contamination documented; not sampled for laboratory analysis.
5) Twelve test borings were proposed in the Work Plan, however, only five borings were installed due to proximity of proposed locations to underground utilities. Soil samples from these borings were evaluated for visual contamination and screened for organic vapors to assist in delineation of extent of contamination.

Atlantic personnel collected 35 sediment samples from streams and standing water in the Area A Wetland, the Area A Downstream and an offsite stream (northern limits of base near perimeter security road). Specific sediment sample information is summarized in Table 2-9. The samples were collected in, adjacent to, or downstream of, one or more of the following:

- Area A Landfill
- Area A Wetland
- Over Bank Disposal Area
- Weapons Storage Area
- Torpedo Shops
- Offsite stream - Perimeter Security Road

Atlantic personnel collected the onsite sediment samples in November and December of 1990 and the offsite samples in January of 1991. Atlantic Procedure 1022 was followed for the collection of sediment samples. The samples were screened in the field, logged and then sent to the laboratory to be analyzed for VOCs, SVOs, pesticides, PCBs, inorganics, and selected samples for metals and pesticides by TCLP extraction procedures.

A total of eight composite sediment samples were collected in the Area A Wetland. The wetland was divided into eight subareas based on physical characteristics noted during the Atlantic site inspection and from the aerial photographs. Each sampling subarea was divided into 12 sampling grids. Each composite sample was collected from four of the 12 grids, which was selected for actual sampling by a random number generator. Furthermore, each selected sampling grid was subdivided into four quadrants and equal amounts of sediment were collected from each quadrant. Each component of the composite sample was screened in the field with an HNu. Composite samples were analyzed for SVOs, pesticides, PCBs, and inorganics. At each of the eight subareas, a discrete sample for VOC analysis was collected at one of the 16 sampling locations which was selected, based on field measured organic vapor readings.

2.8 Ground Water Investigation

The goals of the ground water investigation were to characterize the ground water quality beneath, upgradient and downgradient of selected sites investigated, and to assess hydrogeologic characteristics of the aquifer. Ground water was investigated at all Step II sites and at two Step I sites (Torpedo Shop and Goss Cove Landfill). Fifty-nine ground water monitoring wells were installed onsite. These 59 wells, plus seven existing monitoring wells onsite (Lower Subase), and 22 offsite residential wells were sampled and analyzed for some or all of the following: VOCs, SVOs, pesticides, PCBs, inorganics, TPH, fluorescence, gross alpha and gross beta radiation. In addition, hydraulic conductivity tests were performed on over half of the onsite wells.

2.8.1 Monitoring Well Installation

A total of 59 ground water monitoring wells were installed at NSB-NLON. Table 2-10 includes well construction information by site. The tables provide elevation of top and bottom of well, screened interval elevation, water table, depth elevation, bedrock elevation if encountered, screen length and well type.

TABLE 2–9
AREA A
SUMMARY OF SEDIMENT SAMPLING PROGRAM

SAMPLE ID[2]	SAMPLE DEPTH (ft)	COMMENTS	LABORATORY ANALYSES[1] VOC	SVO	INOR–GANICS	PESTI–CIDES	PCBs	TCLP METALS	TCLP PESTICIDES	TCLP PCBs	TPH	FLUORE–SCENCE	pH
LANDFILL													
None Sampled													
WETLAND													
112690–2WSD1[3]	0 – 0.5	Composite Sample	●	●	●	●	●	●	●				
112690–2WSD2[3]	0 – 0.5	Composite Sample	●	●	●	●	●	●	●				
112690–2WSD3[3]	0 – 0.5	Composite Sample	●	●	●	●	●	●	●				
112690–2WSD4[3]	0 – 0.5	Composite Sample	●	●	●	●	●	●	●				
112690–2WSD5[3]	0 – 0.5	Composite Sample	●	●	●	●	●	●	●				
112690–2WSD6[3]	0 – 0.5	Composite Sample	●	●	●	●	●	●	●				
112690–2WSD7[3]	0 – 0.5	Composite Sample	●	●	●	●	●	●	●				
112690–2WSD8[3]	0 – 0.5	Composite Sample	●	●	●	●	●	●	●				
112690–2WSD9	0 – 0.5	Discrete Sample	●	●	●	●	●	●	●				
DOWNSTREAM													
120390–2DSD1	0 – 0.5	Oily Appearance	●	●	●	●	●	●	●				
120390–2DSD2	0 – 0.5	Oily Appearance	●	●	●	●	●	●	●				
120390–2DSD3	0 – 0.5	Petroleum Odor	●	●	●	●	●	●	●				
120390–2DSD4	0 – 0.5	Sheen on Water	●	●	●	●	●	●	●				
120390–2DSD5	0 – 0.5		●	●	●	●	●	●	●				
120390–2DSD7	0 – 0.5	Sheen on Sample	●	●	●	●	●	●	●				
120390–2DSD8	0 – 0.5	HNu Reading – 2.5; Sheen on Sample	●	●	●	●	●	●	●				
120390–2DSD9	0 – 0.5	Petroleum Odor	●	●	●	●[4]	●[4]	●	●				
120390–2DSD10	0 – 0.5		●	●	●	●[4]	●[4]	●	●				
120390–2DSD11	0 – 0.5	Discoloration	●	●	●	●[4]	●[4]	●	●				
120390–2DSD12	0 – 0.5		●	●	●	●[4]	●[4]	●	●				
120790–2DSD13	0 – 0.5		●	●	●	●	●	●	●				
120790–7SD1	0 – 0.5		●	●	●	●	●						
OVER BANK DISPOSAL AREA													
112990–3SD1	0 – 0.5	HNu Reading – 7 ppm	●	●	●	●[4]	●[4]	●	●				
112990–3SD1	1 – 1.5	HNu Reading – 5 ppm	●	●	●	●[4]	●[4]	●	●				
112990–3SD2	0 – 0.5	HNu Reading – 50 ppm	●	●	●	●[4]	●[4]	●	●				
112990–3SD2	1 – 1.5		●	●	●	●[4]	●[4]	●	●				
112990–3SD3	0 – 0.5	Sheen on Sample	●	●	●	●[4]	●[4]	●	●				
112990–3SD3	1 – 1.5	Sheen on Sample	●	●	●	●[4]	●[4]	●	●				
112990–3SD4	0 – 0.5		●[4]	●	●	●[4]	●[4]	●	●				
112990–3SD4	1 – 1.5	HNu Reading – 2.2 ppm	●[4]	●	●	●[4]	●[4]	●	●				
112990–3SD5	0 – 0.5	Petroleum Odor; Sheen on Sample	●[4]	●	●	●[4]	●[4]	●	●				
112990–3SD5	1 – 1.5	Discoloration	●[4]	●	●	●[4]	●[4]	●	●				

TABLE 2–9 (continued)
AREA A
SUMMARY OF SEDIMENT SAMPLING PROGRAM

			LABORATORY ANALYSES[1]										
SAMPLE ID[2]	SAMPLE DEPTH (ft)	COMMENTS	VOC	SVO	INORGANICS	PESTICIDES	PCBs	TCLP METALS	TCLP PESTICIDES	TCLP PCBs	TPH	FLUORESCENCE	pH
OFFSITE STREAM													
020791–OSSD1	0 – 0.5		•	•	•	•	•						
020791–OSSD2	0 – 0.5		•	•	•	•	•						
020791–OSSD3	0 – 0.5	Sheen on Water	•	•	•	•	•						

NOTES

1) VOC – Volatile Organic Compounds
   SVO – Semi–Volatile Organic Compounds
   Inorganics – Metals and Cyanide
   PCBs – Polychlorinated Biphenyls
   TCLP – Toxicity Characteristic Leachate Procedure
   TPH – Total Petroleum Hydrocarbons
2) SD – Sediment Sample
3) Composite sample for all parameters except VOCs.
4) Original sample data rejected during validation; location resampled at a later date for parameters indicated.

TABLE 2-10
SUMMARY OF MONITORING WELL INFORMATION

WELL ID	WELL TYPE	SCREEN LENGTH	GROUND SURFACE ELEV.	BEDROCK ELEV.	ELEV. OF WELL BOTTOM	TOP OF WELL CASING ELEV	DEPTH/ELEV. OF WATER[3]		ELEV. OF SCREENED INTERVAL	
									BOTTOM	TOP
CBU DRUM STORAGE										
None										
RUBBLE FILL BUNKER A-86										
None										
TORPEDO SHOPS										
7MW1D	Bedrock	11[1]	54.67		29.47	54.08	9.93	44.15	29.47	40.47
7MW2	Overburden	7	48.6		37.6	50.41	5.43	44.98	37.6	44.6
7MW3	Overburden	10	45.98		29.06	45.71	6.2	39.51	29.09	39.09
GOSS COVE LANDFILL										
8MW1	Overburden	10	10.48		-6.25	10.15	8.68	1.47	-5.92	4.08
8MW2	Overburden	10	9.91		-6.02	9.43	6.98	2.45	-6.02	3.98
8MW3	Overburden	10	9.25		-6.54	8.96	6.23	2.73	-6.54	3.46
8MW4	Overburden	10	9.62		-5.76	9.34	6.29	3.05	-5.76	4.24
OVER BANK DISPOSAL AREA, NORTHEAST										
None										
FORMER ACID STORAGE AND DISPOSAL AREA										
None										
FORMER GASOLINE STATION										
None										
AREA A LANDFILL										
2LMW7S	Overburden	10	82.8	52.6	61.15	84.37	9.9	74.47	61.15	71.15
							11.4[4]	72.97		
2LMW7D	Bedrock	10.09[1]	83.1	49.6	39.51	85.16	5.4	79.76	39.51	49.6
							7.6[4]	77.56		
2LMW8S	Overburden	10	86.4		70.9	87.45	0.71	86.74	70.9	80.9
							3.84[4]	83.61		
2LMW8D	Bedrock	77.87	87.1	40.6	-37.27	89.33	0[6]	>89.33	-37.27	35.6
							1.42[4]	87.91		
2LMW9S	Overburden	10	85.3		67.06	86.96	9	77.96	67.06	77.06
							12.65[4]	74.31		
2LMW9D	Bedrock	12.74[1]	85.4	38.4	25.66	87.11	26.87	60.24	25.66	33.4
							28.91[4]	58.2		
2LMW13S	Overburden	10	86.9	70.44	70.44	88.53	13.44	75.09	70.44	80.44
							16.31[4]	72.22		
2LMW13D	Bedrock	37.03[1]	86.8	63.8	26.77	88.2	5.4	82.8	26.77	58.8
							10.38[4]	77.82		
2LMW14S[2]										
2LMW14D	Bedrock	8.5[1]	91.9	73.4	64.9	93.9	5.23	88.67	64.9	68.4
2LMW17S	Overburden	10	82.48		64.73	82.12	5.89	76.23	64.73	74.73
2LMW17D	Bedrock	15.9[1]	82.62	59.62	43.62	82.37	0[6]	>82.37	43.62	54.52
2LMW18S	Overburden	10	77.94		62.2	77.6	6.05	71.55	62.2	72.2
							7.0[4]	70.6		

TABLE 2-10 (continued)
SUMMARY OF MONITORING WELL INFORMATION

WELL ID	WELL TYPE	SCREEN LENGTH	GROUND SURFACE ELEV.	BEDROCK ELEV.	ELEV. OF WELL BOTTOM	TOP OF WELL CASING ELEV	DEPTH/ELEV. OF WATER[3]		ELEV. OF SCREENED INTERVAL	
									BOTTOM	TOP
2LMW18D	Bedrock	8.03[1]	77.67	36.7	28.64	77.34	8.55	68.79	28.64	31.67
							7.51[4]	67.83		
AREA A WETLAND										
2WMW1S[2]										
2WMW1D	Bedrock	90.55[1]	128.05	120.05	29.5	127.58	10.88	116.7	29.5	115.05
2WMW2S[2]										
2WMW2D	Bedrock	40.93[1]	110.45	105.45	60.52	110.22	22.85	87.37	60.52	101.45
2WMW3S	Overburden	15	81.43		58.64	81.04	7.26	73.78	58.64	73.64
							4.90[4]	76.14		
2WMW3D	Bedrock	49.24[1]	81.68	3.68	-45.44	81.36	5.73	75.63	-45.44	-1.32
							7.31[4]	74.05		
2WMW4S[2]										
2WMW4D	Bedrock	106.38[1]	93.07	80.07	-26.31	92.69	7.43	85.26	-26.31	75.07
2WMW5S	Overburden	10	73.5		58.25	76.48	2.68	73.8	60.96	70.96
2WMW6S	Overburden	10	83.4		74.12	84.67	7.63	77.04	74.12	79.12
2WMW6D	Bedrock	30.53[1]	83.2	67.7	37.17	84.87	9.93	74.94	37.17	62.7
AREA A DOWNSTREAM										
2DMW10S[2]										
2DMW10D	Bedrock	16.09[1]	52.8	42.8	26.71	54.52	10.25	44.27	26.71	37.8
2DMW11S	Overburden	10	45.4		32.95	46.85	2.1	44.75	32.95	42.95
2DMW11D	Bedrock	3.55[1]	51.5	31.5	25.95	53.2	7.97	45.23	25.95	29.5
2DMW15S[2]										
2DMW15D	Bedrock	9.51[1]	42.2	37.2	22.69	44.09	5.46	38.63	22.69	32.2
2DMW16S	Overburden	10	35.6		23.91	37.85	3.55	34.3	23.91	24.91
2DMW16D	Bedrock	41.91[1]	35.9	23.4	-24.01	37.69	3.74	33.95	-24.01	17.9
OVER BANK DISPOSAL AREA										
3MW12S	Overburden	10	41		28.66	43.51	2.67	40.84	28.66	38.66
3MW12D	Bedrock	6.1[1]	41.1	26.1	15	42.2	0.5	41.7	15	21.1
DRMO										
6MW1S	Overburden	10	7		-7.02	8.63	7.35	1.28	-7.02	2.98
6MS2S	Overburden	10	5.4		-7.8	7.3	6.18	1.12	-7.8	2.2
6MW3S	Overburden	10	4.3		-9.5	6.1	4.87	1.23	-9.5	0.5
6MW4S	Overburden	10	5.18		-7.6	4.9	3.71	1.19	-7.6	2.4
6MW5S	Overburden	10	14.05		-3.12	13.88	10.75	3.13	-3.12	6.88
6MW5D	Bedrock	4.8[1]	14.23	-10.77	-20.57	13.93	10.75	3.18	-20.57	-15.77

TABLE 2–10 (continued)
SUMMARY OF MONITORING WELL INFORMATION

WELL ID	WELL TYPE	SCREEN LENGTH	GROUND SURFACE ELEV.	BEDROCK ELEV.	ELEV. OF WELL BOTTOM	TOP OF WELL CASING ELEV	DEPTH/ELEV. OF WATER[3]		ELEV. OF SCREENED INTERVAL	
									BOTTOM	TOP
					LOWER BASE					
13MW1	Overburden	10	13.73		−3.76	13.36	9.78	3.58	−3.76	6.24
13MW2	Overburden	10	13.23		−4.44	12.8	9.21	3.59	−4.44	5.56
13MW3	Overburden	10	13.15		−4.21	12.89	9.33	3.56	−4.21	5.79
13MW4	Overburden	10	10.29		−4.66	10.14	6.52	3.62	−4.66	5.34
13MW5	Overburden	10	11.72		−6.2	11.13	13.3	3.34	−6.2	3.8
13MW6	Overburden	10	21.84		−5.98	21.47	18.61	2.86	−5.98	4.02
13MW7	Overburden	10	8.19		−6.15	7.85	5.63	2.22	−6.15	3.85
13MW8	Overburden	10	7.8		−15.91	7.34	6.35	0.99	−5.91	4.09
13MW9	Overburden	10	7.57		−12.21	6.91	6.15	0.76	−7.21	2.79
13MW10	Overburden	10	8.73		−6.31	8.44	6.27	2.17	−6.31	3.69
13MW11	Overburden	10	8.23		−5.82	7.83	5.7	2.13	−5.82	4.18
13MW12	Overburden	10	9.55		−5.79	9.21	6.29	2.92	−5.79	4.21
13MW13	Overburden	10	8.94		−5.65	8.5	5.47	3.03	−5.65	4.35
13MW14	Overburden	10	8.48		−6.32	7.98	7.53	0.45	−6.32	3.68
13MW15	Overburden	10	7.7		−9.9	7.25	6.95	0.3	−4.9	5.1
13MW16	Overburden	10	7.64		−11.9	7.3	6.97	0.33	−5.9	4.1
13MW17	Overburden	10	7.71		−25.83	7.47	6.67	0.8	−5.83	4.17
NESO 4	Overburden	5	8.51		0.62	8.22	6.85	1.37	0.62	5.62
NESO 6	Overburden	5	8.89		2.47	8.67	6.44	2.23	2.47	7.47
NESO 10	Overburden	5	8.42		−0.9	8.1	6.42	1.68	−0.9	4.1
NESO 11	Overburden	5	8.89		0.28	8.78	5.43	3.35	0.28	5.28
WE 1	Overburden	10	9.62		−5.68	9.42	--	--[7]	−5.68	4.32
WE 4	Overburden	10	8.71		−4.69	8.61	--	--[7]	−4.69	5.31
WE 5	Overburden	10	8.37		−5.6	8.25	--	--	−5.6	4.4

NOTES

1) Length of open hole below casing.
2) Proposed wells not installed due to lack of encountered water.
3) Water levels taken on March 21, 1991.
4) Water levels taken on June 7, 1991.
5) Value represents top of floating product in well.
6) Artesian well, water freely flowing out of well standpipe.
7) Well not accessible.

Empire installed the monitoring wells from August through November of 1990. Atlantic personnel inspected the installation of the wells, and logged soils and bedrock information and well construction details.

Overburden monitoring wells were installed by the hollow stem auger method using 4¼ inch I.D. augers. During installation of the shallow wells, soil samples were collected continuously with a split spoon as described in Section 2.7.1. The wells were installed using two inch, Schedule 40 PVC riser and two inch PVC screen with 0.01-inch slots. Screen length is ten feet except where noted. The placement of the screen was designed to intersect the top of the ground water table. The annular space surrounding the screened interval was filled with clean washed Ottawa sand up to two feet above the top of the screen. A two-foot bentonite seal was placed above the sand. The remainder of the annular space was tremie backfilled with cement-bentonite grout.

Nineteen bedrock monitoring wells were drilled. The wells were cased through the overburden and sealed at the bedrock interface to avoid possible contamination of the bedrock aquifer by the material above. The depth to bedrock was determined during the installation of the shallow monitoring well or boring. Using either air rotary or mud rotary methods, an eight or ten inch bit was used to drill through the overburden and the first five feet of bedrock. The mud rotary technique was used in certain wells to keep the hole open to allow the placement of the bedrock casing. The mud did not come in contact with the open hole within the bedrock and, therefore, would not impact the water quality. Six inch diameter casing was installed five feet into the bedrock. The casing was grouted in place with a bentonite-cement slurry and allowed to set for 24 hours. A six inch roller bit or air hammer bit was used to drill through the casing to the bedrock aquifer. The bedrock was cored in selected wells as specified in Atlantic Procedure 1030.

Construction details for each well are included in Appendix B.

2.8.2 Monitoring Well Development

The purpose of well development is to restore the natural hydraulic conductivity of the subsurface materials surrounding a monitoring well and to ensure a low turbidity ground water sample.

Atlantic personnel developed overburden monitoring wells using the surge block method according to Atlantic Procedure 1070. A Honda centrifugal pump and a two inch O.D. teflon surge block were used for development. Each well was developed for a maximum of four hours or until the water remained clear after ten strokes of the surge block. A turbidity meter was used to measure the clarity of the well water after surging; a value of 50 NTUs or less, measured ten minutes after surging was considered adequately clear.

The bedrock wells were developed by Empire under Atlantic supervision. Bedrock wells were developed with compressed air supplied from an oil free compressor. Development was performed immediately after drilling while the drill rods were still in the hole. Development continued until the clarity of the water was comparable to that of a jar of distilled water. Two of the bedrock wells were developed with a submersible pump.

2.8.3 Hydraulic Conductivity Tests

Single well hydraulic conductivity tests were performed on approximately half of the installed wells. The purpose of the testing was to determine order-of-magnitude hydraulic conductivity values.

Hydraulic conductivity tests were performed according to Atlantic Procedure 1071. Wells were chosen for hydraulic conductivity tests based on such factors as aquifer material and areal distribution across the site. Methods of hydraulic conductivity testing were chosen based on criteria presented in Atlantic Procedure 1071 including position of well screen, need to contain discharge water, and site logistics. Based on the above criteria the displacement slug test method was used for all but one well (6MW5D), which used the single well pump test. Single well pump tests proved impractical for most wells because a large volume of water had to be pumped (and contained) to produce measurable drawdown.

Slug tests were performed using PVC devices filled with clean sand and capped with wingnut trap plugs. One inch and four inch diameter, six foot long slugs were used in overburden and bedrock wells, respectively. In some overburden wells a one inch diameter five foot long device was used. The displacement devices were lowered and raised with polypropylene rope. An In-Situ pressure transducer and data logger were used to measure and record water level changes during the tests.

Prior to each test, the static water level was measured with an electronic water level indicator. The pressure transducer and a displacement device were placed in the well and allowed to equilibrate. The displacement device was usually placed in the well the previous day to allow the water level to equilibrate. When the water level returned to its original position, the displacement device was pulled out of the well and the rising water levels recorded.

The slug displacement test data from the overburden wells were analyzed using the Bouwer and Rice method of estimating hydraulic conductivity. Recovery plots and calculated hydraulic conductivities for each well tested are included in Appendix B. All data required to use this method were available except, on occasion, the saturated thickness of the aquifer material. If aquifer thickness in the vicinity of the tested well was not measured, it was estimated to equal the distance from the water table to the bottom of the well.

The Cooper, Bredehoeft, and Papadopulos Method (1967) was used to estimate transmissivity from the slug displacement test data collected from bedrock wells. For the purposes of the calculation, it was assumed that the bedrock acts like a porous media and that the saturated thickness of the bedrock aquifer was 150 feet. The values generated by this method reflect transmissivity values which are representative of the bedrock as a single hydraulic unit. Transmissive properties of discrete fractures intersected by the wells will be greater than the transmissivity calculated by this method. Recovery plots and calculated transmissivities for the bedrock wells are also included in Appendix B.

Hydraulic conductivity test results are discussed in Section 3.0 and the analysis calculations are presented in Appendix B.

2.8.4 Ground Water Sampling

Atlantic personnel collected one round of ground water samples for this investigation. Fifty-eight of the 59 wells installed for this investigation were sampled along with seven wells installed as part of previous investigations at the Lower Subase. The 59th well (2LMW13S) was dry at the time of sampling. Ground water samples were analyzed for a variety of parameters including some or all of the following: VOCs, SVOs, pesticides, PCBs, inorganics, TPH, fluorescence, gross alpha and gross beta radiation. Tables 2-11 (Step I sites), 2-12 (Area A), 2-13 (DRMO), and 2-14 (Lower Subase) provide sample-specific analytical parameters; results are presented and discussed in Section 4.0. The sampling was performed in December of 1990 and February of 1991.

Wells were sampled according to Atlantic Procedure 1023. All overburden wells were purged and sampled with a peristaltic pump outfitted with disposable teflon tubing. In some bedrock wells that contained a large volume of water, a larger volume centrifugal pump was used for purging and the peristaltic pump was used for sampling. In several other bedrock wells where depth of the water level was below 25 feet, submersible pumps were used for purging and single-use teflon bailers were used for sampling.

A minimum of four well volumes were purged while measuring pH, temperature and conductivity at regular intervals. After the evacuation of the four well volumes, the sample was collected when these three parameters stabilized to within five percent fluctuation. In wells where a peristaltic pump was used for purging, the pump and tubing were used to collect non-volatile samples. Following the collection of the last non-volatile sample, the peristaltic pump tubing was removed from the well and the VOC sample was collected with a single-use teflon bailer. When a bailer was used to collect all samples, VOCs were collected first to avoid the loss of volatiles that could be caused by the constant agitation of a bailer. All samples for metals analysis were field filtered with an in-line 0.45 micron filter.

2.8.5 Residential Well Sampling

The objective of the residential well sampling program was to analyze ground water quality in nearby offsite areas to assess what impact, if any, the site was having on area ground water.

The sampling program consisted of two rounds of sampling. In the first round sampling, locations were chosen based on proximity to NSB-NLON and willingness of individual homeowners to have their wells tested. Generally, the wells were located on roads closest to the Area A and DRMO sites. These included Sleepy Hollow Pentway, Pinelock Drive, Long Cove Road and Route 12. A total of 14 wells were sampled in December of 1990. Analytical parameters included VOCs, SVOs, inorganics, pesticides, and PCBs.

The second round of sampling was performed in February of 1991 to confirm selected results of the first round and to expand the sampling area to the east to Baldwin Hill and North Pleasant Valley Roads. Five of the original 14 wells were resampled along with eight additional wells which were located near a home where cadmium was detected above primary drinking water standards. Twelve of these wells were sampled for Inorganics only and the thirteenth was sampled for VOCs only, based on the presence of VOCs in the first sampling round. Table 2-15 provides the analytical summary of this program; results are presented and discussed in Section 4.0.

TABLE 2-11
STEP I SITES
SUMMARY OF GROUND WATER AND SURFACE WATER SAMPLING PROGRAM

		LABORATORY ANALYSES[1]									
SAMPLE ID[2]	COMMENTS	VOC	SVO	INORGANICS	PESTICIDES	PCBs	TPH	FLUORE-SCENCE	GROSS ALPHA	GROSS BETA	pH
CBU DRUM STORAGE AREA											
None											
RUBBLE FILL AT BUNKER A-86											
None											
TORPEDO SHOPS											
120790-7MW1		●	●	●	●	●					6.42
120690-7MW2		●	●	●[3]	●	●					5.95
120690-7MW3		●	●	●	●	●					6.22
GOSS COVE LANDFILL											
121890-8MW1S		●	●	●	●	●			●	●	6.94
121890-8MW2S		●	●	●	●	●			●	●	8.23
121890-8MW3S		●	●	●	●	●			●	●	8.79
121890-8MW4S		●	●	●	●	●			●	●	7.4
121090-8SW1		●	●	●	●	●			●	●	
OVER BANK DISPOSAL AREA, NORTHEAST											
None											
SPENT ACID STORAGE AND DISPOSAL AREA											
None											
FORMER GASOLINE STATION											
None											

NOTES

1) VOC – Volatile Organic Compounds
   SVO – Semi-Volatile Organic Compounds
   Inorganics – Metals and Cyanide
   PCBs – Polychlorinated Biphenyls
2) MW – Ground Water Sample
   SW – Surface Water Sample
   S – Overburden Monitoring Well
   D – Bedrock Monitoring Well
3) Original Sample Data rejected during validation; location resampled at a later date for parameters indicated.

TABLE 2–12
AREA A
SUMMARY OF GROUND WATER AND SURFACE WATER SAMPLING PROGRAM

		LABORATORY ANALYSES[1]									
SAMPLE ID[2]	COMMENTS	VOC	SVO	INORGANICS	PESTICIDES	PCBs	TPH	FLUORE–SCENCE	GROSS ALPHA	GROSS BETA	pH
				LANDFILL							
010391–2LMW7S	H2S Odor	●	●	●	●	●			●	●	6.96
010891–2LMW7D		●	●	●	●	●			●	●	5.85
121490–2LMW8S	Particulates	●	●	●	●	●			●	●	6.03
121790–2LMW8D		●	●	●	●	●			●	●	– –
010291–2LMW9S		●	●	●	●	●			●	●	6.85
011091–2LMW9D		●	●	●	●	●			●	●	6.61
2LMW13S	Dry – Not Sampled										– –
011091–2LMW13D		●	●	●	●	●			●	●	6.54
121790–2LMW14D		●	●	●	●	●			●	●	5.70
010291–2LMW17S		●	●	●	●	●			●	●	5.87
010891–2LMW17D	Particulates	●	●	●	●	●			●	●	5.49
121390–2LMW18S		●	●	●	●	●			●	●	5.94
121390–2LMW18D		●	●	●	●	●			●	●	5.73
				WETLAND							
011591–2WMW1D		●	●	●	●	●			●	●	6.68
011491–2WMW2D		●	●	●	●	●			●	●	5.23
121190–2WMW3S	Cloudy, H2S Odor	●	●	●	●	●			●	●	6.25
011191–2WMW3D		●	●	●	●	●			●	●	– –
012491–2WMW4D		●	●	●	●	●			●	●	7.90
121490–2WMW5S	Cloudy	●	●	●[3]	●	●			●	●	5.91
010291–2WMW6S		●	●	●	●	●			●	●	5.57
121890–2WMW6D		●	●	●	●	●			●	●	6.03
121090–2WSW1		●	●	●	●	●			●	●	– –
121090–2WSW2	Cloudy	●	●	●	●	●			●	●	– –
				DOWNSTREAM							
010791–2DMW10D		●	●	●	●	●			●	●	6.26
010291–2DMW11S		●	●	●	●	●			●	●	6.31
010791–2DMW11D		●	●	●	●	●			●	●	6.66
010791–2DMW15D		●	●	●	●	●			●	●	5.94
010391–2DMW16S	Cloudy	●	●	●	●	●			●	●	6.64
011491–2DMW16D		●	●	●	●	●			●	●	6.23
121090–2DSW1	Cloudy	●	●	●	●	●					
121090–2DSW2	Cloudy	●	●	●	●	●					
121090–2DSW3	Particulates	●	●	●	●	●			●	●	
121090–2DSW4		●	●	●	●	●					
121090–2DSW5		●	●	●	●	●			●	●	
121090–2DSW7		●	●	●	●	●					

TABLE 2–12 (continued)
AREA A
SUMMARY OF GROUND WATER AND SURFACE WATER SAMPLING PROGRAM

		LABORATORY ANALYSES									
SAMPLE ID[2]	COMMENTS	VOC	SVO	INORGANICS	PESTICIDES	PCBs	TPH	FLUORE–SCENCE	GROSS ALPHA	GROSS BETA	pH[4]
					DOWNSTREAM (continued)						
121090–2DSW8		•	•	•	•	•					––
121090–2DSW9		•	•	•	•	•					––
121090–2DSW10		•	•	•	•	•					––
121090–2DSW11		•	•	•	•	•					––
121090–2DSW12	Particulates	•	•	•	•	•					––
121090–2DSW13		•	•	•	•	•					––
121190–7SW1		•	•	•	•	•					––
					OVER BANK DISPOSAL AREA						
010291–3MW12S	Cloudy	•	•	•	•	•			•	•	6.10
010791–3MW12D	Green Sediment	•	•	•	•	•			•	•	6.18
					OFFSITE STREAM						
020791–OSSW1		•	•	•	•	•					
020791–OSSW2		•	•	•	•	•					
020791–OSSW3		•	•	•	•	•					

NOTES

1) VOC – Volatile Organic Compounds
   SVO – Semi–Volatile Organic Compounds
   Inorganics – Metals and Cyanide
   PCBs – Polychlorinated Biphenyls
2) MW – Ground Water Sample
   SW – Surface Water Sample
   S – Overburden Monitoring Well
   D– Bedrock Monitoring Well
3) Original Sample Data rejected during validation; location resampled at a later date for parameters indicated.
4) pH listed is the pH measured in the field just prior to sampling. pH is not listed for surface water samples or wells for which the pH was not used to indicate how long to purge the well.

TABLE 2-13
DRMO
SUMMARY OF GROUND WATER AND SURFACE WATER SAMPLING PROGRAM

		LABORATORY ANALYSES[1]									
SAMPLE ID[2]	COMMENTS	VOC	SVO	INORGANICS	PESTICIDES	PCBs	TPH	FLUORE-SCENCE	GROSS ALPHA	GROSS BETA	pH[3]
121890-6MW1S		●	●	●	●	●			●	●	6.85
121890-6MW2S		●	●	●	●	●			●	●	6.98
121890-6MW3S		●	●	●	●	●			●	●	7.40
121890-6MW4S		●	●	●	●	●			●	●	6.98
121790-6MW5S		●	●	●	●	●			●	●	6.14
121790-6MW5D		●	●	●	●	●			●	●	5.7
120190-6SW1		●	●	●	●	●			●	●	--

NOTES

1) VOC – Volatile Organic Compounds
   SVO – Semi-Volatile Organic Compounds
   Inorganics – Metals and Cyanide
   PCBs – Polychlorinated Biphenyls

2) MW – Ground Water Sample
   SW – Surface Water Sample
   S – Overburden Monitoring Well
   D – Bedrock Monitoring Well

3) pH listed is the pH measured in the field just prior to sampling. pH is not listed for surface water samples or wells for which the pH was not used to indicate how long to purge the well.

TABLE 2-14
LOWER SUBASE
SUMMARY OF GROUND WATER AND SURFACE WATER SAMPLING PROGRAM

		LABORATORY ANALYSES[1]									
SAMPLE ID[2]	COMMENTS	VOC	SVO	INORGANICS	PESTICIDES	PCBs	TPH	FLUORE-SCENCE	GROSS ALPHA	GROSS BETA	pH[3]
011691-13MW1S		●		●			●	●			6.29
011691-13MW2S		●		●			●	●			6.48
011691-13MW3S	Floating Product; Particulates	●		●			●	●			6.44
011791-13MW4S		●		●			●	●			11.11
011791-13MW5S	Floating Product; Particulates	●		●			●	●			6.60
011891-13MW6S		●		●			●	●			6.52
011591-13MW7S		●		●			●	●			9.09
021191-13MW8		●		●			●	●			6.89
011791-13MW9S	Cloudy; Sheen	●		●			●	●			7.34
011891-13MW10S		●		●			●	●			6.58
012191-13MW11S	Cloudy; Particulates	●		●			●	●			6.39
012191-13MW12S		●		●			●	●			6.94
012191-13MW13S		●		●			●	●			6.81
011591-13MW14S		●		●			●	●			6.30
012291-13MW15S	Sheen; Cloudy; Particulates	●		●			●	●			--
012391-13MW16S	Sheen	●		●			●	●			6.91
011591-13MW17S		●		●			●	●			6.00
012291-WEMW1S		●		●			●	●			6.72
012291-WEMW4S		●		●			●	●			6.39
012391-WEMW5S	Particulates	●		●			●	●			6.97
011891-NESOMW4S		●		●			●	●			6.63
012191-NESOMW6S	Particulates	●		●			●	●			6.36
012191-NESOMW10S		●		●			●	●			6.68
012191-NESO11		●		●			●	●			6.80

NOTES

1) VOC – Volatile Organic Compounds
   SVO – Semi-Volatile Organic Compounds
   Inorganics – Metals and Cyanide
   PCBs – Polychlorinated Biphenyls
2) MW – Ground Water Sample
   SW – Surface Water Sample
   S – Overburden Monitoring Well
   D – Bedrock Monitoring Well
3) pH listed is the pH measured in the field just prior to sampling. pH is not listed for surface water samples or wells for which the pH was not used to indicate how long to purge the well.

TABLE 2-15
SUMMARY OF OFFSITE RESIDENTIAL WELL SAMPLING PROGRAM

		LABORATORY ANALYSES[1]								
SAMPLE ID[2]	ADDRESS	VOC	SVO	INORGANICS	PESTICIDES	PCBs	TPH	FLUORE-SCENCE	GROSS ALPHA	GROSS BETA
				FIRST ROUND						
120190-OSW1	1488 Route 12	●	●	●	●	●				
120190-OSW2	7 Pinelock Drive	●	●	●	●	●				
120190-OSW3	1053 Long Cove Road	●	●	●	●	●				
120490-OSW5	1037 Long Cove Road	●	●	●	●	●				
120490-OSW6	1458 Route 12	●	●	●[3]	●	●				
120490-OSW7	40 Pinelock Drive	●	●[3]	●	●	●				
120490-OSW8	1292 Route 12	●	●	●[3]	●	●				
120490-OSW9	1477 Route 12	●	●	●	●	●				
120490-OSW10	10 Sleepy Hollow Pentway	●	●	●	●	●				
120590-OSW11	18 Sleepy Hollow Pentway	●	●	●[3]	●	●				
120590-OSW12	1444 Route 12	●	●	●[3]	●	●				
120590-OSW13	162 Military Highway	●	●	●	●	●				
120590-OSW14	48 Pinelock Drive	●	●[3]	●	●	●				
120690-OSW15	16 Sleepy Hollow Pentway	●	●	●	●	●				
				SECOND ROUND						
020691-OSW6	1458 Route 12			●						
020691-OSW8	1292 Route 12			●						
020691-OSW9	1477 Route 12			●						
020591-OSW12	1444 Route 12			●						
020791-OSW15	16 Sleepy Hollow Pentway	●								
020591-OSW21	1140 North Pleasant Valley Road			●						
020591-OSW22	1130 North Pleasant Valley Road			●						
020591-OSW23	1198 North Pleasant Valley Road			●						
020591-OSW24	1298 North Pleasant Valley Road			●						
020591-OSW25	1320 Route 12			●						
020791-OSW28	1469 Route 12			●						
020791-OSW29	1323 Route 12			●						
020791-OSW30	1319 Baldwin Hill Road			●						

NOTES

1) VOC – Volatile Organic Compounds
   SVO – Semi-Volatile Organic Compounds
   Inorganics – Metals and Cyanide
   PCBs – Polychlorinated Biphenyls
2) MW – Ground Water Sample
   SW – Surface Water Sample
   S – Overburden Monitoring Well
   D – Bedrock Monitoring Well
3) Original Sample Data rejected during validation; location resampled at a later date for parameters indicated. Inorganic rejections pertained only to cyanide.

The procedure for sampling residential wells was as follows: the sample was collected from as close to the well as possible. In general, this involved purging at least one holding tank volume through a faucet or outside spigot (20 minutes minimum). The sample was collected from a spigot on the holding tank if possible. If this was not possible, the sample was taken from a nearby faucet from which any particulate filters had been removed.

Data collected (as available) at the time of sampling indicates depth, location and type of wells and pumps, water treatment (if any), and water pipe material.

2.9 Surface Water Investigation

The objective of the surface water investigation at NSB-NLON was to assess surface water quality of onsite streams within the Area A site, four sampling points along the bank of the Thames River and at an offsite stream originating along the perimeter road at the northern portion of the base, and flowing offsite to the north. The summary of the surface water sampling and analytical program is included with the ground water tables (Tables 2-11, 2-12 and 2-13).

The surface water sampling program consisted of 13 sampling points within the Area A site, three sampling points in the north base offsite stream, and upstream and downstream sampling points in the Thames River. One round of sampling was conducted. All samples were analyzed for VOCs, SVOs, Inorganics, Pesticides, and PCBs. Samples from the Thames River and two of the samples downstream from Area A were analyzed for gross alpha and gross beta radiation.

Atlantic personnel collected all onsite samples in December of 1990 and offsite north base stream samples in February of 1991. The samples were collected according to Atlantic Procedure 1022.

2.10 Ecological Investigation

An ecological survey was conducted for the sites investigated, which is discussed in detail in Section 7.0, Ecological Risk Assessment. Many sites are heavily developed, and a detailed ecological assessment was not acceptable. The principal area where an ecological survey was conducted was Area A, which is within the undeveloped northern portion of NSB-NLON. The ecological survey consisted of an identification of birds, mammals, reptiles, amphibians and vegetation.

2.11 Quality Assurance/Quality Control (QA/QC)

This project was conducted in accordance with the approved Quality Assurance/Quality Control and Data Management Plan and Field Sampling Plan dated April 1989. The QA/QC plan was developed based on guidance provided in *Sample and Chemical Analysis Quality Assurance Requirements for the Navy Installation Restoration Program,* NEESA 20.2-047B. The program implemented at the Subase was performed under NEESA Level C Guidelines. This is equivalent to Data Quality Objective (DQO) Level 3 as defined by the USEPA. The major differences between Navy Level C and Navy Level D (DQO Level 4) occur in the analytical procedures used and validation of data. Level C allows for the use of EPA approved analytical methods whereas Level D requires the use of CLP procedures only. However, CLP analytical procedures were used for this project. Level C involves data review as described in Section 2.11.3 in contrast to the CLP validation required for Level D.

A complete Quality Assurance/Quality Control report is provided in Appendix C. The QA/QC program is summarized below.

2.11.1 Field Quality Control (QC) Samples

The QA/QC plan called for the collection of field duplicates, referee duplicates, trip blanks, field blanks, and equipment rinsates. Matrix spike and matrix spike duplicates were also analyzed as a part of laboratory QA/QC. Quality control samples, specified frequencies to be collected, and actual sample quantity collected as part of this investigation are summarized in Table 2-16.

The referee duplicates were collected by Alliance Technologies, an EPA oversight contractor. To date final results of the referee duplicate analyses have not been received, however, the USEPA has indicated that preliminary results are acceptable. The trip blanks contained deionized laboratory water. The equipment rinsates consisted of distilled water utilized as a final rinse during decon procedures. The field blanks were samples of driller's water, and water used during equipment decon.

A small number of trip blanks contained low levels of volatile organics, but neither trip nor field blanks demonstrated any significant problems. Equipment rinsates were found to contain elevated levels of metals in the beginning of the sampling program. It was determined that the use of ten percent (10%) nitric acid solution as a decon fluid on the driller's split spoons may have been causing leaching of metals into the rinsates. This procedure was modified to use 1% nitric acid solution and the levels of metals in the rinsates diminished. The equipment rinsates analytical results caused the estimation of some inorganic data.

Matrix spikes and matrix spike duplicates were run for volatiles, semi-volatiles, and pesticides/PCBs at a frequency of 1 in 20 samples of similar matrix or one per batch of samples sent to the laboratory, whichever was greater. For metals analysis, a duplicate and a matrix spike were run for every 20 samples of similar matrix or one per batch of samples. Matrix spike recoveries were generally acceptable although small amounts of data were estimated or rejected based on poor matrix spike recoveries. See Appendix C for further discussion.

2.11.2 Field Audits

Several audits were performed by Atlantic's QA coordinator to ensure that the field work was conducted according to the procedures contained in the Field Sampling Plan. Field audits and/or inspections were performed on the following days:

DATE	TYPE OF SAMPLING OBSERVED
August 30, 1990	Subsurface Soils
November 13, 1990	Subsurface Soils
January 15, 1991	Ground Water

TABLE 2-16
SUMMARY OF QA/QC SAMPLES

SAMPLE TYPE	SPECIFIED FREQUENCY	SPECIFIED SAMPLE QUANTITY	ACTUAL SAMPLE QUANTITY
Field Duplicates	10% per matrix	32	36
Referee Duplicates	As determined by USEPA	---	10
Equipment Rinsates	Collect one per day, analyze every other day. Analyze remaining samples if pertinent analytes are found in the rinsates.	73	73
Trip Blanks	One per cooler containing VOC samples.	47	47
Field Blanks	One per source of decon and drilling water.	3	4

1. Matrix spikes and matrix spike duplicates were performed at a frequency of 5% per matrix for organic analyses.
2. Matrix spikes and duplicates were performed at a frequency of 5% per matrix for inorganic analyses.

The field audits indicated general compliance with the required sampling procedures; several minor deviations of the procedures were noted and corrected.

USEPA oversight was provided by Alliance Technologies, Inc.

2.11.3 Data Validation

A checklist was developed to facilitate the review of analytical data generated under Navy Level C requirements (DQO Level 4). The checklist incorporated the provisions for validation presented in the NEESA document entitled *Sampling and Chemical Analysis Quality Assurance Requirements for the Navy Installation Restoration Program,* NEESA 20.2-047B. The criteria presented in the checklist to evaluate sample and quality control results are based on the analytical requirements and validation guidelines defined in NEESA 20.2-047B. The checklist is included in Appendix C.

Data validation involved the checking of laboratory generated forms for sample quality control, standards results, and assigning the data qualifiers if appropriate.

The checklist provides summary pages for listing estimated and rejected data results upon completion of the validation process. The resulting data qualifiers were transcribed onto the laboratory data result forms and subsequently added to any data tables generated. A summary of the data qualifiers are provided on Table 2-17.

It is important to note that there are a variety of reasons for estimating or rejecting data. Reasons for qualification of data are discussed in further detail in Appendix C. The completed data review checklists provide validation information pertaining to any specific samples.

2.11.4 Data Quality Objectives

Data validation was used to evaluate whether the data quality objectives (DQO) for all measurements (field and laboratory) had been reached. The DQOs include considerations of precision, accuracy, and completeness as summarized in the following paragraphs. DQOs are discussed in further detail, including calculations, in Appendix C.

Precision is a test of the repeatability of a measurement and is based upon the results of field or laboratory duplicates. Precision is considered acceptable if the relative percent difference (RPD) between two duplicate samples is within $\pm$ 20 percent. RPDs were calculated as part of the data validation process and seven percent of the analytical results were estimated due to duplicates having RPDs greater than 20 percent.

Accuracy of analysis was determined by the evaluation of matrix spike and matrix spike duplicate samples of known quantities. The degree of accuracy and recovery of an analyte expected for the analysis of QA samples and spiked samples is dependent upon the matrix, method of analysis, and compound or element being determined in the analysis. Unless otherwise specified, the QC objective for accuracy is a recovery of 75 to 125 percent.

Accuracy calculations, prepared by the laboratory, are provided in the laboratory analytical package. Analytes exhibiting values lower or higher than this were estimated in associated samples.

TABLE 2-17
LABORATORY ANALYTICAL DATA QUALIFIERS

Organic Data Qualifier Flags	
ND	None detected.
J	The "J" flag indicates an estimated value due to validation requirements or when the data indicates the presence of a compound that meets identification criteria, but the quantitated value is less than the CRQL.
B	The "B" flag indicates that the analyte was found in the associated blank as well as in the sample.
D	The "D" flag indicates that the sample was diluted due to high concentrations.
E	The "E" flag indicates compound concentrations that exceed the calibration range of the GC/MS instrument.
X or Y	The "X" or "Y" flag indicates that the compound values have been edited on a laboratory data system.
R	The "R" flag indicates that the result is rejected based on validation guidelines.
Inorganic Data Qualifier Flags	
ND	None detected.
J	The "J" flag indicates an estimated value due to laboratory or data validation requirements.
B	The "B" flag indicates that the reported value is less than the CRDL, but greater than the IDL (Instrument Detection Limit).
R	The "R" flag indicates that the result is rejected based on validation guidelines.

Samples for inorganic analysis which were not detected and had associated spike recoveries <30% were rejected as part of data validation. Samples for organic analysis which were not detected and had spike recoveries <10% were rejected as part of data validation. Less than one percent of all analytical data was rejected based on accuracy considerations.

Completeness is a measurement of valid data obtained relative to the total amount of data generated. This project's QC objective for data completeness, as a percentage of valid data reported, was ≥90%. The actual completeness was calculated to be 99%.

Based upon consideration of precision, accuracy, and completeness, the data quality objectives for this project were met or exceeded.

3.0 PHYSICAL CHARACTERISTICS OF THE STUDY AREA

This section describes the characteristics of the study area, including topography, soils, geology and hydrology, climatology and demography. The ecology of the study area is presented in detail in Section 7.0. Detailed site specific discussions are provided which include geology and hydrogeology. The hydrogeology section includes an evaluation of ground water flow direction and velocity.

3.1 Topography

The land around NSB-NLON is a series of low bedrock ridges that trend generally north-south. Lowlands between the ridges are commonly wetlands and poorly-drained stream valleys. The Thames River adjacent to the west of NSB-NLON is flanked by glacially-derived terrace deposits and more recent flood plain deposits.

The topography of NSB-NLON (see Figure 1-2) is dominated by bedrock ridges in the northern (elevation 180 feet MSL) and central (elevation 230 feet MSL) portions of the site as well as an offsite ridge (Baldwin Hill, elevation 245 feet MSL) that is located adjacent to the east of the site. The low lying area (elevation 50 feet MSL) between these ridges slopes to the west (USGS, 1984). The eastern portion of this area is a wetland (Area A) which drains through an earthen dike into an area that is thirty to forty feet below the elevation of the wetland. A review of historical topographic maps and other historical information suggests that the construction of the dike in 1957, and the subsequent filling of the area east of the dike with sediments dredged from the Thames River, contributed to this difference in elevation.

The southern and western portions of NSB-NLON are generally flat with sparse bedrock outcrops.

The topography in several areas of the site has been altered by landfilling and quarrying. A review of topographic maps from 1893, 1938, 1939, and 1952 and other historical information provided the following information.

As discussed above, the low lying area that is now the Area A Wetland was filled in the late 1950s with dredged sediments from the Thames River. Refuse material generated at NSB-NLON was disposed on top of dredge spoil in the Area A Landfill. Boring information from this investigation indicates that the thickness of dredge spoil is approximately 10 to 15 feet on the north section of the wetland and approximately 35 feet on the south portion of the wetland adjacent to the Area A Landfill. Thickness of refuse material in the landfill is estimated to be from ten to 20 feet. Landfill and dredge disposal activities substantially altered the topography of this area.

The DRMO site was previously used as a landfill. Fill material in the northern portion of the site extends from the surface to between five and 20 feet below grade. In the eastern and southern portions of the site, fill was absent or less than five feet thick. Goss Cove was also filled in with landfill material. Depth of fill material, as estimated from boring logs, is between 15 and 20 feet on the west side of the site and ten feet or less on the east side of the site. Fill material lies directly on top of river sediments in most cases. Since both the DRMO and Goss Cove were once part of the Thames River, it is evident that the topography of both sites has been altered significantly.

The Lower Subase is built primarily on fill material. A review of 1893 and 1938 topographic maps and 1934 aerial photographs shows that the original pier was constructed on a parcel of land that protruded into the Thames River. As more buildings and piers were added, fill material was also added. Subsurface soil sampling information from this investigation indicates that the fill consists of clean sand and gravel. Fill is thickest (20 feet) on the west side of the site adjacent to the bulkhead and thins to the east.

The present site of the Torpedo Shops was once a rock quarry. A large lake, Crystal Lake, was located in the southernmost portion of the NSB-NLON adjacent to Crystal Lake Road. Historical topographic maps show that it was filled sometime after 1938.

3.2 Soils

Figure 3-1 is a soils map of NSB-NLON prepared by the Soil Conservation Service (SCS, 1983). In general, soils at NSB-NLON have moderate to moderately rapid permeability according to the SCS information. Available water capacity is moderate to low, and runoff is rapid or very rapid. The pH is strongly to moderately acidic. Erosion hazard is severe. A detailed description of each soil follows (SCS, 1983). Figure 3-1 shows which soil classifications are found at each of the sites investigated.

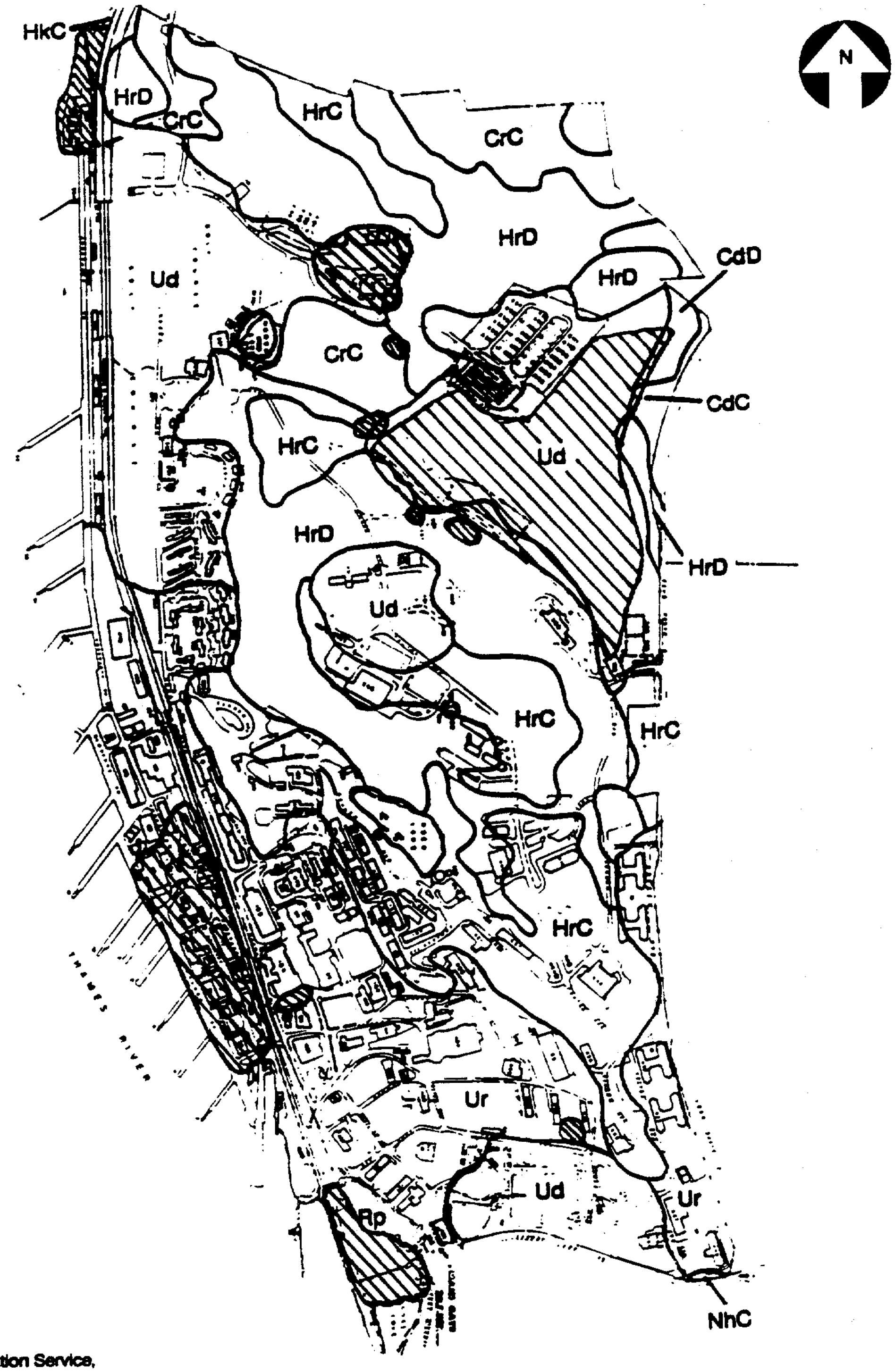
CdC - Canton and Charlton, 3-15 % Slopes - This complex consists of sloping to gently sloping, well drained, extremely stony fine sandy loams found on glacial till upland hills, plains and ridges. Stones and boulders cover eight to 25 percent of the surface.

Charlton, Canton and a number of other soils are mapped together because there are no major differences in use or management. The mapped acreage of this group is approximately 55 percent Canton soil, 25 percent Charlton soil and 20 percent other soils.

Typically, the Canton soil has a black, fine sandy loam surface layer one inch thick. The subsoil is dark, yellowish-brown, fine sandy loam and sandy loam 23 inches thick. The substratum is grayish brown gravelly sand to a depth of 60 inches or more. Permeability of the Canton Soil is moderately rapid in the surface layer and subsoil and rapid in the substratum. Available water capacity is moderate. Canton soil warms up and dries out rapidly in the spring. It is strongly acidic to medium acidic.

The Charlton soil typically has a very dark grayish brown, fine sandy loam surface layer three inches thick. The subsoil is dark yellowish brown, yellowish brown and light olive brown fine sandy loam 26 inches thick. The substratum is grayish brown fine sandy loam to a depth of 60 inches or more. Permeability of the Charlton soil is moderate or moderately rapid. Available water capacity is moderate. Charlton soil warms up and dries out rapidly in the spring. It is strongly acidic to medium acidic. The hazard of erosion is moderate or severe.

CdD - Canton and Charlton, 15-35 % Slopes - This group consists of extremely stony, fine sandy loams with steep to moderately steep slopes. Stones and boulders cover eight to 25 percent of the surface. Most areas mapped CdD are irregular or long and narrow in shape and from two to 50 acres in size. Erosion hazard in these areas is severe. Other characteristics of the Canton and Charlton soils are as described above.



SOURCE: Soil Conservation Service,
U.S. Department of Agriculture

INSTALLATION RESTORATION STUDY
NAVAL SUBMARINE BASE - NEW LONDON
GROTON, CT

LEGEND

CdC - Canton and Charlton, 3-15% slopes
CdD - Canton and Charlton, 15-35% slopes
CrC - Charlton -Hollis, 3-15% slopes
HrC - Hollis-Charlton Rock, 3-15% slopes
HrD - Hollis-Charlton Rock, 15-45% slopes
HkC - Hinkley Sandy Loam, 3-15% slopes
NhC - Narragansett Silt Loam, 3-15% slopes
Rp - Rock Outcrop-Hollis, 3-45% slopes
Ud - Udorthents-Urban Land, 0-15% slopes
Ur - Urban Land, surface covered by pavements or structures

FIGURE 3-1
SOILS MAP

ATLANTIC ENVIRONMENTAL SERVICES, INC.

CrC - Charlton-Hollis, 3-15 % Slopes - This gently sloping to sloping complex consists of very rocky fine sandy loams that are somewhat excessively drained to well drained. Rock outcrops cover up to ten percent of the surface. Stones and boulders cover one to eight percent of the surface. Most areas mapped CrC are irregular in shape and two to 60 acres. This complex is about 55 percent Charlton soil, 20 percent Hollis soil, and 25 percent other soils and rock outcrops. Erosion hazard is moderate to severe.

The Hollis soil typically has a very dark brown, fine sandy loam surface layer two inches thick. The subsoil is dark brown and dark yellowish brown fine sandy loam 15 inches thick. Hard unweathered bedrock is usually at a shallow depth. Permeability of the Hollis soil is moderate to moderately rapid above bedrock. Available water capacity is low, and runoff is medium or rapid. Hollis soil warms up and dries out rapidly in the spring. It is strongly acidic to medium acidic.

Characteristics of the Charlton Soils are described above.

HrC - Hollis-Charlton Rock, 3-15 % Slopes - This gently sloping to sloping complex consists of somewhat excessively drained and well drained soils and rock outcrop on glacial till uplands. Stones and boulders cover one to eight percent of the surface. Mapped areas are irregular in shape and two to 45 acres in size. The complex consists of 40 percent Hollis soil, 25 percent Charlton soil, 20 percent rock outcrop, and 15 percent other soils. The hazard of erosion is moderate to severe. Characteristics of Hollis and Charlton soils are described above.

HrD - Hollis-Charlton Rock, 15-45 % Slopes - This moderately steep to very steep complex consists of somewhat excessively drained and well drained soils and rock outcrop on glacial till uplands. Stones and boulders cover one to eight percent of the surface. Mapped areas are irregular in shape and two to 45 acres in size. The complex consists of 40 percent Hollis soil, 25 percent Charlton soil, 20 percent rock outcrop, and 15 percent other soils. The hazard of erosion is severe. Characteristics of Hollis and Charlton soils are described above.

HkC - Hinckley Sandy Loam, 3-15 % Slopes - This gently sloping and sloping excessively drained soil is a gravelly, sandy loam that is found on stream terraces, outwash plains, kames and eskers. Most mapped areas are irregular in shape and between two and 25 acres in size. Erosion hazard is moderate or severe.

Typically, the Hinckley soil has a dark brown, gravelly sandy loam surface layer seven inches thick. The subsoil is yellowish-brown gravelly loamy sand 15 inches thick. The substratum is brownish-yellow very gravelly coarse sand to a depth of 60 inches or more. Permeability is rapid in the surface layer and subsoil and very rapid in the substratum. Available water capacity is low, and runoff is medium or rapid. Hinckley soil warms up and dries out rapidly in the spring. It is strongly acidic or medium acidic.

NhC - Narragansett Silt Loam, 3-15 % Slopes - This extremely stony silt loam is a gently sloping to sloping, well drained soil which is found on glacial till uplands hills, ridges and plains. Stones and boulders cover eight to 25 percent of the surface. Most mapped areas are irregular in shape and from 2 to 40 acres in size. The hazard of erosion is moderate or severe.

Typically, this Narragansett soil has a dark brown, silt loam surface layer three inches thick. The subsoil is dark yellowish-brown and yellowish-brown silt loam 25 inches thick. The substratum is light olive brown gravelly, loamy coarse sand to a depth of 60 inches or more. Permeability of the Narragansett soil is moderate in the surface layer and subsoil and moderately rapid or rapid in the substratum. The available water capacity is high, and runoff is medium to rapid. Narragansett soil warms up and dries out rapidly in the spring. It is strongly acidic or medium acidic.

Rp - Rock Outcrop-Hollis, 3-45 % Slopes - This gently sloping to very steep complex consists of rock outcrop and a somewhat excessively drained soil on glacial till uplands. Stones and boulders cover one to eight percent of the surface. Mapped areas are irregular in shape and mostly two to 15 acres in size. This complex is about 50 percent rock outcrop, 30 percent Hollis soil, and 20 percent other soils. The hazard of erosion is severe. Rock outcrop is hard, unweathered, exposed bedrock.

The characteristics of the Hollis soil are described above.

Ud - Udorthents-Urban Land, 0-15 % Slopes - This complex consists of excessively drained to moderately well drained soils that have been disturbed by cutting and filling, and areas that are covered by buildings or pavement. Mapped acres are mostly five to 40 acres in size. About 60 percent of the complex is Udorthents, 25 percent is urban land, and 15 percent is other soils.

Some areas of Udorthents have been cut to a depth of two feet or more, and some have been covered with more than two feet of fill. Permeability of the Udorthents is slow to very rapid. The available water capacity and runoff are variable.

Urban land consists mainly of areas of developed or disturbed land.

Ur - Urban Land - This group consists of land where more than 85 percent of the surface is covered by streets, parking lots, buildings and other structures. Most urban land is in densely populated areas and units are five to 30 acres in size.

Most of the underlying soils have been altered by excavating or have been covered with fill material.

3.3 Bedrock Geology

Information regarding the geology of the site and surrounding area is based on data published by the United States Geological Survey (USGS, 1967) and supplemented by field observations.

NSB-NLON is situated in the Eastern Uplands region of Connecticut, an area that is characterized by irregular hilly areas with many swamps, exposed bedrock, and poorly drained, uneven valleys. The Eastern Uplands can be divided into two geologic terranes according to their origins -the Avalonian Terrane which originated from continental crust, and the Iapetus Terrane which originated from oceanic crust (Rodgers, 1985). The Avalonian Terrane is considered to be the remnant of a relatively small continental land mass that collided with the North American continent in the late Permian Period (approximately 250 million years ago). The Iapetus Terrane is composed of sediments from the ocean that lay between the Avalonian continent and the North American continent and were intensely deformed prior to and during the collision (Bell, 1985). The northern portion of eastern Connecticut is part of the Iapetus Terrane. The southeasternmost portion of Connecticut, including NSB-NLON, consists of intensely deformed rocks that make up the Avalonian Terrane. A major east-west trending fault, the Honey Hill Fault, separates the two terrains approximately six miles north of NSB-NLON. Avalonian rocks, including the bedrock at NSB-NLON, consist of metamorphosed sedimentary and igneous rocks.

According to the USGS Bedrock Geologic Map (USGS, 1967), the bedrock at NSB-NLON can be divided into three age groups, Pre-Silurian, Pre-Pennsylvanian, and Pennsylvanian or younger. The local bedrock contains a complex series of folds, faults, anticlines and synclines. Figure 3-2 shows the bedrock geology of the site and Figure 3-3 presents a generalized geologic cross-section of the site area.

Pre-Silurian rocks at the site consist primarily of members of the Mamacoke Formation and, to a lesser extent, the Plainfield Formation. Mamacoke Formation rocks are composed of indistinctly layered light-to-dark gray, medium-grained, biotite-quartz-feldspar gneiss. Minor layers contain sillimanite, garnet, hornblende and microcline as well. Members are locally granitoid and migmatic. Rocks from a member of the Plainfield Formation underlie the northeast portion of the site. The unit is a dark green hornblende-biotite-quartz-plagioclase gneiss.

Pre-Pennsylvanian rocks occurring at NSB-NLON are members of the Sterling Plutonic Group and consist of igneous intrusives that have been metamorphosed to granitic gneisses. The Sterling Plutonic Group is further divided into the Alaskite Gneiss and the Granite Gneiss.

The Alaskite Gneiss is an orange-pink to light gray, fine- to medium-grained, equigranular, gneissic granite composed of equal amounts of quartz, microcline and albitic-to-sodic oligoclase, with small amounts of magnetite and biotite.

The Granitic Gneiss is an orange-pink to light gray, medium-grained gneissic biotite granite. The main constituents are equal amounts of quartz and microcline, oligoclase, and from two to seven percent biotite and iron oxides. In both the Granitic and Alaskite Gneisses, the biotite tends to be concentrated on the boundaries of lenses.

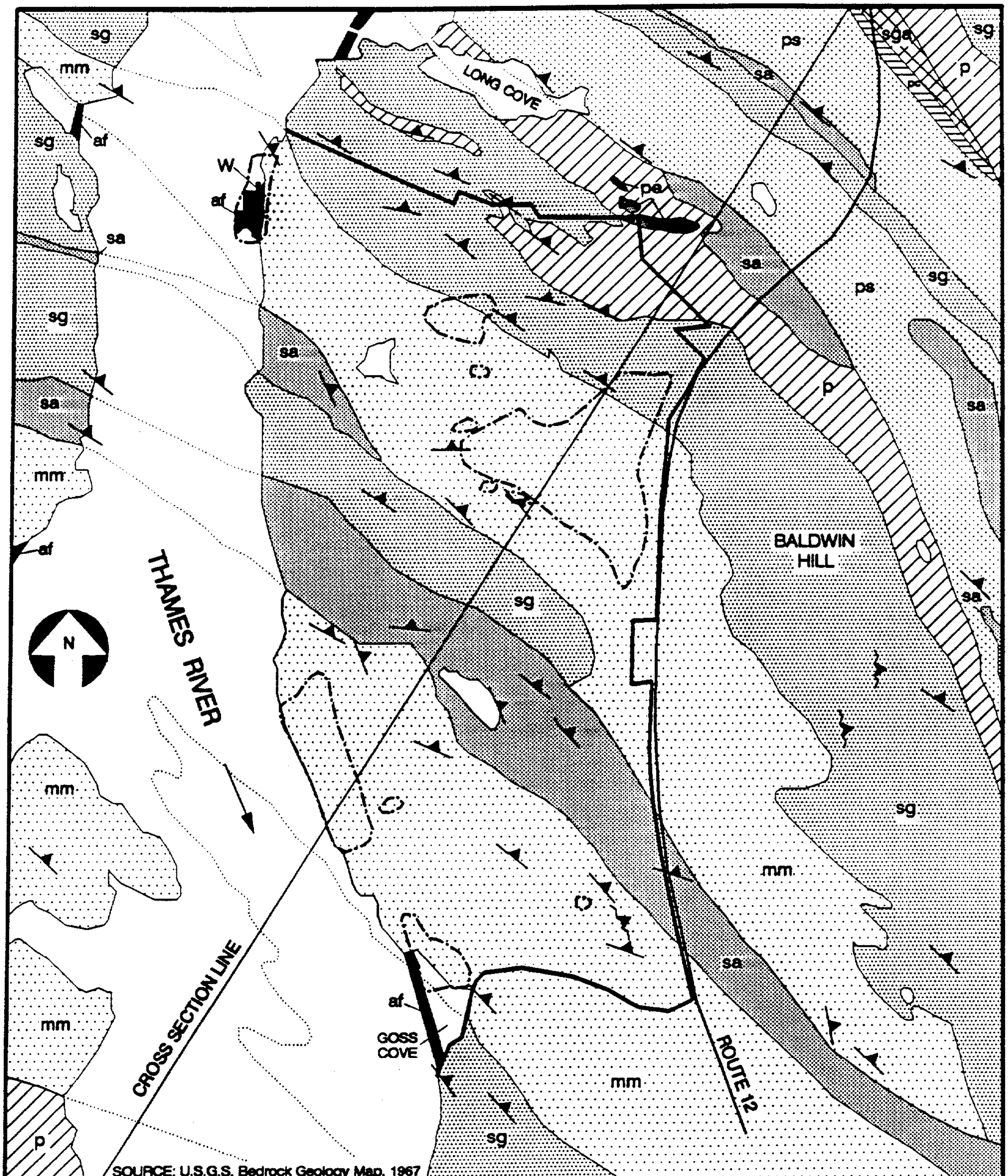
One occurrence of the Westerly Granite has been mapped on the northwest portion of the site. The Westerly Granite occurs in dikes of gray fine- to medium-grained, equigranular granite that is composed of primarily calcic oligoclase with equal amounts of quartz and microcline, about 3% biotite, 1% muscovite and accessory minerals.

3.4 Surficial Geology

Information regarding the surficial geology present at the site was obtained from the USGS Surficial Geology of the Uncasville Quadrangle Map (USGS, 1960). Figure 3-4 shows the surficial geology of the site.

Most of the surficial deposits onsite are unconsolidated glacial materials deposited during the Pleistocene Age. The remainder of the surficial deposits are the products of post-glacial geologic processes and man-made modifications.

The glacial deposits are divided into two types: nonstratified drift (also known as till or ground moraine) and stratified drift (also known as outwash). Nonstratified drift was deposited in



LEGEND

Refer to Figure 3-3 for formation descriptions.

- mm
- ps
- sg
- sa
- pa
- af
- p
- sga
- pc

w - Westerly Granite

- Sites Investigated

Strike & Dip of Mineral Foliation

- Inclined
- Gently Folded

INSTALLATION RESTORATION STUDY

NAVAL SUBMARINE BASE - NEW LONDON

GROTON, CT

FIGURE 3-2

BEDROCK GEOLOGY MAP

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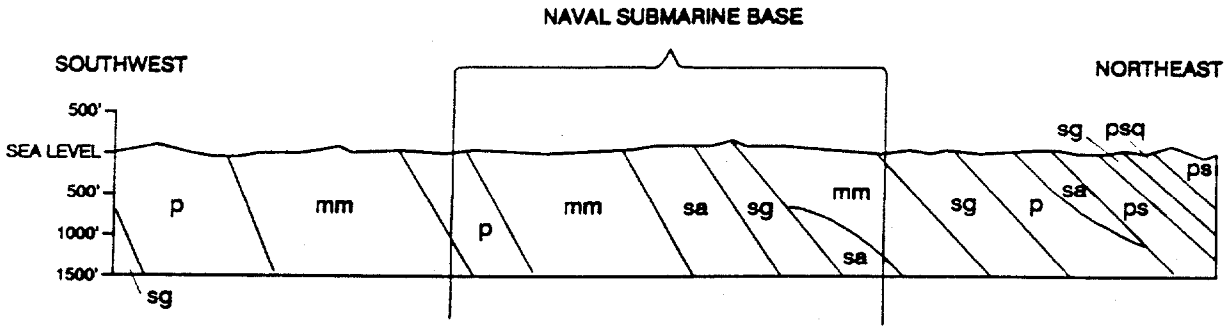


Cross-section location shown on Figure 3-2

Legend

Alaskite gneiss

sa - orange-pink to light-grey, fine to medium-grained, equigranular gneissic granite composed of about equal amounts of quartz, microcline and albite to sodic oligoclase, and about 1 percent magnetite or as much as 2 percent magnetite and biotite.

Granite gneiss

sg - orange-pink to light-grey, medium-grained, gneissic biotite granite, main constituents quartz - microcline oligoclase with 2-7 percent biotite and iron oxides. Locally contains muscovite and garnet; somewhat uneven in mineral distribution. Foliation typically marked by parallelism of alternate flat lenses of quartz and feldspars, and parallelism of biotite flakes. Biotite tends to be concentrated on surfaces between lenses. Some masses have slightly coarser grained streaks rich in orange-pink microcline in finer grained grey quartz-microcline-plagioclase rock. Locally mafic-poor similar to biotitic phases of the alaskite gneiss (sob).

Mamacoke Formation

mm - indistinctly layered light- to dark-grey, biotite-, quartz-feldspar gneiss and minor hornblende-biotite-quartz-feldspar gneiss; locally granitoid and migmatic. Thin layers of amphibolite and quartzite. Biotite flakes typically small and mostly evenly distributed.

Plainfield Formation

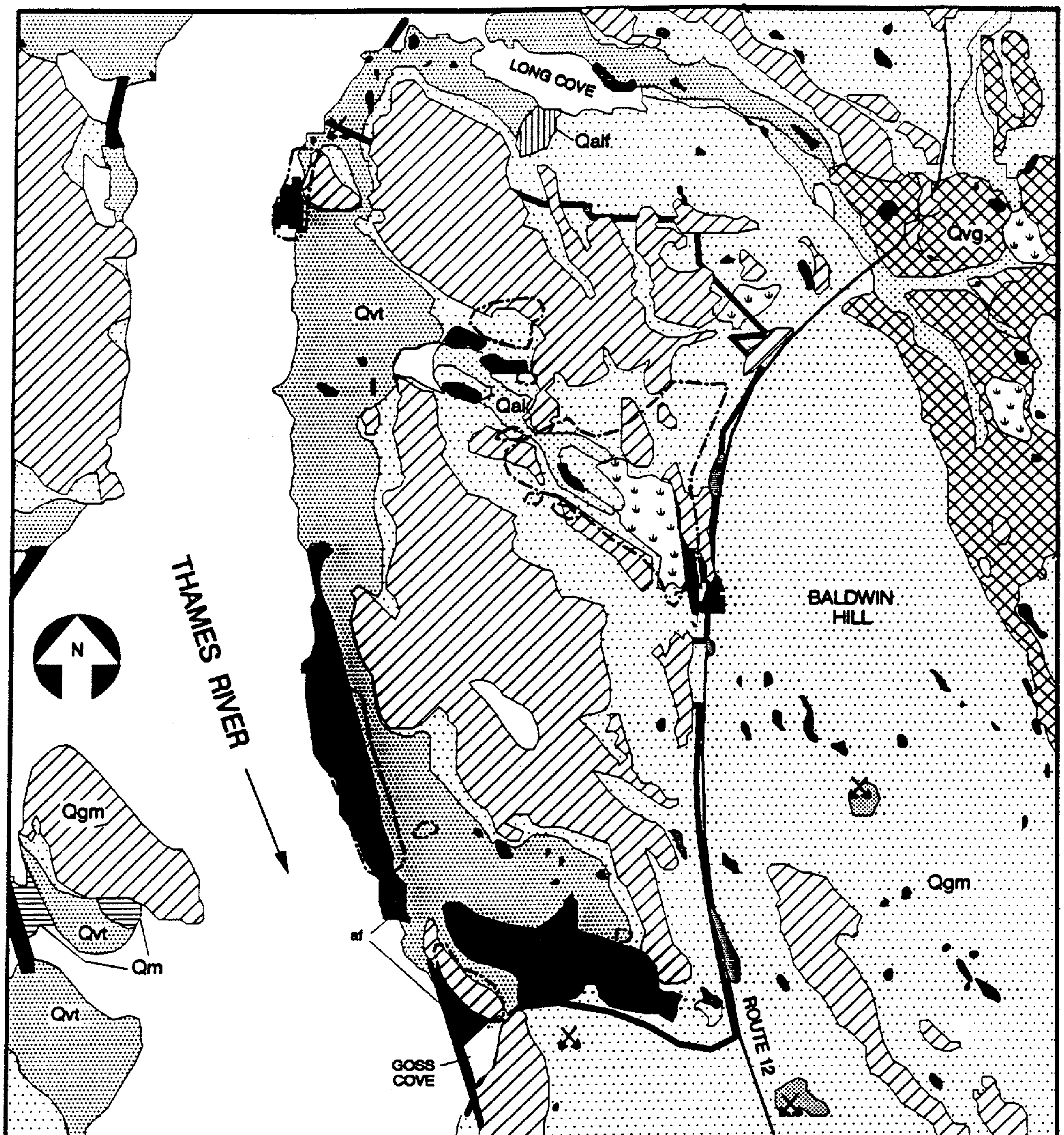
p - dark-green hornblende-biotite-quartz-plagioclase gneiss, in part diopsidic; dark biotite-quartz-plagioclase gneiss with variable amounts of microcline; garnet-biotite-quartz-feldspar schist and gneiss; amphibolite; light-grey sugary textured biotite- feldspar-quartz gneiss; thin grey quartzite, rare thick white quartzite.

pc - calc-silicate quartzite and gneiss.

pa - garnet-sillimanite-biotite-quartz-feldspar schist and gneiss; garnet- biotite-quartz-feldspar gneiss; biotite-quartz-feldspar gneiss; minor biotite-quartz-andesine gneiss with diopside and colorless amphibole; thin-bedded quartzite, locally pyritic.

psq - thick- to thin-bedded, white or tan, to light-grey, rarely greenish quartzite; thin-bedded micaceous quartzite, locally graphitic; thin interlayers of garnet and sillimanite-bearing schist and gneiss.

INSTALLATION RESTORATION STUDY NAVAL SUBMARINE BASE - NEW LONDON GROTON, CT	LEGEND SOURCE: U.S.G.S. Bedrock Geology Map, 1967	FIGURE 3-3 BEDROCK GEOLOGY CROSS-SECTION LINE ATLANTIC ENVIRONMENTAL SERVICES, INC.



Qm - Marsh Deposits
Qs - Swamp Deposits
Qal - Alluvium
Qalf - Alluvial/ Colluvial Fan Deposits
Qsu - Silt, Sand and Gravel, Undifferentiated
Qvt - Terrace Deposits along Thames River
Qvg - Valley Train Deposits along Great Brook
Qgm - Ground Moraine Deposits

INSTALLATION RESTORATION STUDY
NAVAL SUBMARINE BASE - NEW LONDON
GROTON, CT

LEGEND
- Bedrock Exposures
- Artificial Fill
- Borrow Pit, Active
- Sites investigated

SOURCE: U.S.G.S. Surficial Geology Map, 1960

FIGURE 3-4
SURFICIAL GEOLOGY MAP

ATLANTIC ENVIRONMENTAL SERVICES, INC.

direct contact with the glaciers. Stratified drift was deposited by meltwater streams from a near or distant ice mass.

Most of the bedrock onsite is mantled by a thin layer of till which consists of a dense, heterogeneous mixture of clay, silt, sand and rock fragments ranging in size from cobbles to boulders. The majority of the material is unstratified but locally contains small pockets or lenses of stratified sand and gravel. Till is exposed on most of the upland surface and underlies outwash materials in the valleys. It varies considerably in thickness and in some places is absent, but averages less than ten feet thick. The till is thickest on the north slopes of hills and thin to absent on the summit and south sides. Till on the site consists of either locally fissile, bouldery sand and gravel or a fissile, bouldery, silt and clay.

Till has been mapped at the Area A Landfill, OBDANE, CBU Drum Storage Area, and the Rubble Fill at Bunker A-86 site.

Stratified drift is stratified silt, sand and gravel that was deposited by glacial meltwater. As the ice melted and local base levels of streams were lowered, the stratified deposits were left as ridges, mounds, terraces and pitted valley floors. At NSB-NLON, stratified drift is shown as terrace deposits of the Thames River and is mapped in the western portion of the site, at the southwestern end of the site adjacent to the former location of Crystal Lake, and beneath such sites as the southern portion of DRMO, the Area A Downstream, the Former Gasoline Station and portions of the Lower Subase. The Spent Acid Storage and Disposal Area is located on the contact between stratified drift and the limit of artificial fill in the southeastern part of the site.

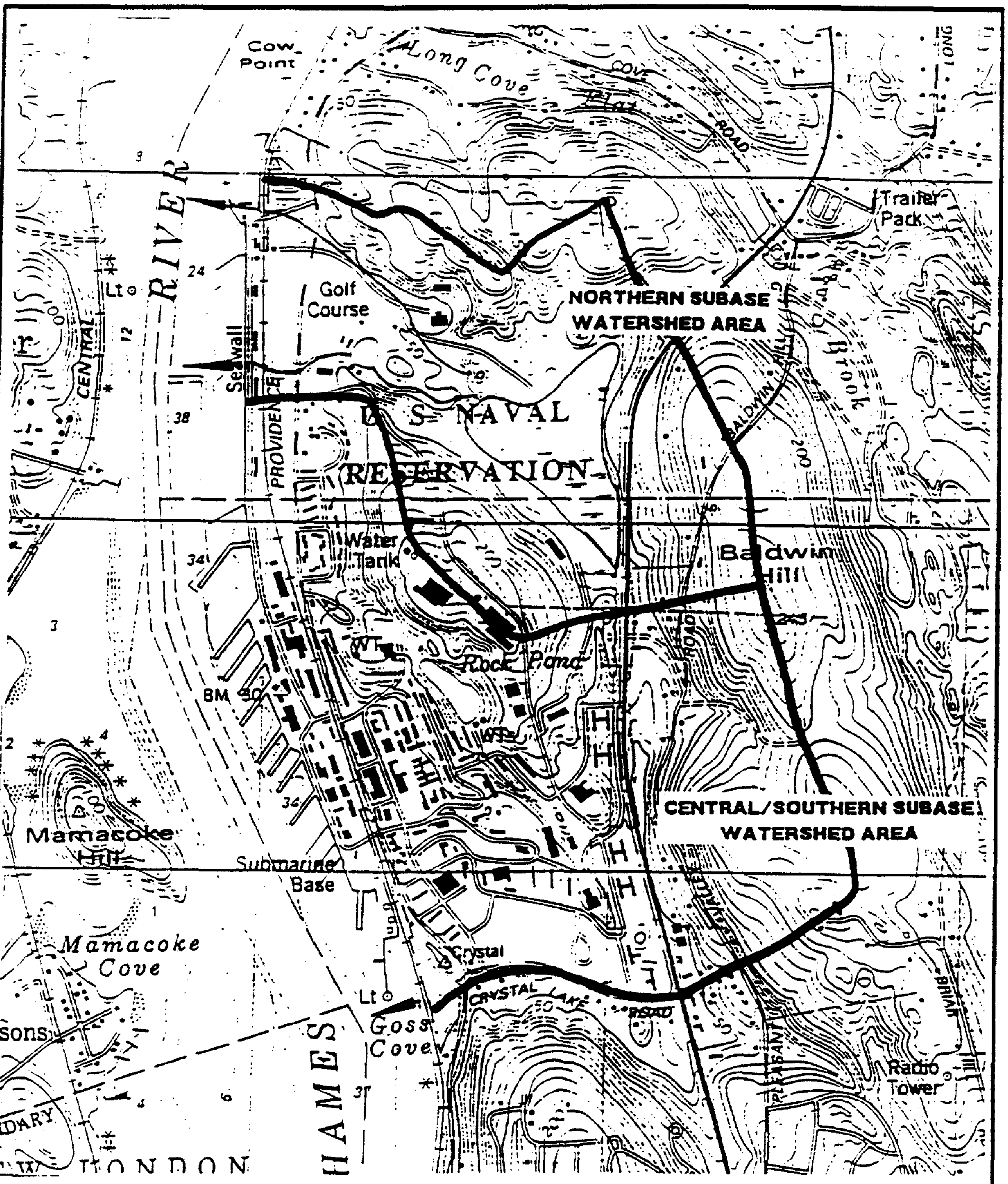
The northwestern end of the Area A Wetland, as well as the Over Bank Disposal Area and the Area A Downstream Watercourses, is mapped as Quaternary Alluvium. Quaternary alluvium consists of recently deposited sand, silt and gravel in flood plains.

Artificial fill is mapped in the areas of Goss Cove Landfill, DRMO, the majority of the Lower Subase, and the southernmost portion of NSB-NLON (former location of Crystal Lake). Extensive bedrock outcrops are mapped and were observed throughout NSB-NLON at or adjacent to all sites except the Lower Subase.

3.5 Surface Water Hydrology

NSB-NLON is located on the east bank of the Thames River within the Thames River Watershed. The Thames River and its tributaries drain approximately 1,400 square miles of eastern Connecticut, western Rhode Island, and south central Massachusetts. The Thames River originates at the City of Norwich Harbor, at the confluence of the Shetucket and Yantic Rivers, and discharges into Long Island Sound approximately six miles south of NSB-NLON. The Thames River estuary extends from Long Island Sound north 16 miles to Norwich. Widths of the river vary from 1.5 miles at New London Harbor to approximately 500 feet at Norwich Harbor.

Surface water from the site drains west toward the Thames River via streams and storm sewers. Figure 3-5 shows site drainage basins. The offsite portion of these watersheds includes a sparsely developed residential area located to the east along Route 12 and an area with limited commercial development located north of the intersection of Crystal Lake Road and Route 12.



INSTALLATION RESTORATION STUDY NAVAL SUBMARINE BASE - NEW LONDON GROTON, CT	LEGEND SOURCE: U.S.G.S. Topographic Map, 1984 Uncasville, Ct. N Major Surface Water Discharge Points	FIGURE 3-5 WATERSHED AREAS IN THE VICINITY OF NSB-NLON ATLANTIC ENVIRONMENTAL SERVICES, INC.

Onsite drainage includes several streams and ponds located in the north central section of NSB-NLON. These water courses discharge to the Thames River through discharge points located at the DRMO, on the Lower Subase north of Pier 33, and at the Goss Cove Landfill. More specific information regarding the watercourse and drainage features associated with each site investigated is provided in Section 1.2.5.

3.6 Ground Water Hydrology

Information on area aquifers was obtained from the Connecticut Water Resource Bulletin Numbers 15 and 16 (USGS/CWRC, 1968).

In the site vicinity, ground water is obtained from stratified drift, bedrock and to a lesser extent, till. General aquifer characteristics for each type encountered onsite are described below.

A fine-grained stratified drift aquifer is mapped on the western and southwestern portions of the site. Mapped thickness of stratified drift ranges from ten feet along the banks of the Thames River to a maximum depth of 80 feet at the former location of Crystal Lake in the southwestern portion of the site. Average estimated permeabilities of wells in stratified drift in the area range from 250 to 1400 gallons per day per square foot (gpd/ft^2). Well yields in the area range from 40 to 200 gallons per minute (gpm).

The bedrock in the site area consists of fractured metamorphic rock covered by glacial material that is thick in the lowlands and thinner in the uplands. In bedrock aquifers, ground water movement is along joint planes rather than through intergranular openings. Well records indicate that bedrock wells in the site vicinity yield from between one and 65 gpm. Potential well yields in bedrock wells are dependent on degree of fracturing, topography, and type and thickness of overburden. In general, the greatest well yields occur in valleys where bedrock is highly fractured and is overlain by over 50 feet of stratified drift.

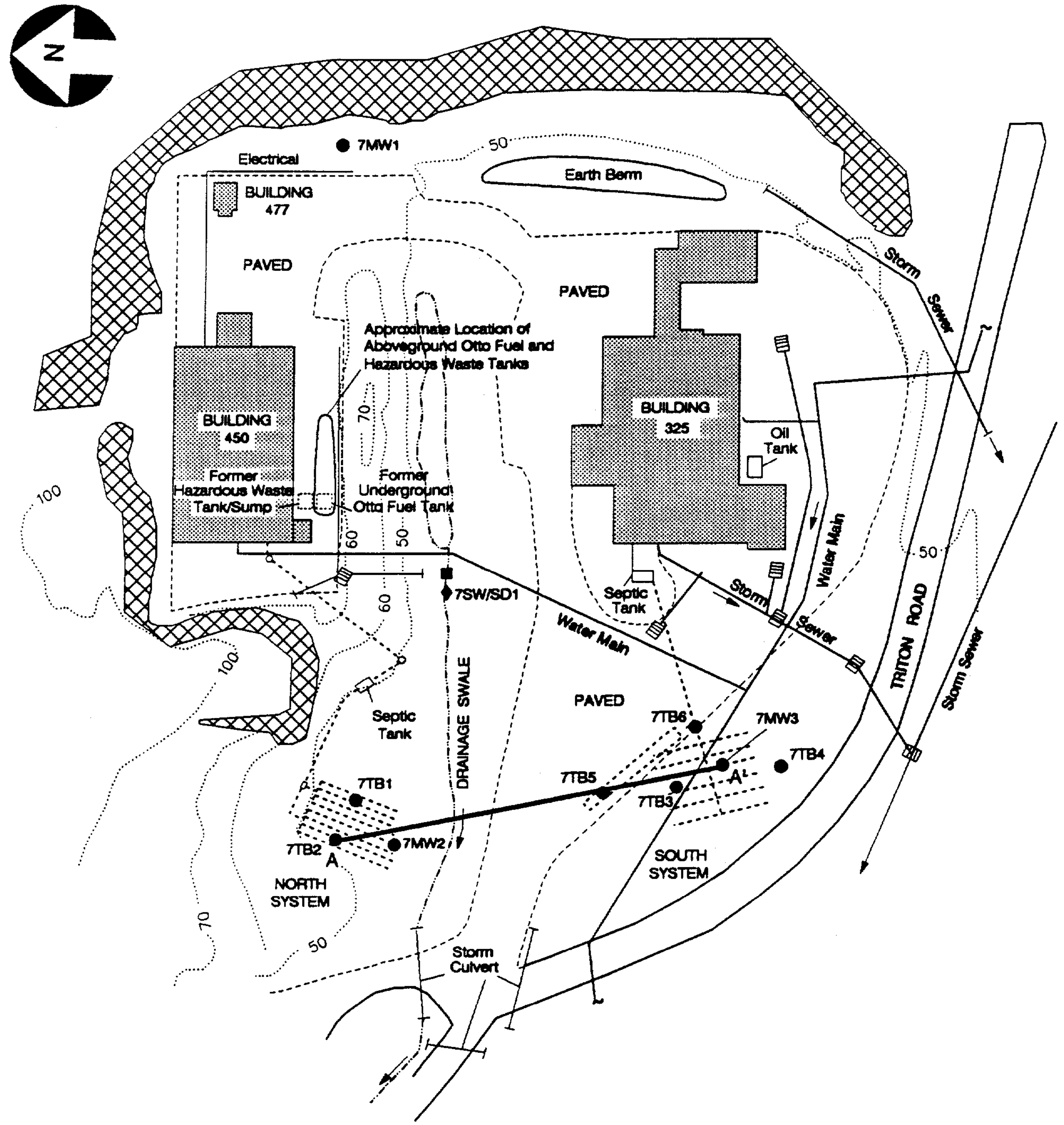
Till covers bedrock at locations previously discussed in this section. Till generally has low permeability and low water yield.

3.7 Site Specific Geology and Hydrogeology

The specific geology and hydrogeology data is provided for Step I sites where subsurface investigations were conducted (Torpedo Shop, Goss Cove Landfill, Spent Acid and Disposal Area, and Former Gasoline Station), and for all Step II sites. Information discussed includes soils classification, subsurface geology, bedrock information where available, and ground water hydrology (sites with monitoring wells). Test boring logs, monitoring well details, and aquifer property data is provided in Appendix B.

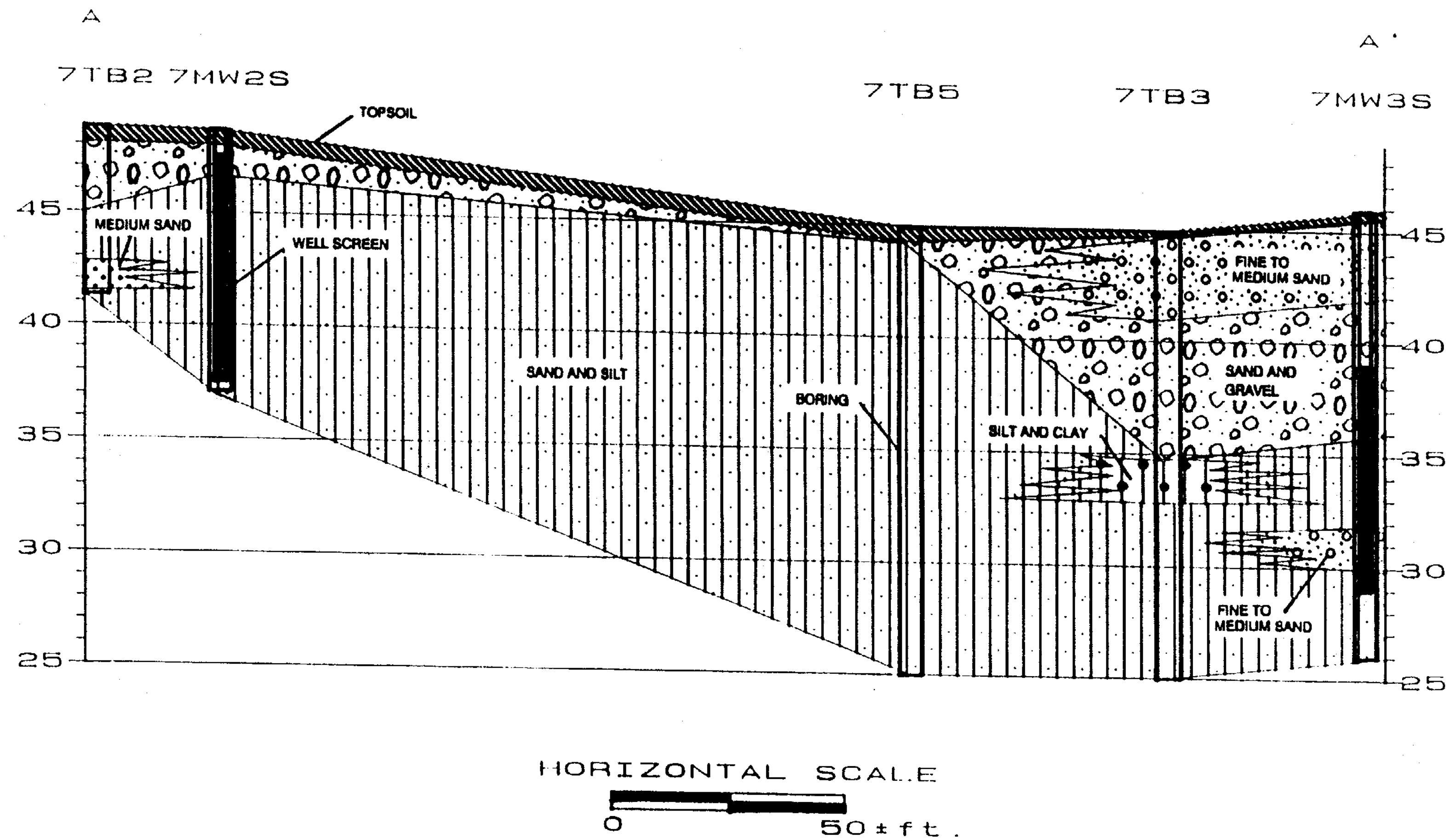
3.7.1 Torpedo Shops

The subsurface at the Torpedo Shops was characterized with nine soil borings. Eight of the soil borings were located in the western portion of the site and the remaining one was located on the east side of the site. The borings were extended to auger refusal or a maximum depth of 20 feet. Figure 3-6 shows the geologic cross-section location as well as test boring and monitoring well locations. Figure 3-7 is the geologic cross-section showing subsurface conditions encountered during the boring program.



NOTE:
1. Underground utility locations are approximate.
2. Base map and utility information from maps of NSB-NLON prepared by Loureiro Engineering Associates, Dec 1980. Elevations are based on NSB-NLON datum which is 1.41 feet below NGVD.

INSTALLATION RESTORATION STUDY NAVAL SUBMARINE BASE - NEW LONDON GROTON, CT	LEGEND		FIGURE 3-6 GEOLOGIC CROSS-SECTION LOCATION TORPEDO SHOPS
	- Exposed Bedrock	····95···· - Existing Grade	
	- Catch Basin	– – – – - Former Septic System	
	● TB1 - Test Boring	- Building	
	● MW1 - Monitoring Well	- Watercourse	
	■ SD1 - Sediment Sample	Approximate Scale 0 40 80'	
	◆ SW1 - Surface Water Sample		ATLANTIC ENVIRONMENTAL SERVICES, INC.



INSTALLATION RESTORATION STUDY
NAVAL SUBMARINE BASE - NEW LONDON
GROTON, CT

FIGURE 3-7
GEOLOGIC CROSS-SECTION A - A'
TORPEDO SHOPS

ATLANTIC ENVIRONMENTAL SERVICES, INC.

The 1967 USGS Bedrock Geology Map (Figure 3-2) shows that the Torpedo Shops are located at a contact between the biotite-quartz-feldspar gneiss of the Mamacoke Formation and gneissic biotite-granite of the Sterling Plutonic Group. Figure 3-2 shows the contact between the two in the northern portion of the site. This contact was not observed in the field, nor was any bedrock coring performed to determine the nature of the bedrock at specific boring locations.

Steep bedrock outcrops are located on the north and east borders of the site. Bedrock was encountered during the installation of 7MW1 at a depth of two feet below grade. The depth to bedrock was not confirmed at any other location at the Torpedo Shops.

Atlantic personnel measured the orientation of joints in the bedrock outcrops onsite and observed that the major joint set strikes east-southeast to west-northwest. Vertical fractures were also observed striking north-south.

The 1983 SCS Soils Map (Figure 3-1) shows Udorthents-Urban Land at the Torpedo Shops. This description is consistent with the history of quarrying and filling at the Torpedo Shops. The 1960 USGS Surficial Geology Map (Figure 3-4) shows nonstratified drift varying from sandy, gravelly till to a more compact till containing more silt and clay sized particles. Information obtained from Figure 3-4 is generally consistent with information obtained during soil sampling at the site, although it is likely that borings drilled through former septic systems record the lithology of fill material rather than native material.

The following subsurface soil descriptions were recorded during the installation of test borings and monitoring wells. In the southwestern portion of the site, the top six feet of soil consists of fine-grained sand, silt and gravel which is underlain by boulders. The boulders extend down to approximately ten feet below the surface. Below the boulders, the subsurface material consists of sand and silt with a trace of clay from ten feet to 20 feet.

The northwestern portion of the site (in the vicinity of 7MW2, 7TB1 and 7TB2) consists of fine-grained sand and silt with a trace of clay. The easternmost boring, 7TB1, contained medium- to coarse-grained sand and gravel from six feet to twelve feet. In the northwestern area, auger refusal occurred at depths of 12.7, 7.3 and 11.5 feet at 7TB1, 7TB2 AND 7MW2, respectively. Although no coring was performed at these locations, it is likely that bedrock is at or near these depths based on observation of nearby bedrock outcrops.

Two overburden ground water monitoring wells and one bedrock monitoring well were installed at this site. Ground water elevations in overburden wells were approximately three feet below grade in the northwestern portion of the site and six feet below grade in the southwestern portion of the site. Based on the limited amount of information available from the two overburden wells, the ground water flow direction appears to be toward the south/southwest. Ground water flow direction in the bedrock aquifer is presented in Section 3.7.5 with the discussion of Area A bedrock monitoring wells.

Slug displacement tests were performed in overburden well 7MW2 and bedrock well 7MW1 in the Torpedo Shops area. Well 7MW2 is screened ten feet in fine-grained sand and silt in the northwestern part of the site. The hydraulic conductivity of the fine-grained sand and silt was calculated to be 6.5 feet per day (feet/day) from slug test data. The ground water velocity was not calculated for this site due to limited information on the ground water table gradient.

Bedrock well 7MW1 is located in the eastern part of the site and has an 11 foot open interval in the bedrock. The transmissivity of the bedrock was calculated to be 7000 square feet per day, assuming a porous aquifer thickness of 150 feet. This is an average depth of typical bedrock residential wells. The transmissivity of the fracture(s)/joint(s) intersected by this well probably is greater than the calculated transmissivity.

3.7.2 Goss Cove Landfill

The subsurface at Goss Cove Landfill was characterized with seven test borings, four of which were finished as monitoring wells. The borings were drilled under or adjacent to the Nautilus Museum parking lot and were extended to auger refusal or a maximum depth of 20 feet. Geologic cross-sections were constructed from soil boring data. Cross-section locations are shown on Figure 3-8, and cross-sections are shown as Figures 3-9, and 3-10.

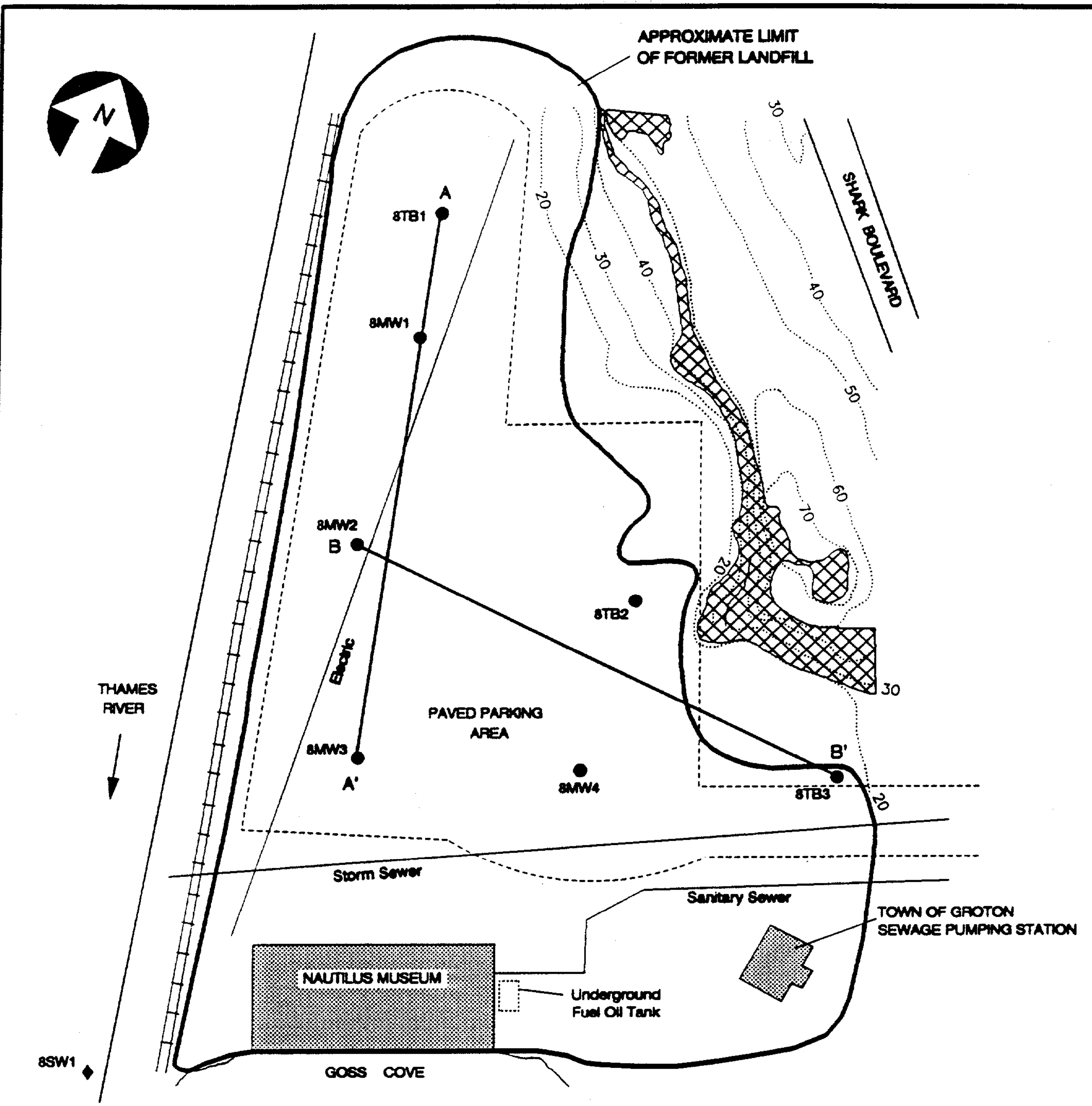
The 1967 USGS Bedrock Geology Map (Figure 3-2) shows the Goss Cove Landfill site as an open cove flanked on the west by the artificial fill of the railroad bed. Figure 3-1 shows that the southwestern portion of the site is underlain by a gneissic biotite granite known as the Granite Gneiss Member of the Sterling Plutonic Group. The bedrock in the northeastern corner of the site, which includes the bedrock outcrops present onsite, consists of a biotite-quartz-feldspar-gneiss that is a member of the Mamacoke Formation.

Bedrock was encountered in two borings (8TB2 and 8TB3) located on the east portion of the site at the foot of a bedrock cliff. In both borings, auger refusal occurred at approximately 12 feet below the surface. Because the borings are located at the base of a bedrock outcrop, bedrock is assumed to be at this elevation. Bedrock was not cored to confirm these observations. In addition to this information, depth to bedrock information is also available from borings drilled for the construction of the Nautilus Museum. Information from these previous borings also indicates that depth to bedrock is between 25 and 100 feet below grade at the site and increases from east to west.

The 1983 SCS Soils Map (Figure 3-1) shows the Goss Cove Landfill site as rock outcrop covered by Hollis soil and urban land. This description is consistent with observed conditions at the site. The 1960 USGS Surficial Geology Map (Figure 3-4) shows artificial fill at the Goss Cove Landfill site. This information is consistent with observed conditions.

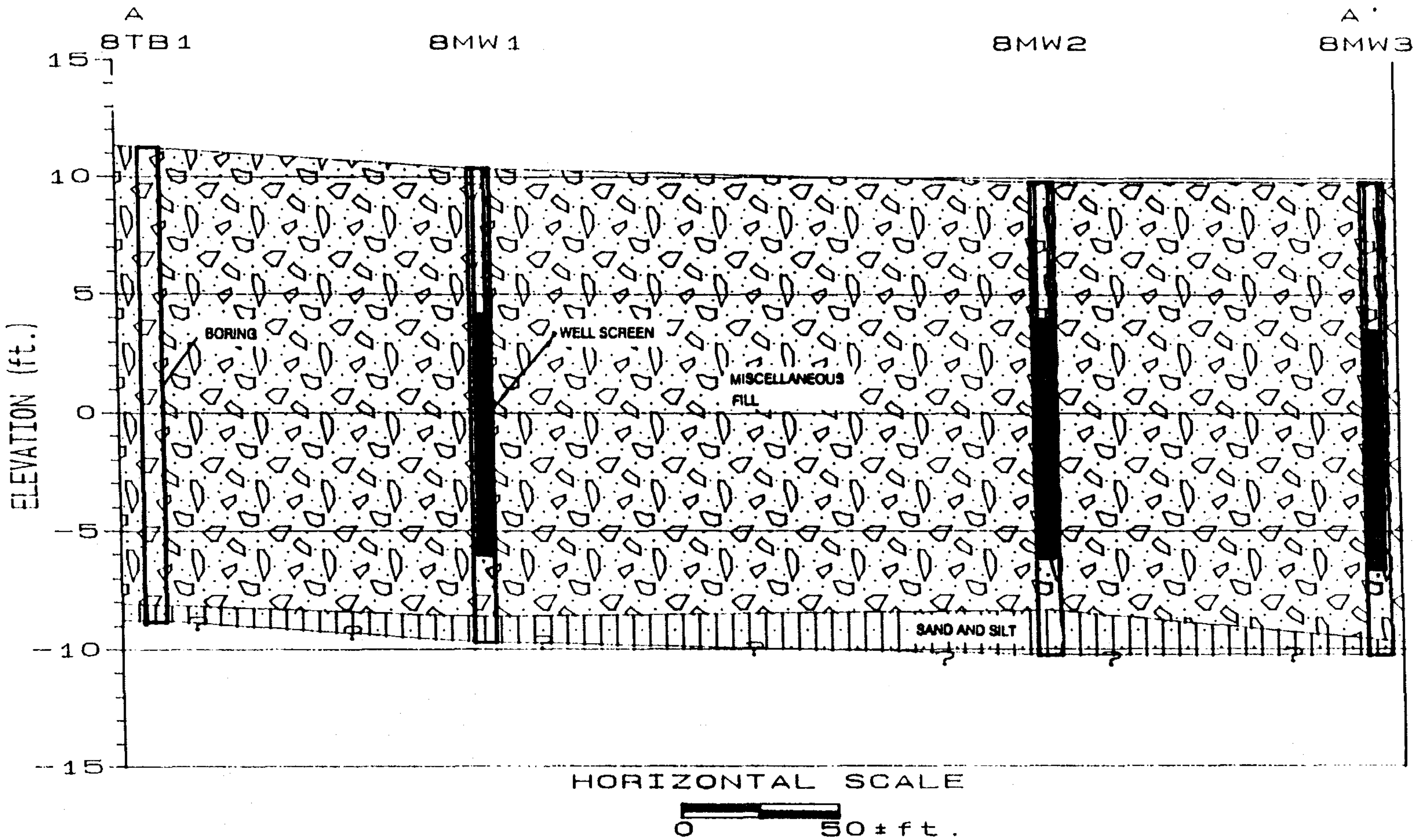
Subsurface conditions encountered during soil sampling and monitoring well installation are described as follows. The western portion of the site is underlain by ten to 20 feet of miscellaneous fill material. Fill material is generally comprised of fine- to coarse-grained sand and gravel with ash, metal fragments, glass, brick and other refuse. Below the fill material is a layer of native material consisting of fine-grained sand and silt with traces of clay, shell fragments, and organic matter. The thickness of this layer could not be determined from borings installed for this investigation. However, previous borings installed for the construction of the Nautilus Museum indicate that this layer is between ten and 15 feet thick and is underlain by a layer of fine sand that extends to bedrock.

Four overburden monitoring wells were installed at the Goss Cove Landfill. Ground water elevation is between six and eight feet below the surface. Ground water elevation measurements from these wells, collected at low tide, indicate that ground water flow direction is north -



NOTE:
1. Underground utility locations are approximate.
2. Base map and utility information from maps of NSB-NLON prepared by Loureiro Engineering Associates, Dec 1980. Elevations are based on NSB-NLON datum which is 1.41 feet below NGVD.

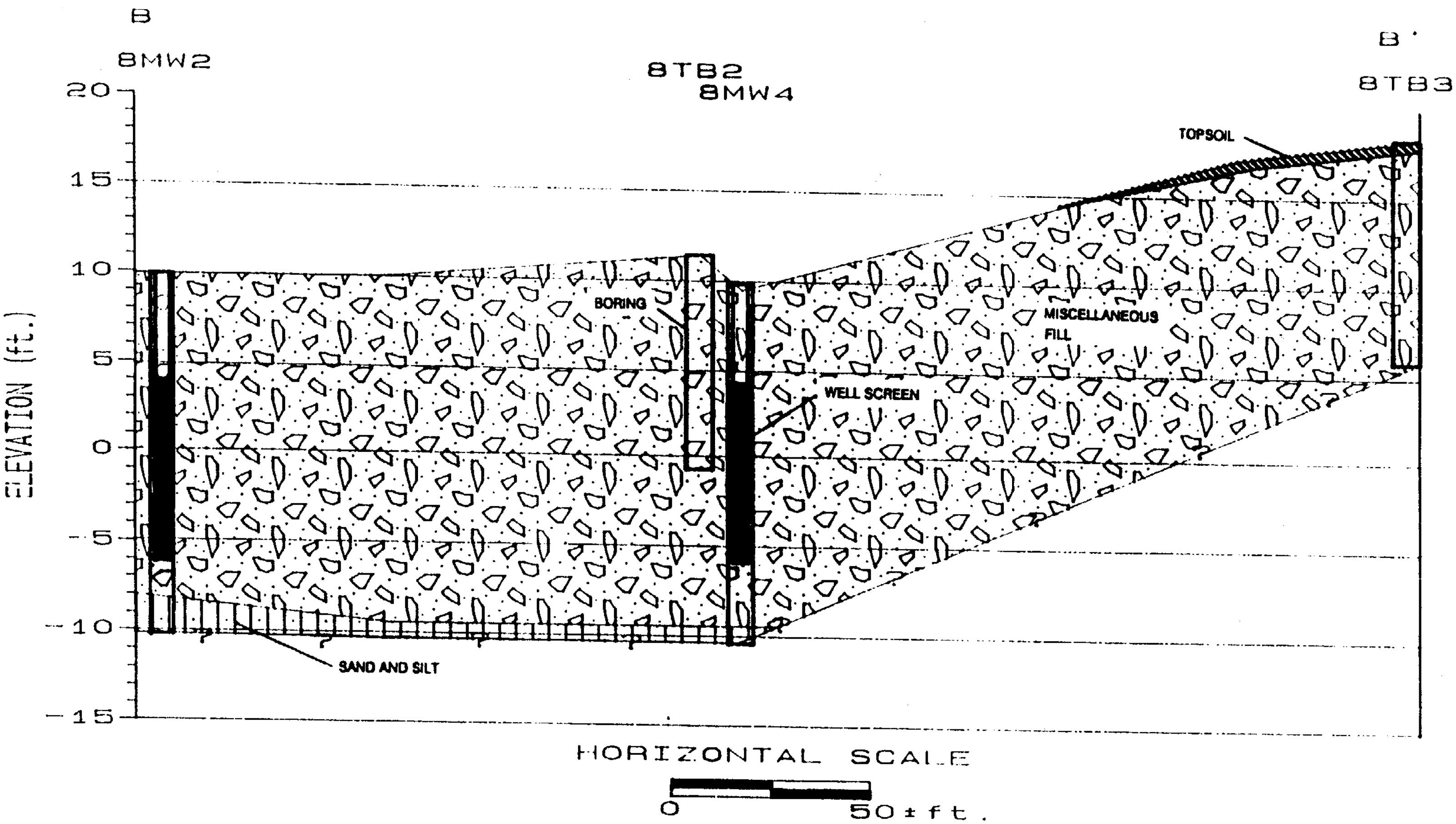
INSTALLATION RESTORATION STUDY NAVAL SUBMARINE BASE - NEW LONDON GROTON, CT	LEGEND - Exposed Bedrock ● TB1 - Test Boring ● MW1 - Monitoring Well ♦ SW1 - Surface Water Sample	·····95····· - Existing Grade - Building Approximate Scale 0 20 40'	FIGURE 3-8 GEOLOGIC CROSS-SECTION LOCATIONS GOSS COVE LANDFILL ATLANTIC ENVIRONMENTAL SERVICES, INC.



INSTALLATION RESTORATION STUDY
NAVAL SUBMARINE BASE - NEW LONDON
GROTON, CT

FIGURE 3-9
GEOLOGIC CROSS-SECTION A - A'
GOSS COVE LANDFILL

ATLANTIC ENVIRONMENTAL SERVICES, INC.



INSTALLATION RESTORATION STUDY NAVAL SUBMARINE BASE - NEW LONDON GROTON, CT		FIGURE 3-10 GEOLOGIC CROSS-SECTION B - B' GOSS COVE LANDFILL ATLANTIC ENVIRONMENTAL SERVICES, INC.

northwest. A survey of the effect of the tidal cycle on ground water elevations was performed for this investigation at the Lower Subase (see Section 3.7.7). Data from this survey indicates that tidal fluctuation will affect the ground water flow and direction at this site. Figure 3-11 shows a ground water elevation contour map of the Goss Cove Landfill at low tide. It is unclear why ground water flow is toward the northwest, rather than directly to the west toward the Thames River. It may be related to the railroad embankment which likely extends to the base of the former cove, and which may be constructed of a less permeable material than the fill material in the cove.

Slug displacement tests were performed in the four overburden wells installed in the Goss Cove Landfill. These wells are screened predominantly in fill material comprised of fine- to coarse-grained sand and gravel with ash, metal fragments, glass, brick and other refuse. Review of the slug test data indicates that the slug displacement test was an ineffective method for determining the hydraulic conductivity of the fill material due to its high permeability. The hydraulic conductivity of this material was estimated to be 280 feet per day based on published values for clean sand and gravel from Freeze and Cherry (1979). The ground water flow velocity through the fill material was estimated to be 1.7 feet per day, assuming a hydraulic conductivity of 280 feet per day, a porosity of 0.40 (Freeze and Cherry, 1979), and a hydraulic gradient of 0.002, based on Figure 3-11. The fill material was determined to have a maximum thickness of 20 feet. The thickness of unconsolidated sediments in the Goss Cove Landfill is between 25 and 100 feet. For purposes of estimating the volume of ground water discharging to the Thames River from the Goss Cove Landfill, the thickness of sediments is assumed to be 50 feet. Based on the calculated flow velocity, the length of the area perpendicular to the flow path, and an estimated thickness of 50 feet, the volume of water discharging to the Thames River is estimated to be 20,400 cubic feet per day (152,600 gpd). The majority of this discharge probably is derived from the fill material which is assumed to be more permeable than the underlying fine-grained sand and silt.

3.7.3 Spent Acid Storage and Disposal Area

The subsurface at the Spent Acid Storage and Disposal area was characterized with three soil borings. The borings were located within an area approximately 150 square feet and extended to a depth of 20 feet below the surface. A geologic cross-section was constructed from boring data. Sample and cross-section locations are shown on Figure 3-12. A geologic cross-section is provided as Figure 3-13.

The 1967 USGS Bedrock Geology Map (Figure 3-2) shows that the site is underlain by a biotite-quartz-feldspar gneiss of the Mamacoke Formation. Bedrock was not encountered during the subsurface investigation.

The 1983 SCS Soils Map (Figure 3-1) depicts the Spent Acid Storage and Disposal site as urban land. This classification is consistent with observed conditions at the site.

The 1960 USGS Surficial Geology Map (Figure 3-4) shows that this site is located in terrace deposits of the Thames River, which consist of stratified silt, sand and gravel that was deposited by glacial meltwater. Subsurface soil conditions observed during soil sampling are consistent with this description.

Subsurface material at this site consists of fine- to medium-grained sands and silt with traces of clay. Where clay is present, it usually occurs in discreet, silty lenses of less than a half-inch in

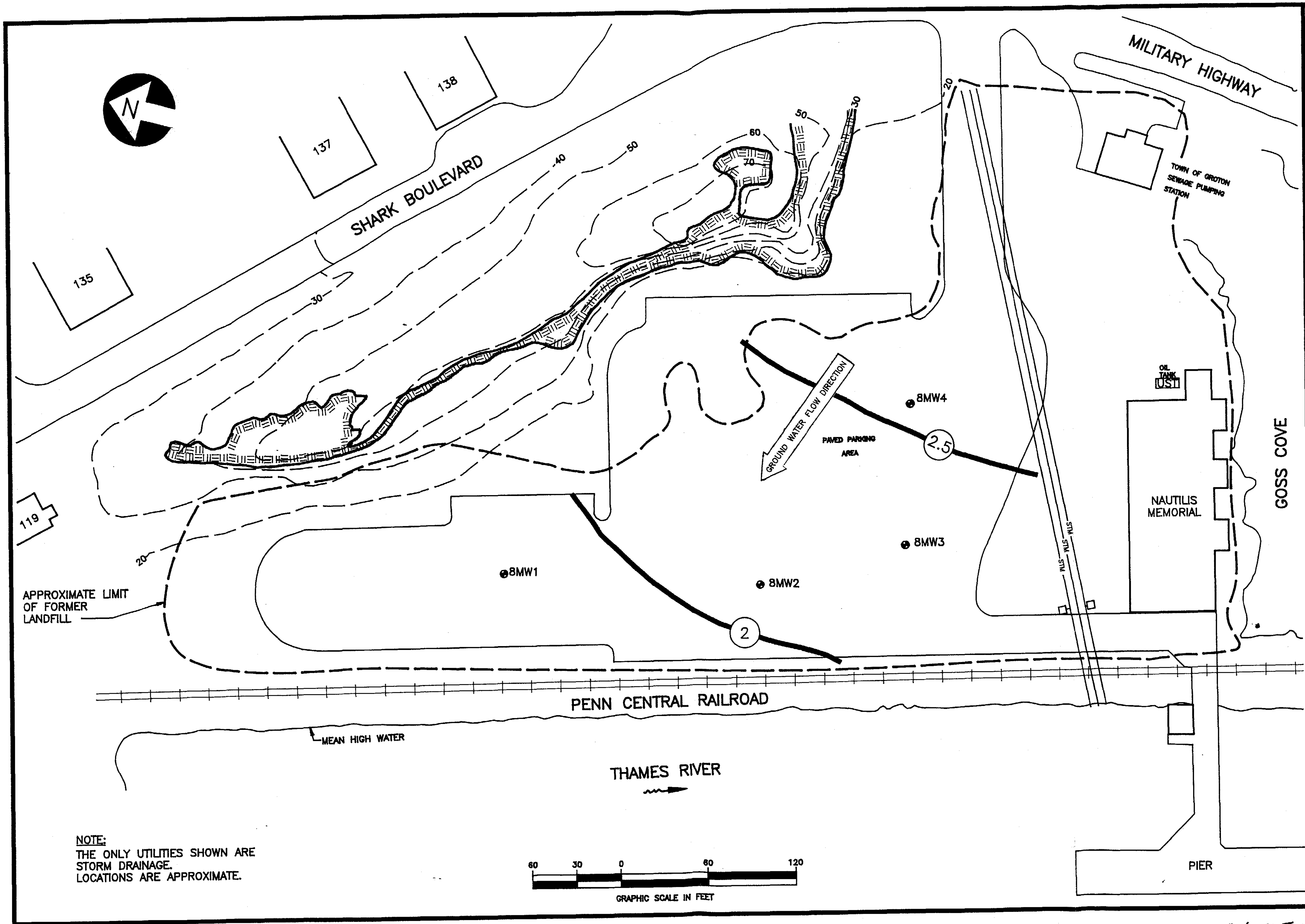
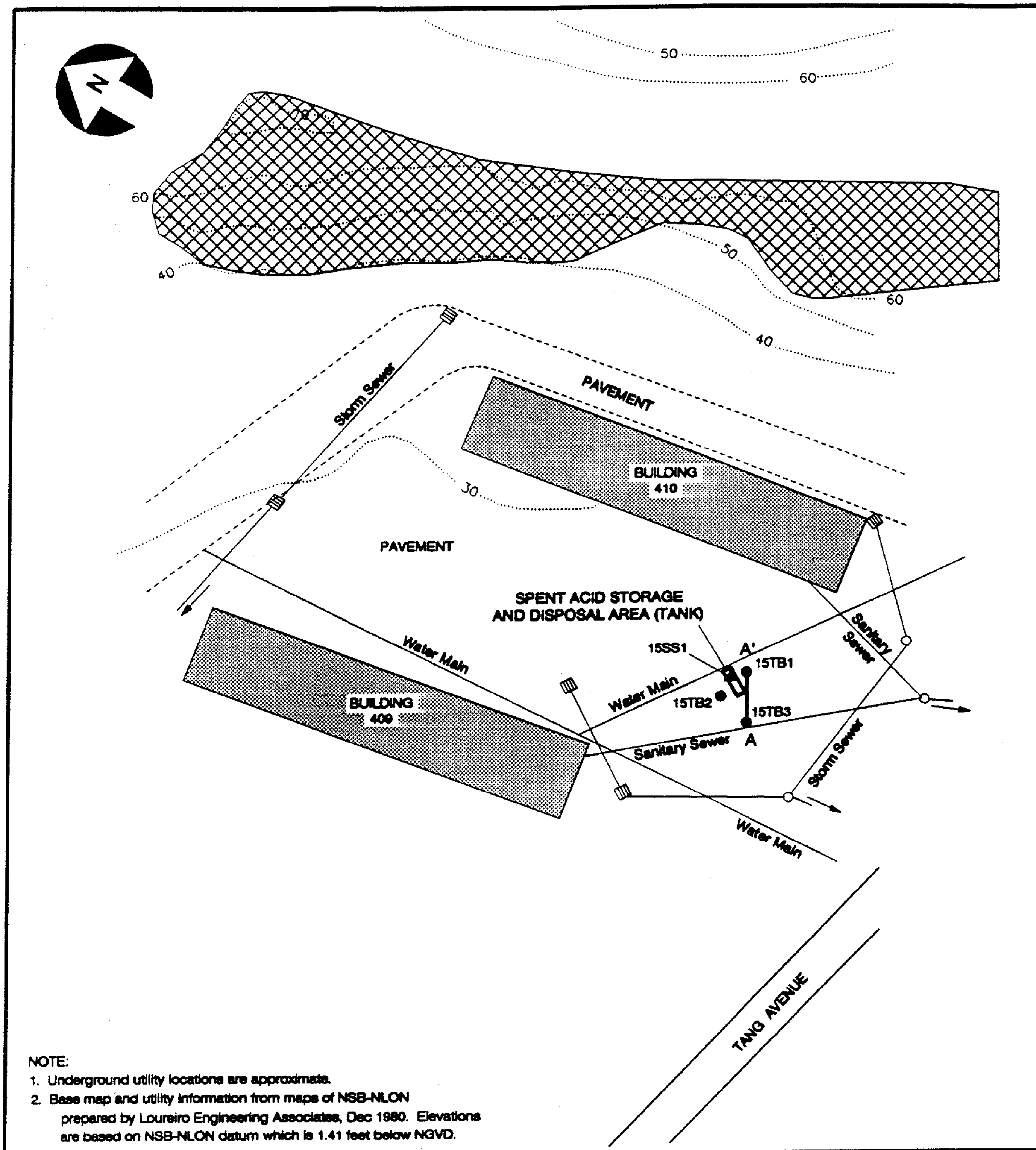


FIGURE 3-11
GROUND WATER CONTOUR MAP
GOSS COVE LANDFILL

ATLANTIC ENVIRONMENTAL SERVICES, INC.

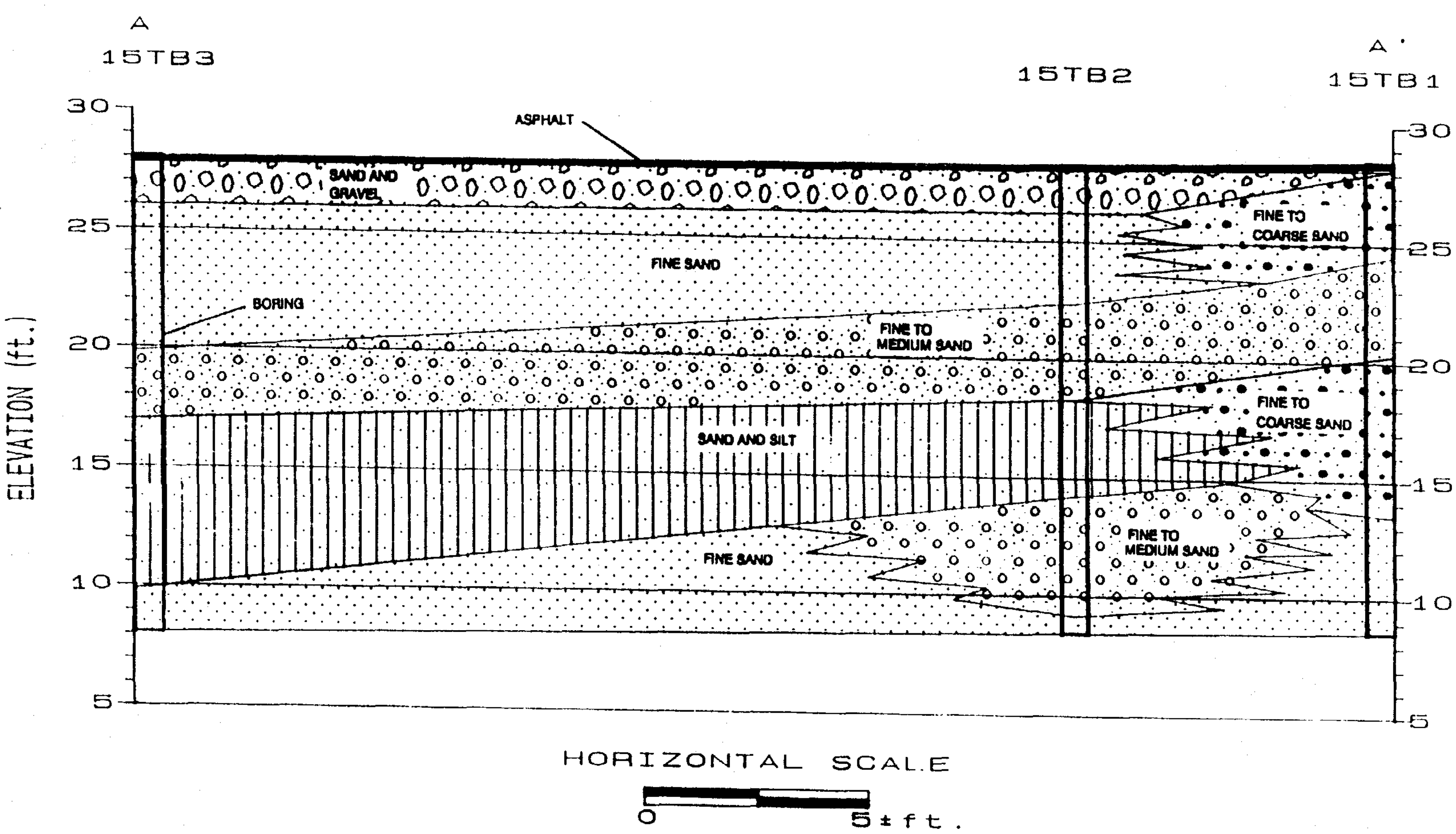
INSTALLATION RESTORATION STUDY
NAVAL SUBMARINE BASE-NEW LONDON
GROTON, CONN.

06751301Z



NOTE:
1. Underground utility locations are approximate.
2. Base map and utility information from maps of NSB-NLON prepared by Loureiro Engineering Associates, Dec 1980. Elevations are based on NSB-NLON datum which is 1.41 feet below NGVD.

INSTALLATION RESTORATION STUDY NAVAL SUBMARINE BASE - NEW LONDON GROTON, CT	LEGEND - Exposed Bedrock - Catch Basin - Manhole TB1 - Test Boring SS1 - Surface Soil Sample ·····95······ - Existing Grade - Building Approximate Scale 0 20 40'	FIGURE 3-12 GEOLOGIC CROSS-SECTION LOCATION SPENT ACID STORAGE AND DISPOSAL AREA ATLANTIC ENVIRONMENTAL SERVICES, INC.



INSTALLATION RESTORATION STUDY NAVAL SUBMARINE BASE - NEW LONDON GROTON, CT	LEGEND	FIGURE 3-13 GEOLOGIC CROSS-SECTION A - A' SPENT ACID ATLANTIC ENVIRONMENTAL SERVICES, INC.

thickness. Rust colored staining and mottling were common in borings 15TB1 and 15TB3 located on the east and south side of the spent acid tank, respectively.

No ground water monitoring was performed at this site. Ground water was encountered at six to eight feet below the surface during the drilling of test borings. Ground water flow is projected to be generally to the west/southwest.

3.7.4 Former Gasoline Station

Five subsurface soil borings were drilled at the Former Gasoline Station to characterize subsurface conditions. The borings were extended 20 feet below grade. Neither bedrock nor ground water was encountered in any of the borings. A geologic cross-section of subsurface material was constructed from boring data. The cross-section location is shown on Figure 3-14. Cross-section A-A' is provided as Figure 3-15.

The 1967 USGS Bedrock Geology Map (Figure 3-2) shows that the site is underlain by a biotite-quartz-feldspar gneiss of the Mamacoke Formation. Bedrock was not encountered during the subsurface investigation.

The 1983 SCS Soils Map (Figure 3-1) depicts the Former Gasoline Station as urban land. This classification is consistent with observed site conditions.

The USGS Surficial Geology Map (Figure 3-4) shows that the site is located in terrace deposits of the Thames River.

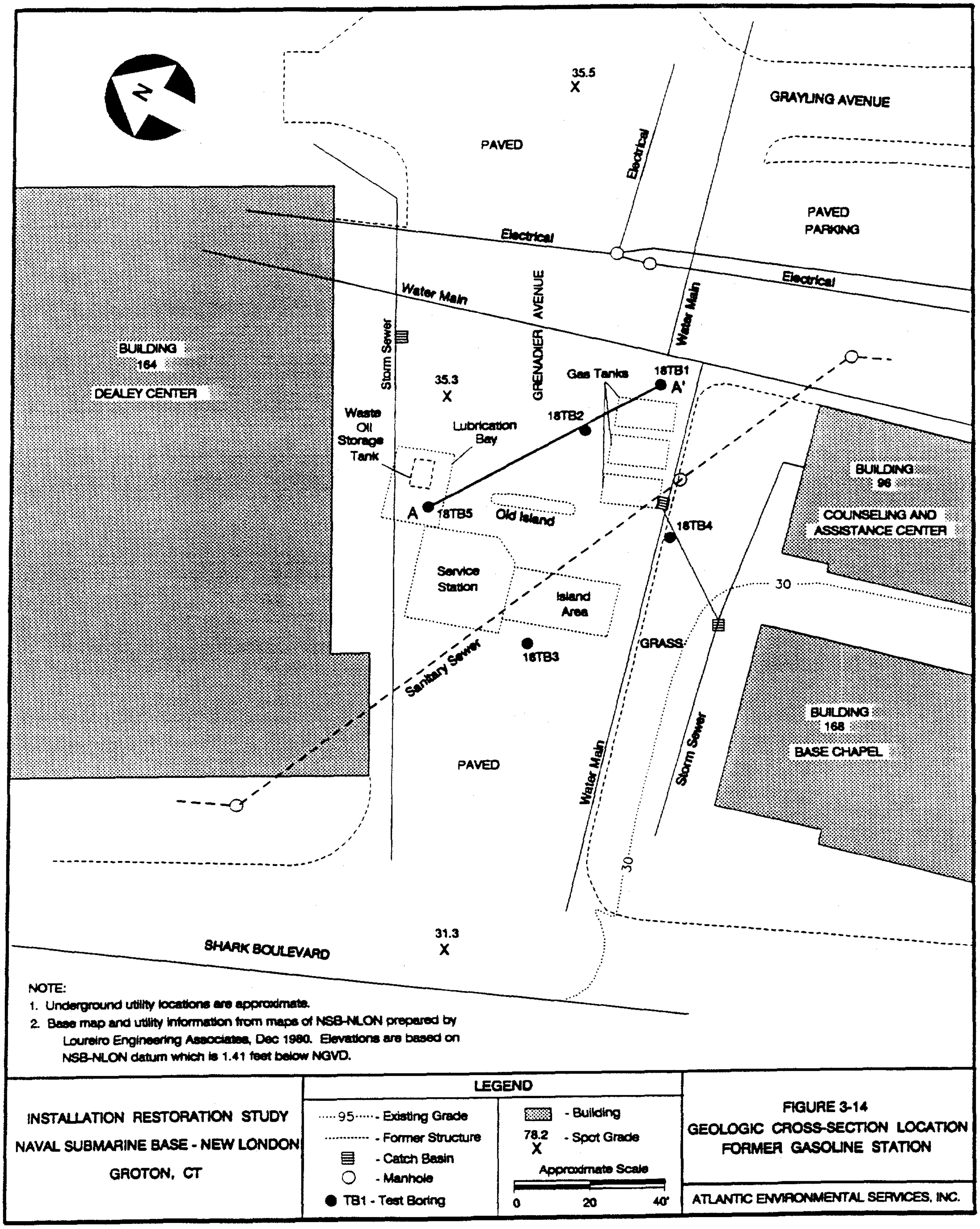
Subsurface material encountered during soil sampling consists of fine- to medium-grained sand with some gravel. The sands are generally loosely compacted in the first five feet and more dense below.

No ground water monitoring was performed at this site, however, based on topography, ground water likely flows west to the Thames River.

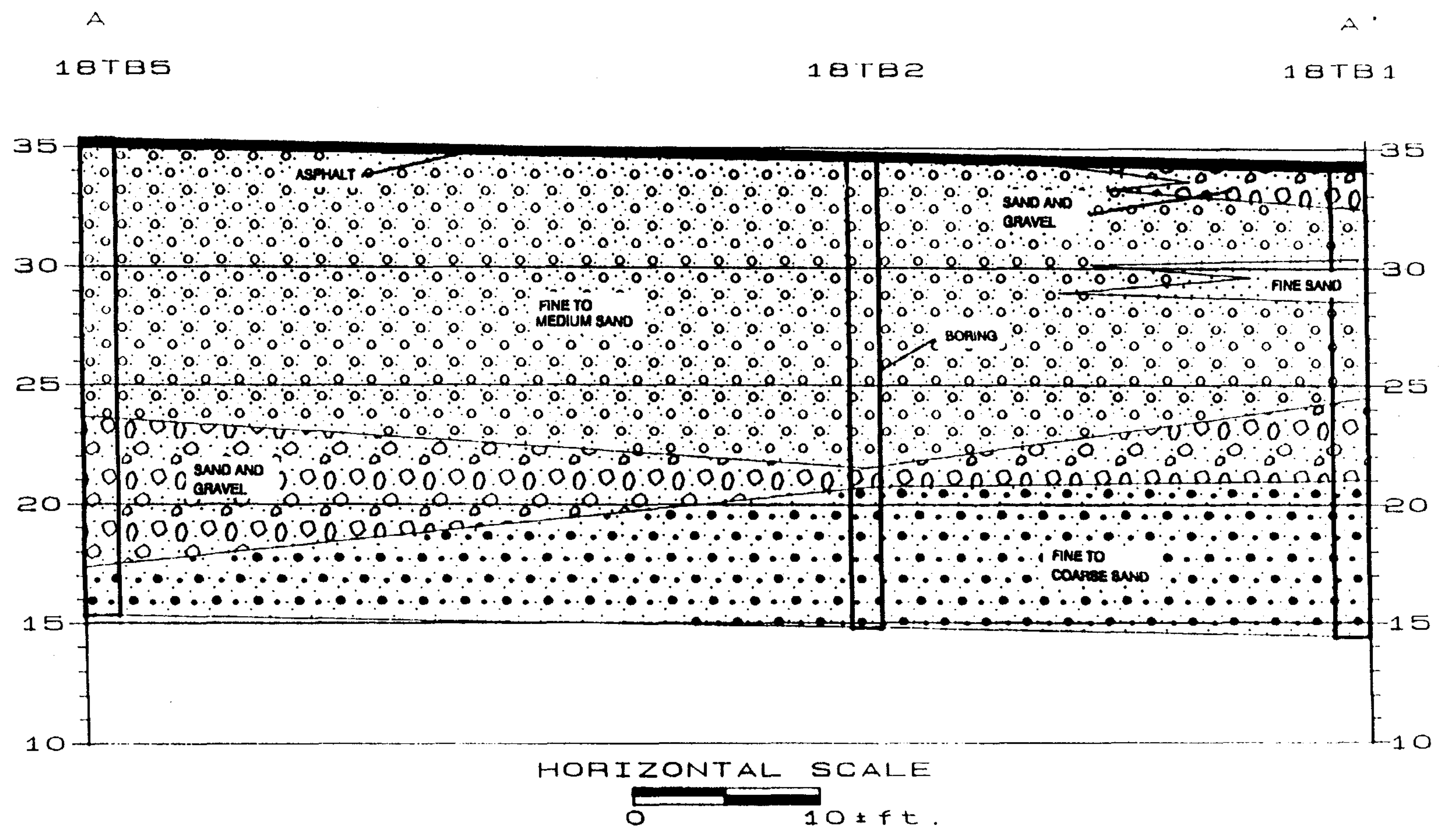
3.7.5 Area A and OBDA

The Area A Landfill, Wetland and Downstream and the Over Bank Disposal Area were characterized with a total of 49 soil borings which included 20 test borings, 12 overburden monitoring wells and 17 bedrock monitoring wells. Test borings were generally extended to auger refusal (except those in the landfill which were installed for field soil screening only, 2LTB1-2LTB7). Borings for overburden monitoring wells were extended to bedrock or auger refusal, and borings for bedrock monitoring wells were extended through the overburden and into bedrock until sufficient water was encountered. Soils were not sampled in the latter, but information on the elevation of the bedrock surface was obtained from them. Several generalized geologic cross-sections were prepared from boring data; Plate 3-1 depicts the locations of cross-sections referred to in the text, as well as locations of all monitoring wells and test borings.

The 1967 USGS Bedrock Geology Map (Figure 3-2) indicates that the bedrock underlying the majority of Area A is biotite-quartz-feldspar gneiss of the Mamacoke Formation. Figure 3-2 shows that all of the Area A Landfill and the Overbank Disposal Area, the southern portion of the



35.5
X
GRAYLING AVENUE
PAVED
Electrical
PAVED
PARKING
Electrical
Electrical
Water Main
GRENADIER AVENUE
Water Main
Storm Sewer
BUILDING
164
DEALEY CENTER
35.3
X
Gas Tanks
18TB1
A'
18TB2
Waste
Oil
Storage
Tank
Lubrication
Bay
A
18TB5
Old Island
18TB4
BUILDING
96
COUNSELING AND
ASSISTANCE CENTER
Service
Station
Island
Area
30
GRASS
18TB3
Sanitary Sewer
BUILDING
168
BASE CHAPEL
Storm Sewer
PAVED
Water Main
30
31.3
X
SHARK BOULEVARD
NOTE:
1. Underground utility locations are approximate.
2. Base map and utility information from maps of NSB-NLON prepared by Loureiro Engineering Associates, Dec 1980. Elevations are based on NSB-NLON datum which is 1.41 feet below NGVD.
INSTALLATION RESTORATION STUDY
NAVAL SUBMARINE BASE - NEW LONDON
GROTON, CT
LEGEND
·····95······ - Existing Grade
············ - Former Structure
- Catch Basin
- Manhole
TB1 - Test Boring
- Building
78.2 X - Spot Grade
Approximate Scale
0
20
40'
FIGURE 3-14
GEOLOGIC CROSS-SECTION LOCATION
FORMER GASOLINE STATION
ATLANTIC ENVIRONMENTAL SERVICES, INC.



INSTALLATION RESTORATION STUDY NAVAL SUBMARINE BASE - NEW LONDON GROTON, CT		FIGURE 3-15 GEOLOGIC CROSS-SECTION A - A' FORMER GASOLINE STATION ATLANTIC ENVIRONMENTAL SERVICES, INC.

Area A Wetland, and the northern and eastern portions of the Area A Downstream Watercourses is underlain by bedrock of the Mamacoke Formation. The northernmost portion of the wetland is underlain by a gneissic biotite granite that is mapped as the Granite Gneiss Member of the Sterling Plutonic Group. The southwestern portion of the Area A Downstream Watercourses is mapped as an equigranular gneissic granite known as the Alaskite Gneiss Member of the Sterling Plutonic Group.

Bedrock cores were drilled and collected at four monitoring well locations in Area A shown on Figure 3-16. Bedrock was cored until the rock quality designation (RQD) was greater than 75 percent or a minimum of 20 feet. In all cores, an RQD of 75 percent or greater was reached within 25 feet of the bedrock surface.

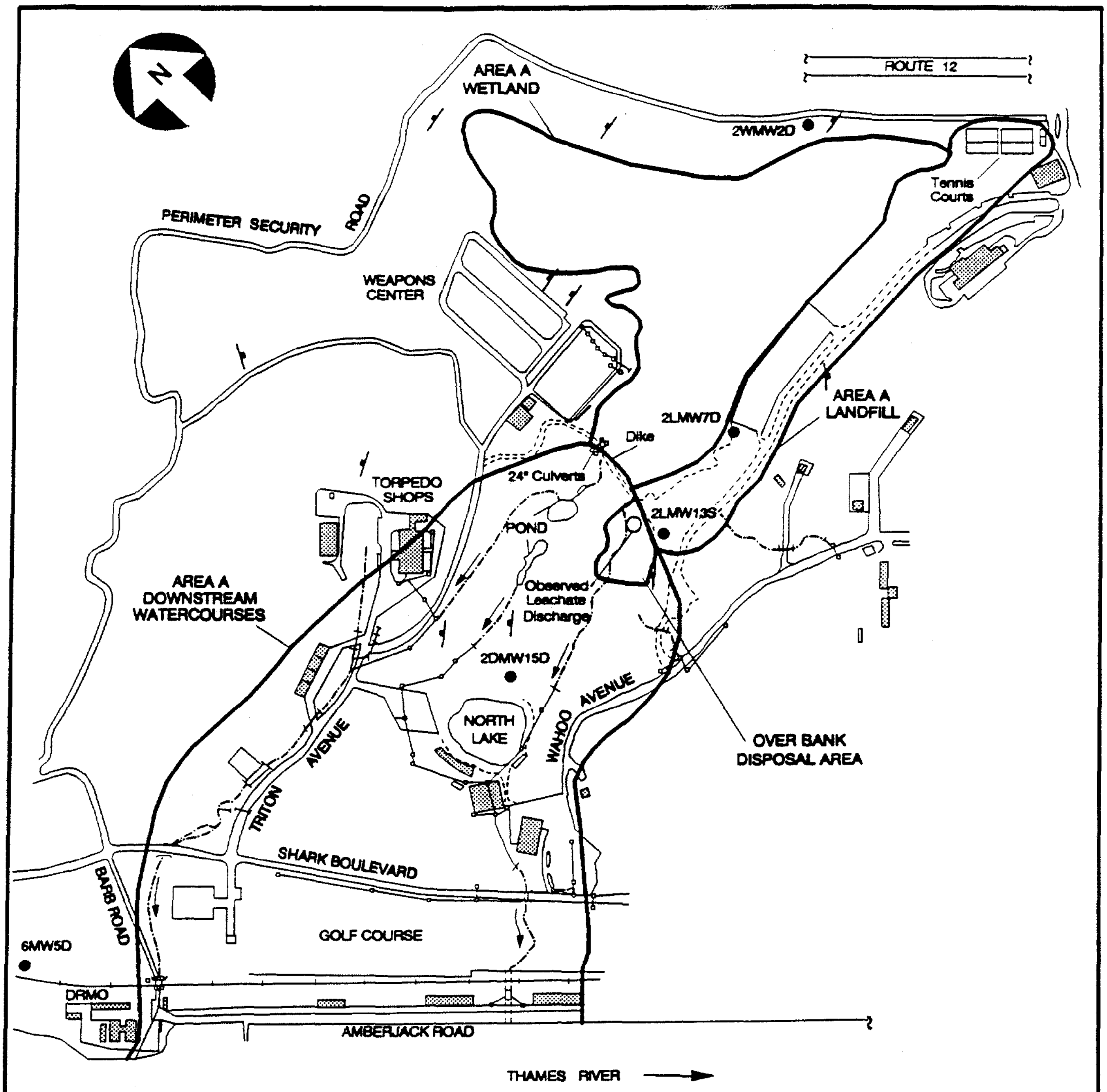
The bedrock at all four coring locations is mapped as the Mamacoke Formation. The mineralogy and texture of the bedrock cores is generally consistent with that of the biotite-quartz-feldspar gneiss of the Mamacoke Formation.

In addition to logging the mineralogy and texture of bedrock cores, Atlantic personnel noted such features as the degree of fracturing, weathering on fracture surfaces, and whether the fractures were dominantly horizontal or vertical. This information was used to determine hydrogeologic characteristics of the bedrock aquifer. In general, fracture orientations in the bedrock cores parallel compositional banding in the gneiss. Biotite-rich bands with parallel alignment of micas tend to be both highly fractured and highly weathered; the fractures are parallel to banding and are oriented 45-60° from horizontal. More massive, quartz- and feldspar-rich bands tend to be less fractured, and fractures are generally horizontal.

In the bedrock cores logged for this investigation, orientation of fractures ranges from predominantly horizontal (2WMW2D), to 45° from horizontal (2DMW15D), to combinations and gradations of the two. The core from 2LMW7D shows primarily horizontal fractures with little weathering, but includes a two foot thick zone of highly weathered, fractured biotite-rich rock with fractures that are inclined approximately 60° from the horizontal. The core from 2LMW13D graded from horizontal, somewhat weathered fractures in the first ten feet to highly weathered fractures oriented 45° from horizontal in the last ten feet.

Subsurface bedrock elevation data was obtained for seventeen points in Area A. From this data it appears that the bedrock surface is at its highest elevation at the northeast corner of Area A in the vicinity of well 2WMW1D. The lowest bedrock elevations were measured at 2WMW3D (near the tennis courts) and 2DMW16D (near North Lake). The bedrock surface elevation is greater in the Area A landfill than in the surrounding Wetland or Downstream. Between the landfill and the northeast corner of the wetland is a bedrock valley. This valley dips to the southeast (toward 2WMW3D) on the south side of the dike and dips to the northwest (toward 2DMW16D) on the north side of the dike.

To better predict ground water flow in the bedrock aquifer, Atlantic personnel examined bedrock outcrops in the northern portion of NSB-NLON and measured the orientations of prominent joints and fractures. Figure 3-16 shows the orientation of joint sets. The most prominent joints are those that strike east-southeast to west-northwest and dip to the north. Vertical fractures that were measured strike generally north-south. Most of the measurements were taken from bedrock outcrops that are mapped as Mamacoke Formation.



NOTE:

1. Underground utility locations are approximate.
2. Base map and utility information from maps of NSB-NLON prepared by Loureiro Engineering Associates, Dec 1980. Elevations are based on NSB-NLON datum which is 1.41 feet below NGVD.

INSTALLATION RESTORATION STUDY
NAVAL SUBMARINE BASE - NEW LONDON
GROTON, CT

LEGEND

- Storm Culvert
- Strike and dip direction of joints Field Observation by Atlantic
- Coring Location
- Building
- Watercourse

Approximate Scale
0 200 400'

FIGURE 3-16
BEDROCK STRUCTURES
AND CORING LOCATIONS

ATLANTIC ENVIRONMENTAL SERVICES, INC.

Area A Wetland: The 1983 SCS Soils Map (Figure 3-1) depicts the Area A Wetland as Udorthents-Urban Land. This classification is consistent with conditions observed during the field investigation.

The 1960 USGS Surficial Geology Map (Figure 3-4) shows the Area A Wetland as a swamp overlying non-stratified drift (till) and alluvium (western portion of the present wetland). This classification generally agrees with observed conditions onsite and historical information about the site, however, the presence of alluvium and nonstratified drift below the artificial fill in the wetland was not completely documented as part of the soils investigation. The omission of artificial fill in the wetland portion of the map is likely a result of the fact that the area was mapped prior to or during the time the dredge and fill operation was in progress.

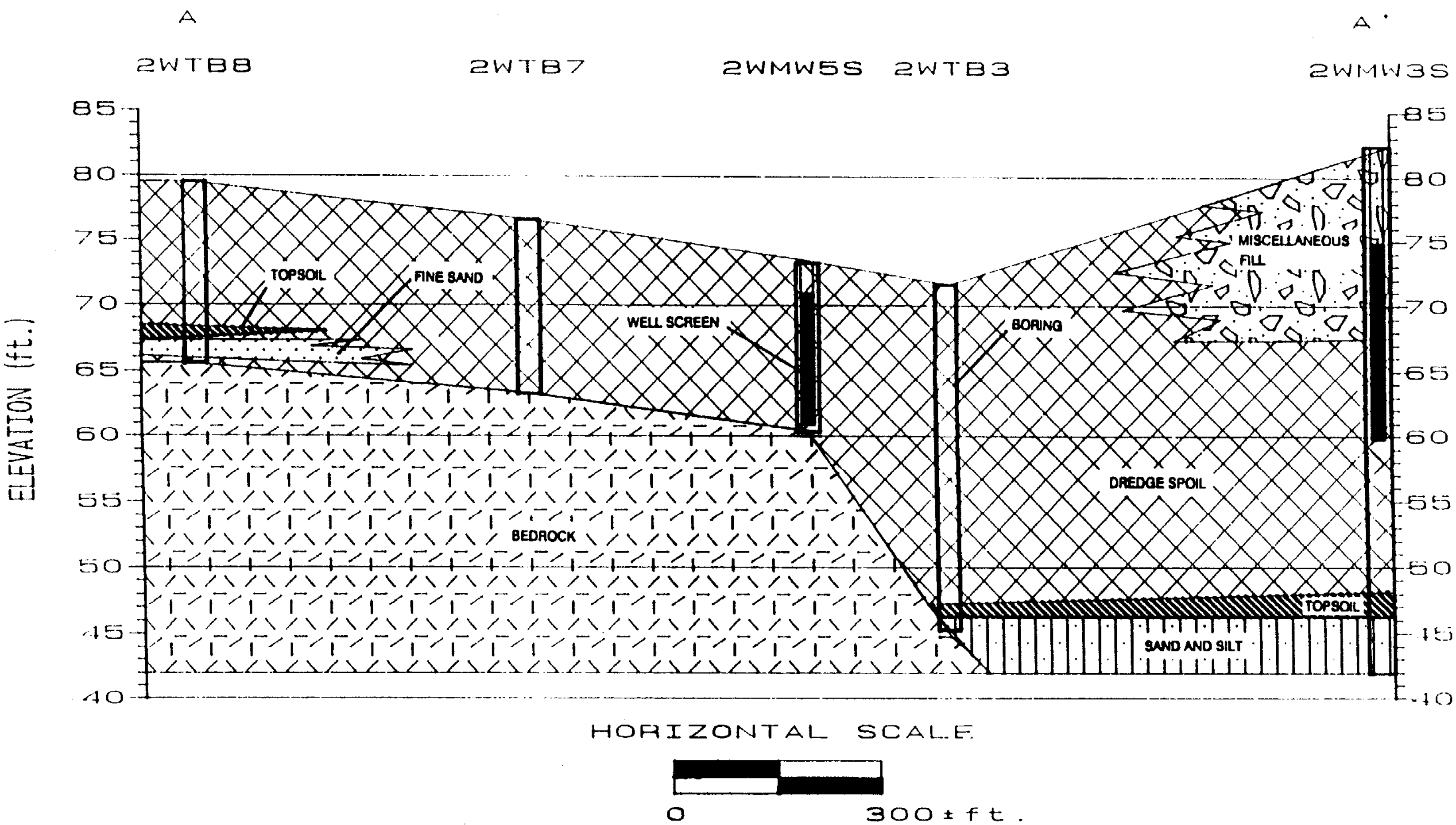
Soil sampling indicates that the surface of the Area A Wetland is covered with a two-foot layer of roots and plant fragments derived from *phragmites* plants that grow in the wetland. The Area A Wetland is underlain by dredge spoil which consists of silt and clay with traces of fine sand and shell fragments. The lateral extent of dredge spoil includes the present wetland and extends south to 2WMW3 (near the tennis courts), and southwest beneath the Area A Landfill, as observed in subsurface soils collected at locations 2LMW18, 17, 8, 7, and 9. Dredge spoil is between 25 and 35 feet thick on the south side of the wetland adjacent to the landfill and ten to 15 feet thick on the northeast side of the wetland. Where dredge spoil does not lie directly on bedrock it is underlain by a thin remnant of topsoil consisting of dark, organic-rich silt and clay with traces of fine sand and roots. Topsoil is underlain by sands and gravel. Geologic cross-section A-A' (Figure 3-17) extends from north to south across the length of the wetland. Geologic cross-section B-B' (Figure 3-18) shows subsurface conditions from the northwest portion of the Area A Landfill to the east side of the wetland.

Area A Landfill: The 1983 SCS Soils Map (Figure 3-1) shows the majority of the Area A Landfill as Udorthents-Urban Land. The southwestern slope of the Landfill (which also includes the CBU Drum Storage Area and the Rubble Fill at Bunker A-86) is classified as Hollis-Charlton Rock, 15-45% slopes. Both classifications are generally consistent with the soils and topography observed at the Area A Landfill.

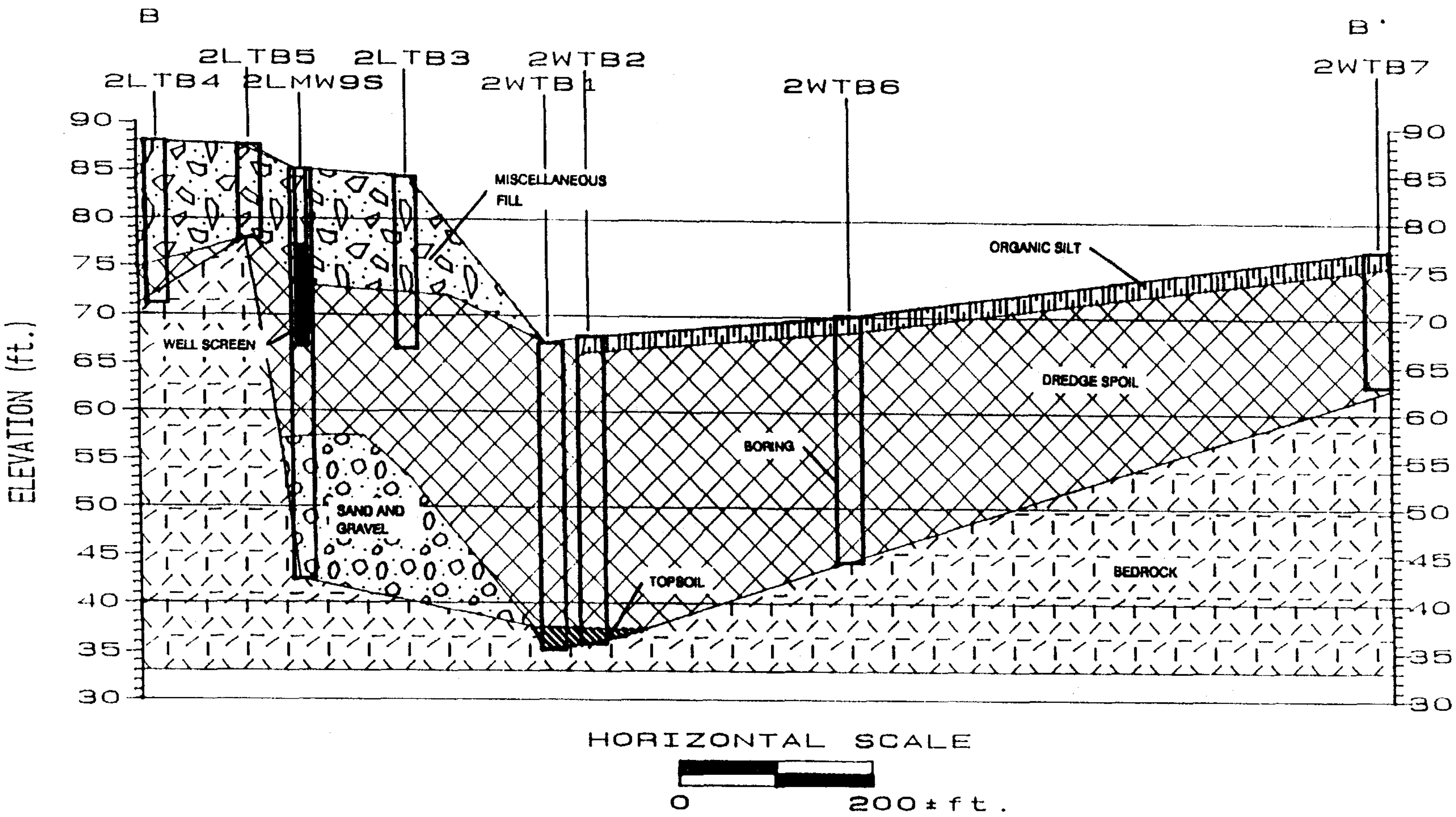
The 1960 USGS Surficial Geology Map (Figure 3-4) shows nonstratified drift in the Area A Landfill. This classification is consistent with soils observed below fill material and dredge spoil in the eastern portion of the landfill and soils at the surface in the western portion of the landfill, the CBU Drum Storage Area and the Rubble Fill at Bunker A-86.

The Area A Landfill is underlain by 10 to 20 feet of miscellaneous fill material which is comprised of fine- to coarse-grained sand and gravel and refuse including ash, wood fragments, paper, brick fragments, and asphalt. The fill is generally underlain by ten to 20 feet of dredge spoil. On the southwestern side, fill material is underlain by compact sand, silt and gravel which extends down to bedrock. Geologic cross-section C-C' (Figure 3-19) shows the subsurface conditions along the east - west axis of the landfill.

Downstream Water Courses/OBDA: The 1983 SCS Soils Map (Figure 3-1) shows the Area A Downstream Watercourses as Udorthents-Urban Land to the north and west of North Lake. The portion of the Downstream Watercourses between the earthen dike and North Lake is depicted as Charlton-Hollis, 3-15% slopes. Both classifications are consistent with observed soil



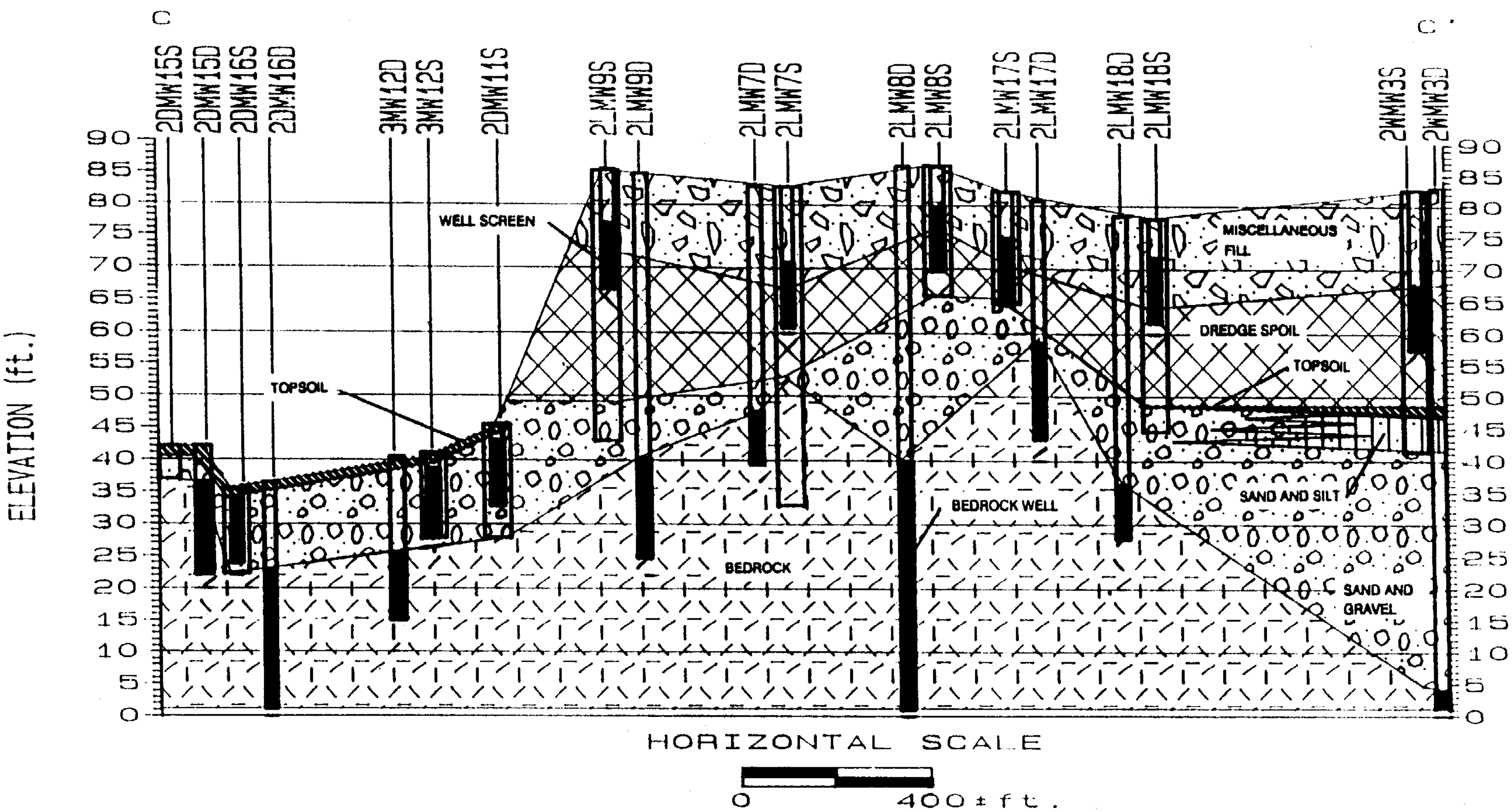
INSTALLATION RESTORATION STUDY NAVAL SUBMARINE BASE - NEW LONDON GROTON, CT		FIGURE 3-17 GEOLOGIC CROSS-SECTION A - A' AREA A ATLANTIC ENVIRONMENTAL SERVICES, INC.



INSTALLATION RESTORATION STUDY
NAVAL SUBMARINE BASE - NEW LONDON
GROTON, CT

FIGURE 3-18
GEOLOGIC CROSS-SECTION B - B'
AREA A

ATLANTIC ENVIRONMENTAL SERVICES, INC.



INSTALLATION RESTORATION STUDY NAVAL SUBMARINE BASE - NEW LONDON GROTON, CT		FIGURE 3-19 GEOLOGIC CROSS-SECTION C - C' AREA A ATLANTIC ENVIRONMENTAL SERVICES, INC.

conditions, topography and development in this area. The Over Bank Disposal Area is also shown as Hollis-Charlton Rock, 15-45% slopes. This classification is consistent with observed site soil conditions and topography.

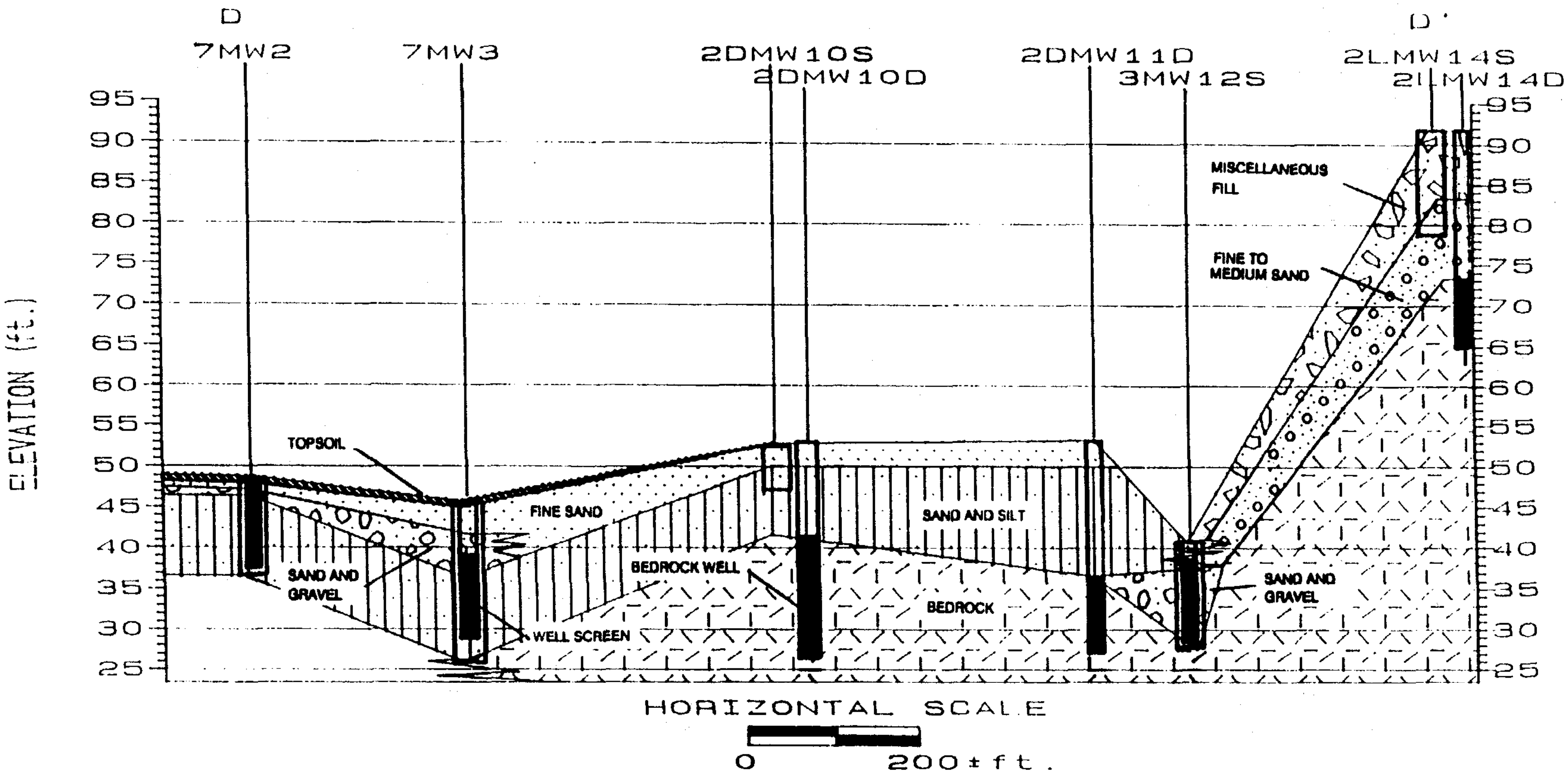
The 1960 USGS Surficial Geology Map (Figure 3-4) shows alluvium along the downstream watercourses from (and including) the Over Bank Disposal Area to North Lake. Figure 3-4 shows artificial fill in the Area A Downstream at the present location of Triton Road, and Thames River terrace deposits from North Lake west to the Thames River. All classifications are generally consistent with observed soil conditions in the specified areas.

The Area A Downstream and Over Bank Disposal Area (OBDA) are physically separated from the Area A Wetland by an earthen dike and from the Area A Landfill by a steep slope. Cross-section C-C' (Figure 3-19) shows the relative elevations of the Landfill, Downstream and OBDA. The subsurface is also distinct in that no evidence of fill material was observed in the Downstream or OBDA. Unconsolidated material at the bottom of the slope (2DMW11) consists of fine-grained sand and silt with rust-colored mottling. Similar soils were observed at 2DMW10 and in borings at the Torpedo Shops to the north, as illustrated in geologic fence diagram D-D' (Figure 3-20). The sediments at 3MW12 consist of yellow and brown, mottled, fine-grained sand, silt and clay overlying fine- to medium-grained sand and gravel. Based on the sediments found in this area and the mapped surficial deposits in the vicinity, it is likely that these are alluvial deposits from either the present stream system or one that was in place before the earthen dike was constructed.

Twelve overburden monitoring wells and 17 bedrock monitoring wells were installed in the Area A Landfill, Wetland, and Downstream and the Over Bank Disposal Area. A ground water elevation contour map for the overburden aquifer at Area A is shown as Plate 3-2. As this map shows, the highest ground water elevation was measured in the middle of the Area A Landfill at 2LMW8S. It appears that ground water in the central/eastern portion of Area A flows north toward the Area A Wetland and ground water in the northwestern portion of the Area A Landfill flows northwest toward the Area A Downstream and eventually to the Thames River.

Slug displacement test data from six overburden wells were analyzed in order to estimate the *in situ* hydraulic conductivity of the overburden materials throughout Area A. The majority of the wells were screened ten feet into various depths of fill material and dredge spoil (see boring logs for wells 2WMW3S, 2LMW7S, 2LMW8S, AND 3MW12S). Well 2WMW5S is screened only in the dredge spoil. Well 2DMW16S is screened four feet in coarse sand and gravel, two feet in very fine sand and silt, and four feet in medium sand and gravel. The geometric mean hydraulic conductivity of the fill material and the dredge spoil combined was calculated to be 3 feet/day. The hydraulic conductivity of the dredge spoil was calculated to be 1.1 feet/day. The hydraulic conductivity of the material surrounding well 2DMW16S (Downstream Area) was calculated to be 4 feet/day.

The velocity of ground water flow through sediments in the landfill and wetland portions of Area A was estimated to be 0.04 feet/day, using a hydraulic conductivity of 3 feet/day, a porosity of 0.30 (Freeze and Cherry, 1979) and a hydraulic gradient of approximately 0.004 from Plate 3-2. The ground water flow velocity through the soils in the Area A downstream, using a hydraulic conductivity of 4 feet/day, 0.30 for the porosity, and 0.01 for the hydraulic gradient (from Plate 3-2), was calculated to be 0.13 feet/day.



INSTALLATION RESTORATION STUDY NAVAL SUBMARINE BASE - NEW LONDON GROTON, CT	LEGEND	FIGURE 3-20 GEOLOGIC FENCE DIAGRAM D - D' AREA A ATLANTIC ENVIRONMENTAL SERVICES, INC.

To characterize the bedrock aquifer in the study area, 17 monitoring wells were installed in Area A, one well was installed at the Torpedo Shops and one was installed upgradient at the DRMO. To further characterize ground water flow in the bedrock aquifer at the boundaries of the site, ground water elevations were measured in five offsite wells located to the north, east and southeast of Area A. The procedure for calculating water level elevations in offsite wells is as follows: the ground surface elevation estimate for each offsite well was obtained from either Town of Ledyard topographic maps (contour interval, ten feet) or NSB-NLON maps (contour interval, two feet). When the former were used, elevations were corrected to NSB-NLON datum. Using an electronic water level indicator, Atlantic personnel measured depth to water from the top of the well casing. When possible, the wells were pumped for twenty minutes and the water levels measured again. The lowest water level elevations were used when comparing water levels offsite to those onsite and when constructing ground water elevation contour maps. Well data and elevation estimates are listed in Table 3-1. The accuracy of well water elevations derived from Town of Ledyard maps is estimated to be ±5 feet. The accuracy of elevation from NSB-NLON maps is estimated to be ±1 foot.

Onsite and offsite data was compiled to make a ground water elevation contour map for the bedrock aquifer which is presented as Plate 3-3.

TABLE 3-1
SUMMARY OF OFFSITE RESIDENTIAL WELL ELEVATION DATA

WELL NUMBER	ADDRESS	GROUND ELEVATION (SOURCE)	APPROXIMATE WATER ELEVATION (feet)
OSW-8	1292 Route 12	82 (NSB-NLON)	74.8*
O8W-12*	1444 Route 12	138 (Ledyard)	123.4
OSW-24	1298 N. Pleasant Valley Road	171 (Ledyard)	161.5
OSW-28	1469 Route 12	119.6 (NSB-NLON)	98.7
OSW-29*	1323 Route 12	115 (NSB-NLON)	80.1*

* indicates static water level, no pumping conducted

Of importance to this investigation is the direction of bedrock ground water flow in this area, due to the detection of cadmium in several offsite residential wells to the east of Route 12. Inspection of the bedrock ground water contour map indicates that the residential wells along Route 12, Baldwin Hill Road and North Pleasant Valley Road are upgradient of Area A, and would not be affected by conditions at the site. Most of these wells had bedrock ground water elevations substantially higher than wells containing cadmium in Area A (2WMW3D, elevation 76 feet). However, residential wells near the NSB-NLON east gate, southeast of Area A, had bedrock water elevations (75-80') in the same range as 2WMW3D, the closest bedrock well in Area A. Therefore, based on the available data, it is indeterminate if these wells are upgradient or downgradient of the western portion of the Area A Landfill. This issue is further discussed in Section 4.0 and Section 8.0.

Vertical hydraulic head gradients were assessed at paired wells within the Area A Landfill. The data generated indicates that there is an upward flow component, which is expected due to the landfill's location adjacent to the wetland. The exception is at 2LMW9S&D, where there is a strong downward head gradient. This apparently is due to the proximity of these wells to the dike, where there is a steep drop in topographic and ground water elevation. The vertical head gradient at the two paired well locations within the downstream area is not significant. At 3MW12S&D, a $\pm$1 foot upward gradient was recorded, while at 2DMW16S&D (near North Lake), no significant vertical gradient was recorded. This data for 2DMW16 suggests that bedrock ground water likely does not discharge to North Lake.

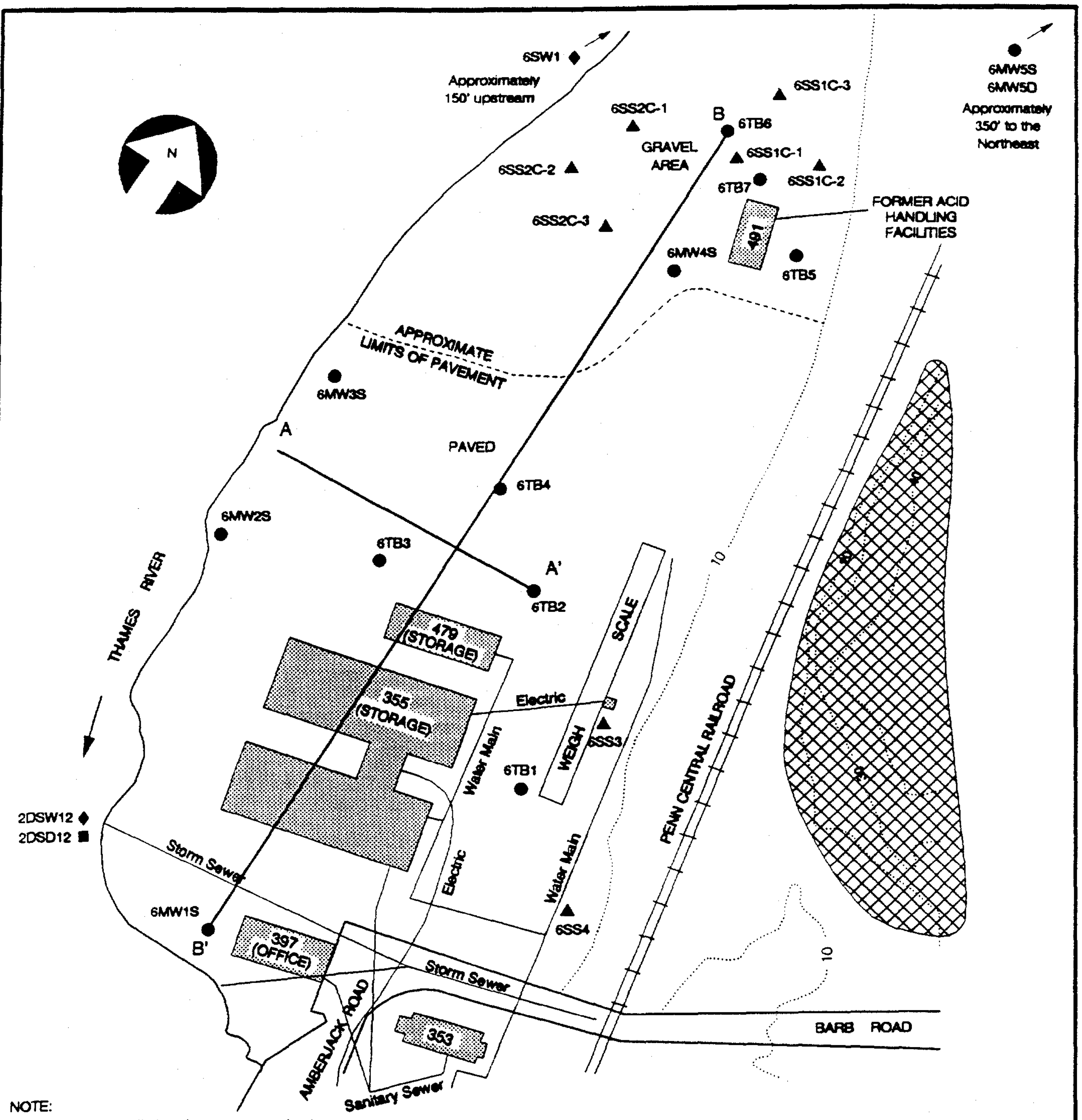
Slug displacement tests were conducted in bedrock wells 2WMW1D, 2WMW2D, 2WMW3D, and 2WMW6 in the Area A Wetland. The calculated transmissivities using slug displacement test data from the aforementioned wells are 250 ft^2/day, 1200 ft^2/day, 4.7 ft^2/day, and 16.6 ft^2/day, respectively, assuming a porous aquifer thickness of 150 feet. Slug displacement tests were conducted in bedrock wells 2LMW7D and 2LMW18D in the Area A Landfill. The open bedrock interval in well 7D is eight feet, and in well 18D it is ten feet. The calculated transmissivity from well 7D slug test data is 69 ft^2/day, and from well 18D it is 220 ft^2/day, assuming a porous aquifer thickness of 150 feet. Two bedrock wells, 2DMW10D and 2DMW16D, were slug tested in Area A Downstream. The open interval in well 10D extends 16 feet into bedrock. The bedrock transmissivity was calculated to be 20 ft^2/day, using data collected from well 10D. The open bedrock interval in well 16D is 47 feet. The calculated transmissivity, using data from well 16D, is 3.9 ft^2/day. The transmissive properties of the discrete fracture(s)/joint(s) intersected by these wells probably are greater than the calculated values. The wide range of transmissivity values generated from the test data indicate the high variability of transmissive properties within the fractured bedrock below the site.

3.7.6 DRMO

The subsurface at the DRMO area was characterized during the installation of 13 subsurface soil borings, six of which were completed as ground water monitoring wells. In general, the borings were extended to auger refusal or a maximum depth of 20 feet below the surface.

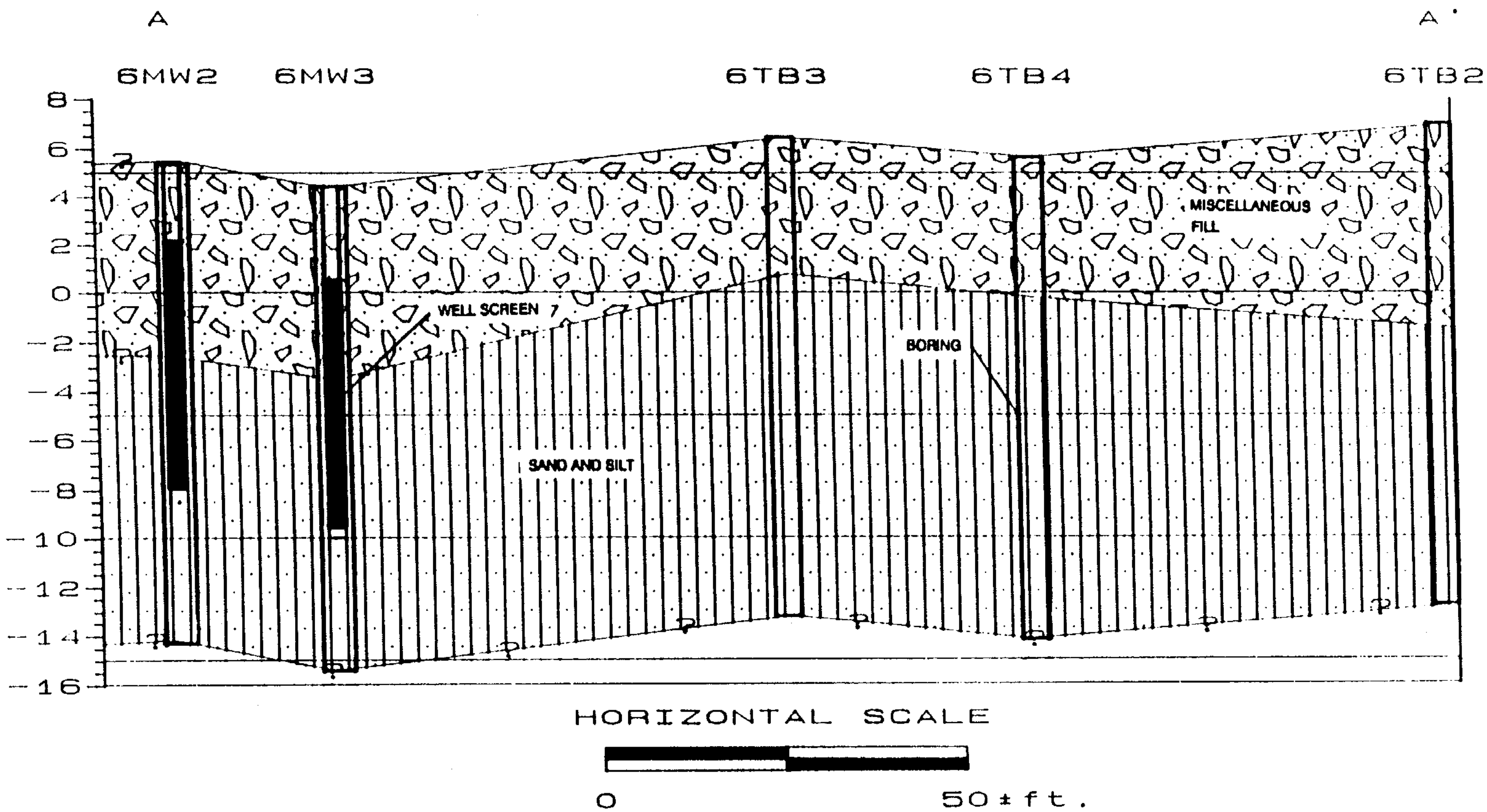
Generalized geologic cross-sections were prepared from boring information. Sampling locations and geologic cross-sections locations are shown on Figure 3-21. Geologic cross-sections are provided as Figures 3-22, and 3-23.

The 1967 USGS Bedrock Geologic Map (Figure 3-2) shows the DRMO site as artificial fill underlain by a biotite-quartz-feldspar gneiss of the Mamacoke Formation. The northernmost portion of the DRMO is mapped as a gneissic biotite granite known as the Granite Gneiss Member of the Sterling Plutonic Group. An outcrop of the Westerly granite is also mapped on the east side of the DRMO site. Field observations of fill material and bedrock outcrops are generally consistent with mapped classifications, although the Westerly Granite was not positively identified in the field. Bedrock was encountered northeast of the DRMO site (6MW5D) at a depth of 25 feet below grade. Twenty feet of bedrock was cored at this location. The mineralogy and texture of the core sample is consistent with that described as the Granite Gneiss Member of the Sterling Plutonic Group. Weathered and partially covered bedrock outcrops were present on the east side of the DRMO site adjacent to the railroad tracks. In addition, a prominent bedrock cliff is located to the east of both the DRMO site and railroad tracks.



NOTE:
1. Underground utility locations are approximate.
2. Base map and utility information from maps of NSB-NLON prepared by Loureiro Engineering Associates, Dec 1980. Elevations are based on NSB-NLON datum which is 1.41 feet below NGVD.

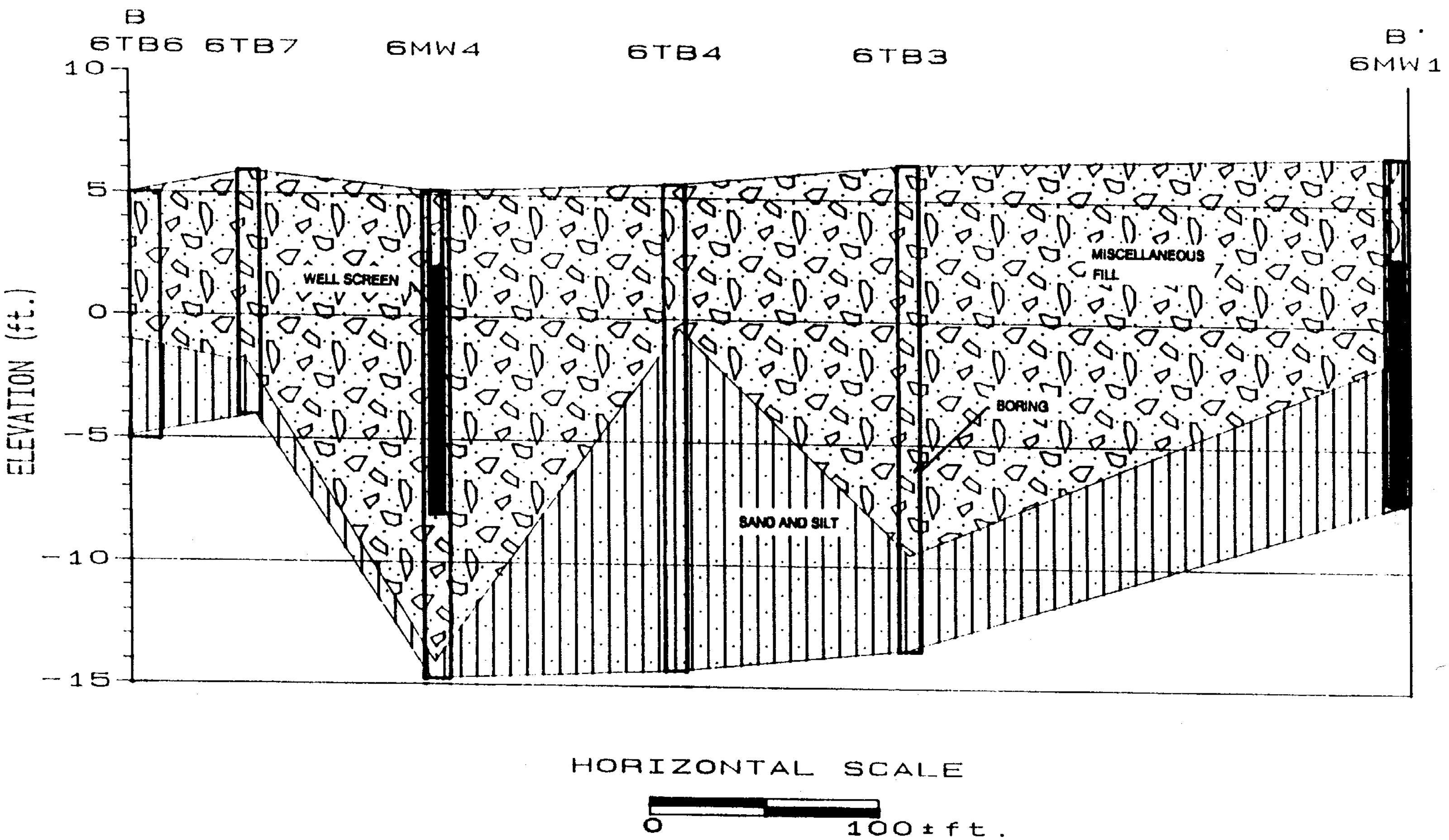
INSTALLATION RESTORATION STUDY NAVAL SUBMARINE BASE - NEW LONDON GROTON, CT	LEGEND ● MW1- Monitoring Well ● TB1- Test Boring ■ SD1- Sediment Sample ▲ SS1- Surface Soil Sample ♦ SW1- Surface Water Sample	·····95····· - Existing Grade - Building - Exposed Bedrock Approximate Scale 0 20 40'	FIGURE 3-21 GEOLOGIC CROSS-SECTION LOCATIONS DRMO ATLANTIC ENVIRONMENTAL SERVICES, INC.



INSTALLATION RESTORATION STUDY
NAVAL SUBMARINE BASE - NEW LONDON
GROTON, CT

FIGURE 3-22
GEOLOGIC CROSS-SECTION A - A'
DRMO

ATLANTIC ENVIRONMENTAL SERVICES, INC.



INSTALLATION RESTORATION STUDY NAVAL SUBMARINE BASE - NEW LONDON GROTON, CT		FIGURE 3-23 GEOLOGIC CROSS-SECTION B - B' DRMO ATLANTIC ENVIRONMENTAL SERVICES, INC.

The 1983 SCS Soils Map (Figure 3-1) depicts the DRMO site as Udorthents-Urban land on the portion of the site that is adjacent to the Thames River and Hinckley Sandy Loam on the northernmost portion of the site. The 1960 USGS Surficial Geology Map (Figure 3-4) shows artificial fill in the portion of the DRMO that is adjacent to the Thames River and terrace deposits of the Thames River in the northern portion of the DRMO. The classifications of Udorthents-Urban land and artificial fill are consistent with the past and present conditions on the southern portion of the DRMO site. Subsurface soil sampling data from the northern portion of the DRMO site is consistent with the description of Hinckley sandy loam provided by the SCS and discussed in Section 3.2. Soils observed at the northern portion of the DRMO site are consistent with a coarse fraction of the terrace deposits. Figure 3-4 also shows an active borrow pit in the northern portion of the DRMO. No evidence of current excavation activity was observed at this location during the field investigation, however, the wells were located in an abandoned road that may have been used as part of an excavation operation.

DRMO is underlain by between 5 and 20 feet of miscellaneous fill material. In the northern portion of the site adjacent to Building 491, fill material is thickest, measuring up to 15 feet thick (at 6MW4). The sand and gravel is underlain by sand and silt that contains shell fragments.

In the southern portion of the site, fill material overlies sand, silt and clay. Shell fragments were observed in all borings in the southern portion except 6MW1. Shell fragments in fine-grained soils likely represent the original river bed. Depth to fine-grained soils ranges from ten feet in the central portion of the site to 20 feet in the northern portion.

Four overburden monitoring wells and one bedrock monitoring well were installed at DRMO. Ground water elevations in the overburden aquifer were approximately four to six feet below grade in the southern portion of DRMO and approximately 12 feet below grade in the north portion of DRMO. Water level measurements taken at the five overburden monitoring wells indicate that ground water flow is toward the west. Figure 3-24 is a ground water elevation contour map of the site. As with other sites adjacent to the Thames River, ground water flow at DRMO site is influenced by tidal fluctuation in the water level in the Thames River.

Slug displacement tests were conducted in overburden wells 6MW4S and 6MW5S in DRMO. Single well pumping tests were conducted in overburden well 6MW2 and bedrock well 6MW5D. Well 6MW4S is screened two feet in fill material and eight feet in underlying fine to coarse sand and gravel. The slug test method was ineffective in determining the hydraulic conductivity of this combination of material due to its high permeability. Well 6MW5S is screened ten feet in fine to coarse sand and gravel with a trace of silt. The hydraulic conductivity of this material was calculated to be 1.6 feet per day. Overburden well 6MW2 is screened five feet in fine to coarse sand and gravel, four feet of silt and clay, and one foot of fine to coarse sand and silt. Well 6MW2 was pumped at a rate of 15 gallons per minute for 62 minutes. The maximum drawdown caused by this pumping was 0.89 feet. Analyses for the pump test data (Cooper and Jacob Method, 1946) indicate that the hydraulic conductivity of these materials is 70 feet per day. Estimating the average hydraulic conductivity and the porosity of these sediments to be 50 feet per day and 0.35, respectively (Freeze and Cherry, 1979), and using a hydraulic gradient of 0.005 from Figure 3-24, the calculated ground water flow velocity would be 0.7 feet per day. The volume of water discharged from the overburden to the Thames River is estimated to be approximately 23,100 cubic feet per day (172,800 gpd), based on a flow velocity of 0.7 feet per day, a saturated thickness of 50 feet and a 660 foot length of area perpendicular to the flow path. It is noted that flow to the river is likely higher during low tide.

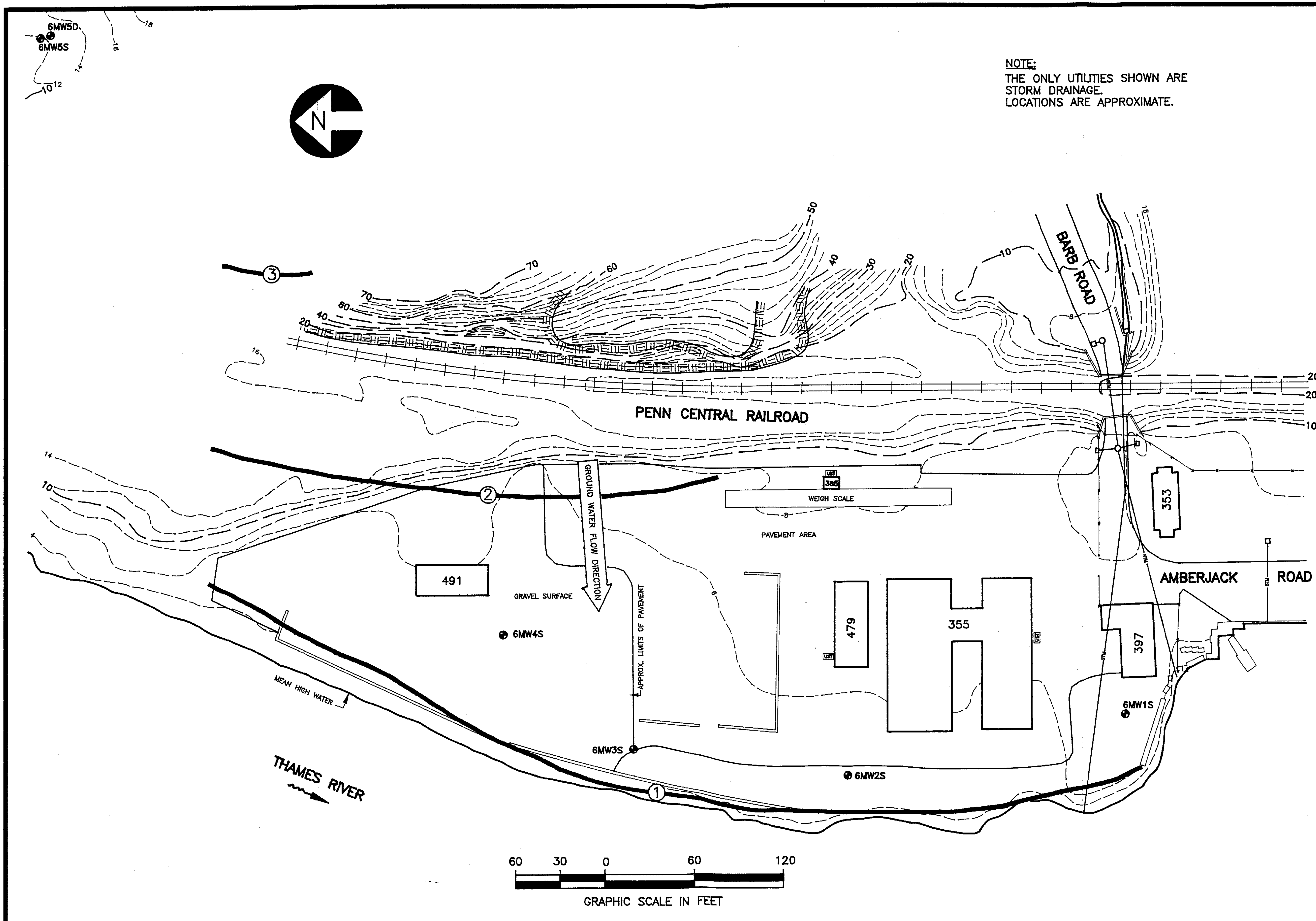


FIGURE 3-24
GROUND WATER CONTOUR MAP
DRMO

ATLANTIC ENVIRONMENTAL SERVICES, INC.

INSTALLATION RESTORATION STUDY
NAVAL SUBMARINE BASE-NEW LONDON
GROTON, CONN.

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Bedrock well 6MW5D (ten foot open bedrock interval) was pumped at a rate of 12.5 gallons per minute for 60 minutes and experienced a maximum drawdown of 2.49 feet. Steady-state conditions were reached in the well within the first ten minutes of pumping. Data analyses indicate that the transmissivity of the bedrock in the vicinity of this well is 1,675 square feet per day, assuming a porous aquifer thickness of 150 feet.

3.7.7 Lower Subase

A total of 22 soil borings were installed in the Lower Subase. Seventeen of these borings were extended ten feet below the water table and finished as monitoring wells. The remaining borings were drilled to 20 feet below the surface.

Geologic cross-sections were prepared from boring data. Figure 3-25 shows monitoring well and test boring locations as well as the location of cross-sections referred to in the text.

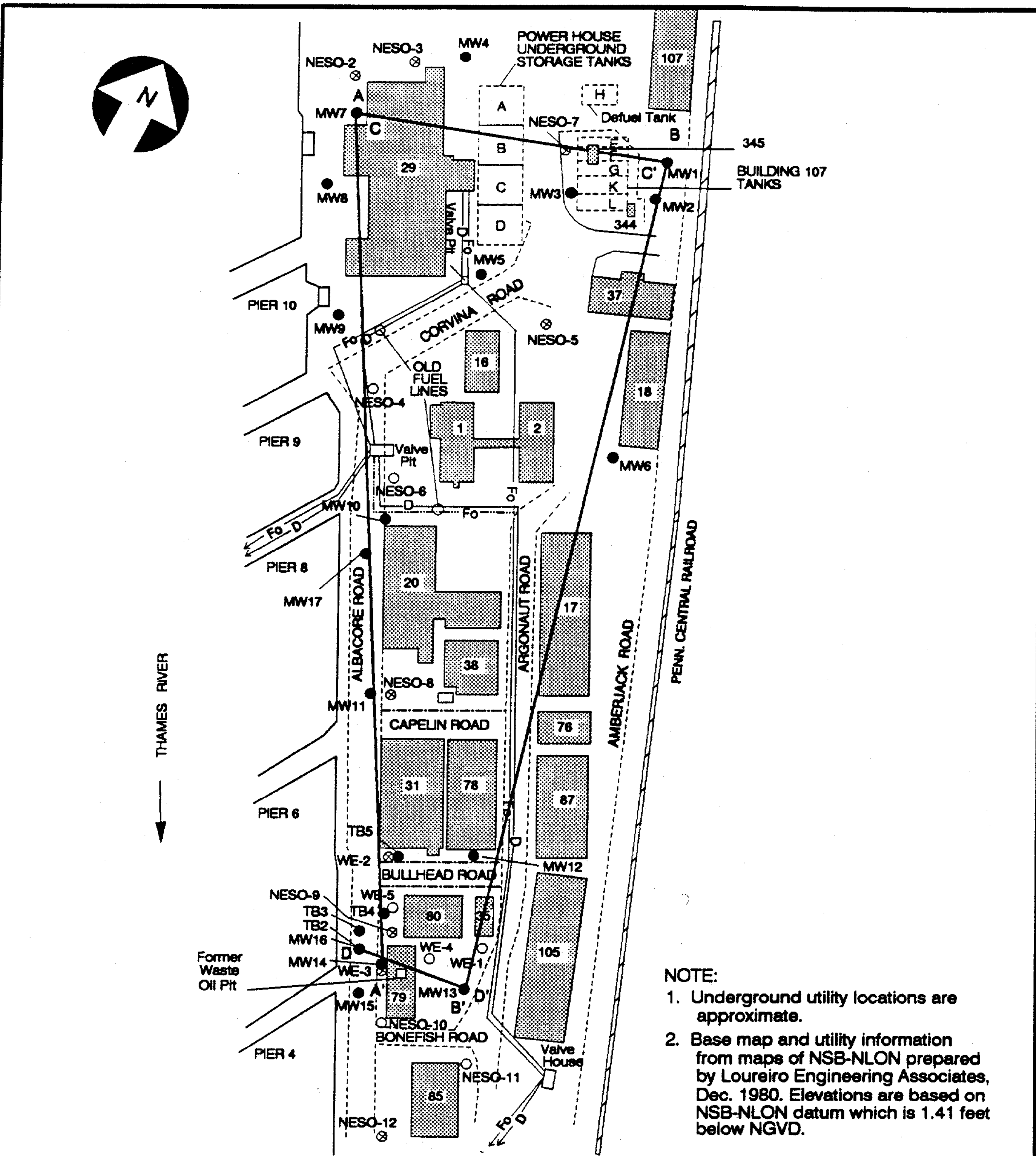
The 1967 USGS Bedrock Geology Map (Figure 3-2) shows that the Lower Subase is underlain by a biotite-quartz-feldspar gneiss of the Mamacoke Formation. No bedrock outcrops were observed in the Lower Subase site and no bedrock was encountered during the installation of monitoring wells and test borings.

The 1983 SCS Soils Map (Figure 3-1) depicts the Lower Subase site as Urban Land. This classification is consistent with the present site development.

The 1960 USGS Surficial Geology Map (Figure 3-4) depicts the surficial deposits at the Lower Subase as artificial fill. This classification is consistent with information obtained during the installation of test borings and monitoring wells.

Data collected for this investigation indicates that the Lower Subase is underlain by a layer of sand and gravel which is ten to 20 feet thick on the west side of the Lower Subase and ten to 15 feet thick on the east side. Cross-sections A-A' and B-B'(Figure 3-26) are north-south cross-sections along the east and west sides of the site that show the gravel layer thinning eastward. As shown on cross-sections A-A', C-C', and D-D' (Figures 3-26 and 3-27), the sand and gravel layer is underlain by a layer of fine sand and silt with shell fragments. The sand and silt lens is thickest on the west side of the site and pinches out to the east. The maximum thickness of this lens is not known, as the bottom of this lens was not encountered in any of the borings on the west side of the site. On the east side of the site (cross-section B-B'), the sand and gravel layer is underlain by fine- to medium-grained sand. As previously discussed (Section 3.1), the Lower Subase is largely constructed on fill material; the sand and gravel layer observed in the soil borings is likely a layer of artificial fill that is underlain by river-bottom sediments, consisting of fine sand and silt with shell fragments.

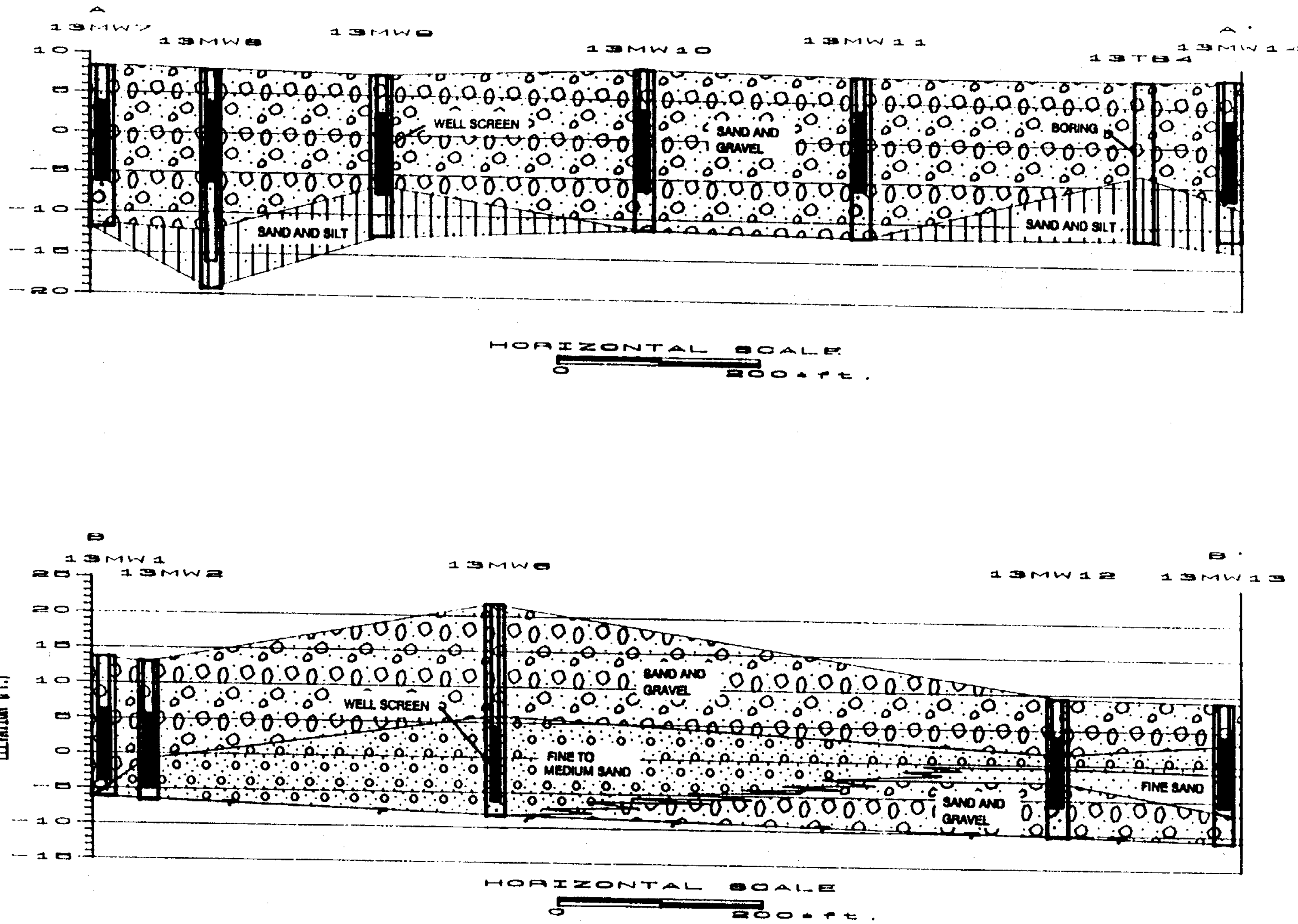
Seventeen ground water monitoring wells screened in the overburden were installed in the Lower Subase. Seven additional wells installed during previous environmental investigations were also used for this investigation. Water levels at 16 Lower Subase wells and points on the river were monitored hourly during a 12 hour tidal cycle (April 18, 1991) to determine what effect the changing water level in the river has on ground water flow at the Lower Subase. Figures 3-28 and 3-29 present the ground water elevation contours at low tide and high tide, respectively. At low tide ground water flows west toward the Thames River. At high tide, ground water flows east from the



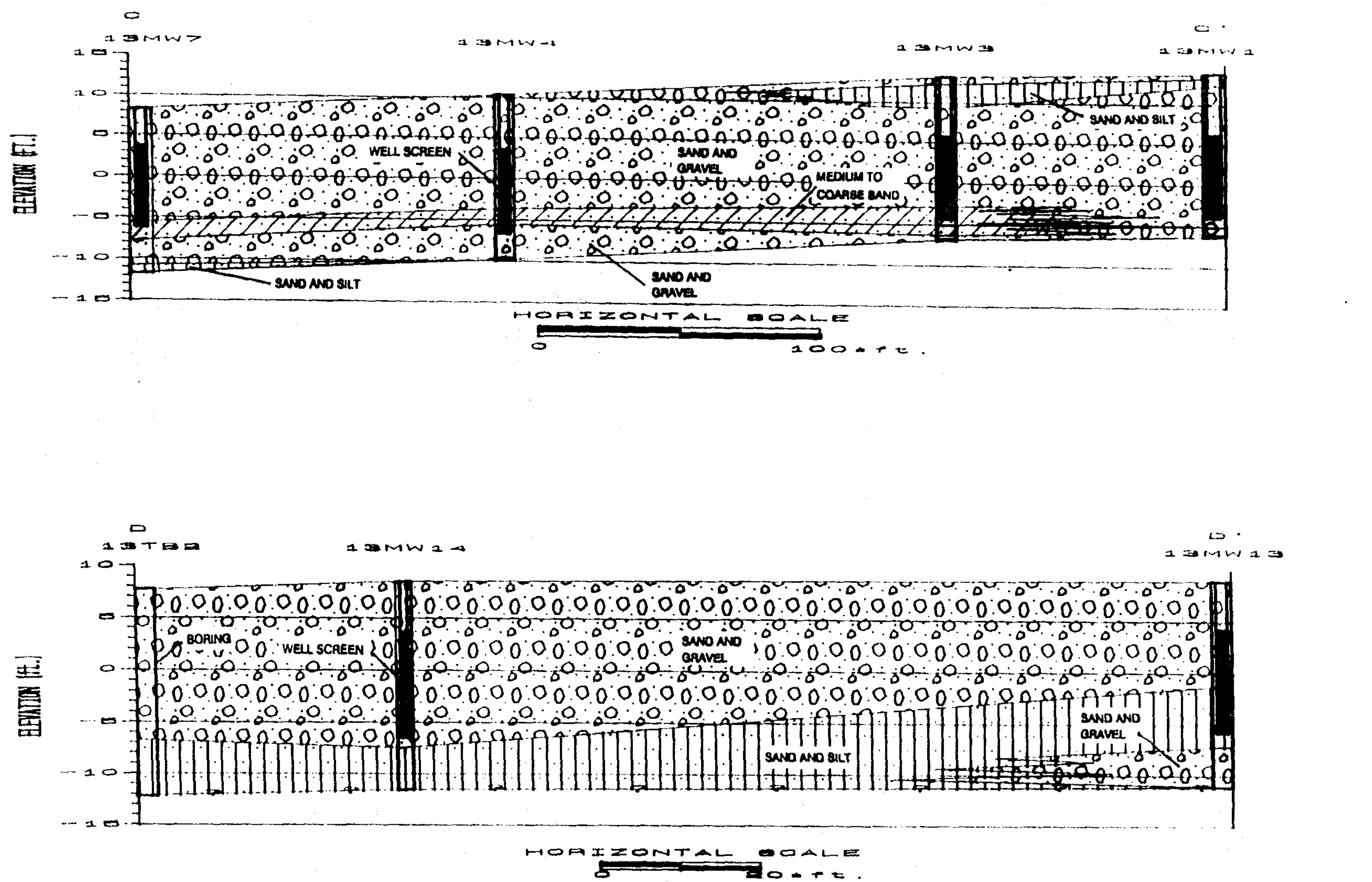
NOTE:

1. Underground utility locations are approximate.
2. Base map and utility information from maps of NSB-NLON prepared by Loureiro Engineering Associates, Dec. 1980. Elevations are based on NSB-NLON datum which is 1.41 feet below NGVD.

INSTALLATION RESTORATION STUDY NAVAL SUBMARINE BASE - NEW LONDON GROTON, CT	LEGEND ● MW1 - Monitoring Well ● TB1 - Test Boring ○ NESO-1 - NESO Well ○ WE-1 - Wehran Well ⊗ - Destroyed Well -·- Fo -·- - Out of Service Fuel Oil Line	- Building — D — - Diesel Line — Fo — - Fuel Oil Line Approximate Scale 0 100 200'	FIGURE 3-25 GEOLOGIC CROSS-SECTION LOCATIONS LOWER SUBASE ATLANTIC ENVIRONMENTAL SERVICES, INC.



INSTALLATION RESTORATION STUDY NAVAL SUBMARINE BASE - NEW LONDON GROTON, CT		FIGURE 3-26 GEOLOGIC CROSS-SECTIONS A - A' & B - B' LOWER SUBASE ATLANTIC ENVIRONMENTAL SERVICES, INC.



INSTALLATION RESTORATION STUDY NAVAL SUBMARINE BASE - NEW LONDON GROTON, CT		FIGURE 3-27 GEOLOGIC CROSS-SECTIONS C - C' & D - D' LOWER SUBASE ATLANTIC ENVIRONMENTAL SERVICES, INC.

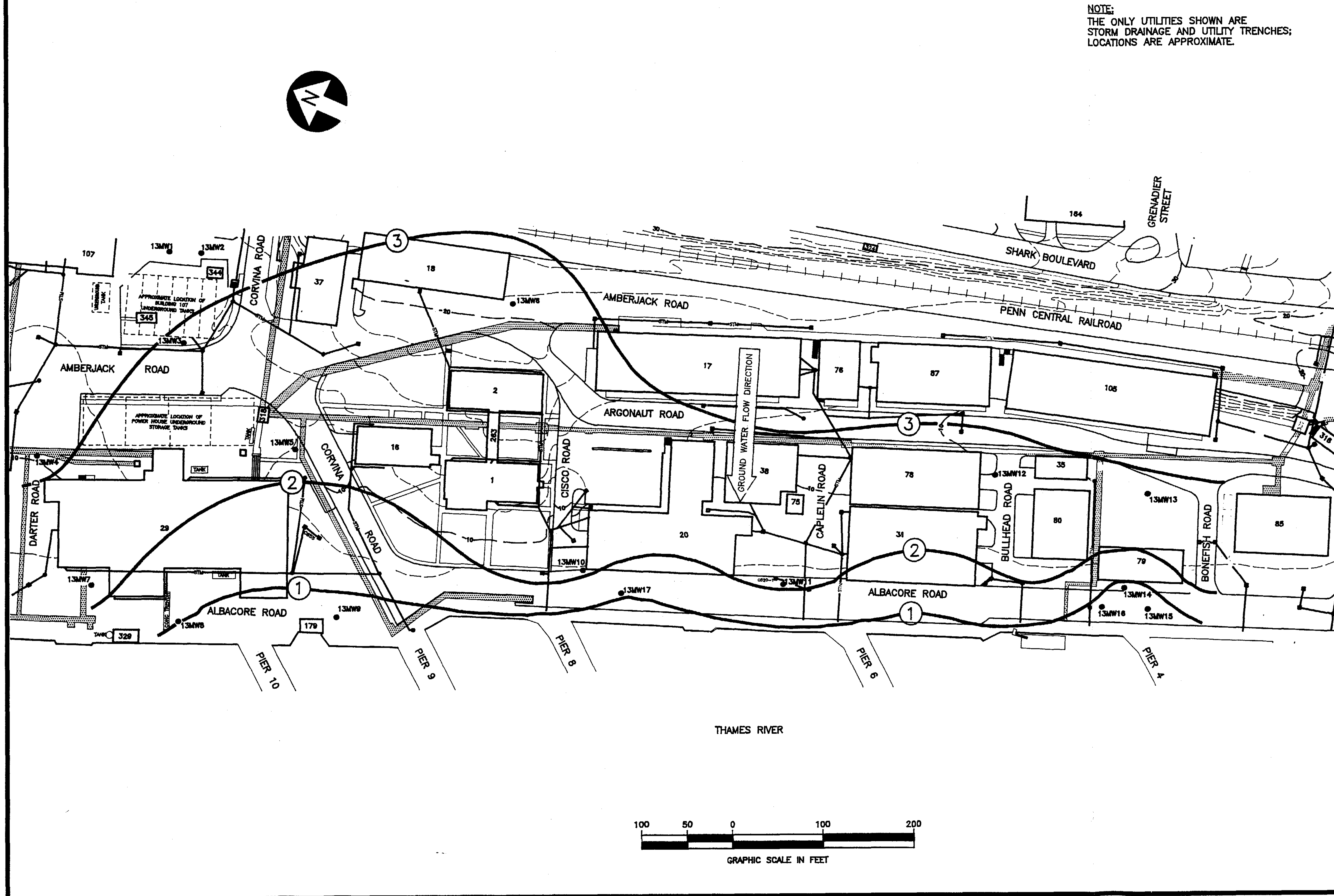


FIGURE 3–28
LOW TIDE GROUND WATER CONTOUR MAP
LOWER SUBASE

ATLANTIC ENVIRONMENTAL SERVICES, INC.

LEGEND

- 10 — EXISTING CONTOUR
- 123 BUILDING NUMBER
- O MH73 EXISTING MANHOLE
- UNDERGROUND UTILITY TRENCH
- —STM— STORM SEWER
- GROUND WATER CONTOUR
- 6MW1S MONITORING WELL

INSTALLATION RESTORATION STUDY
NAVAL SUBMARINE BASE–NEW LONDON
GROTON, CONN.

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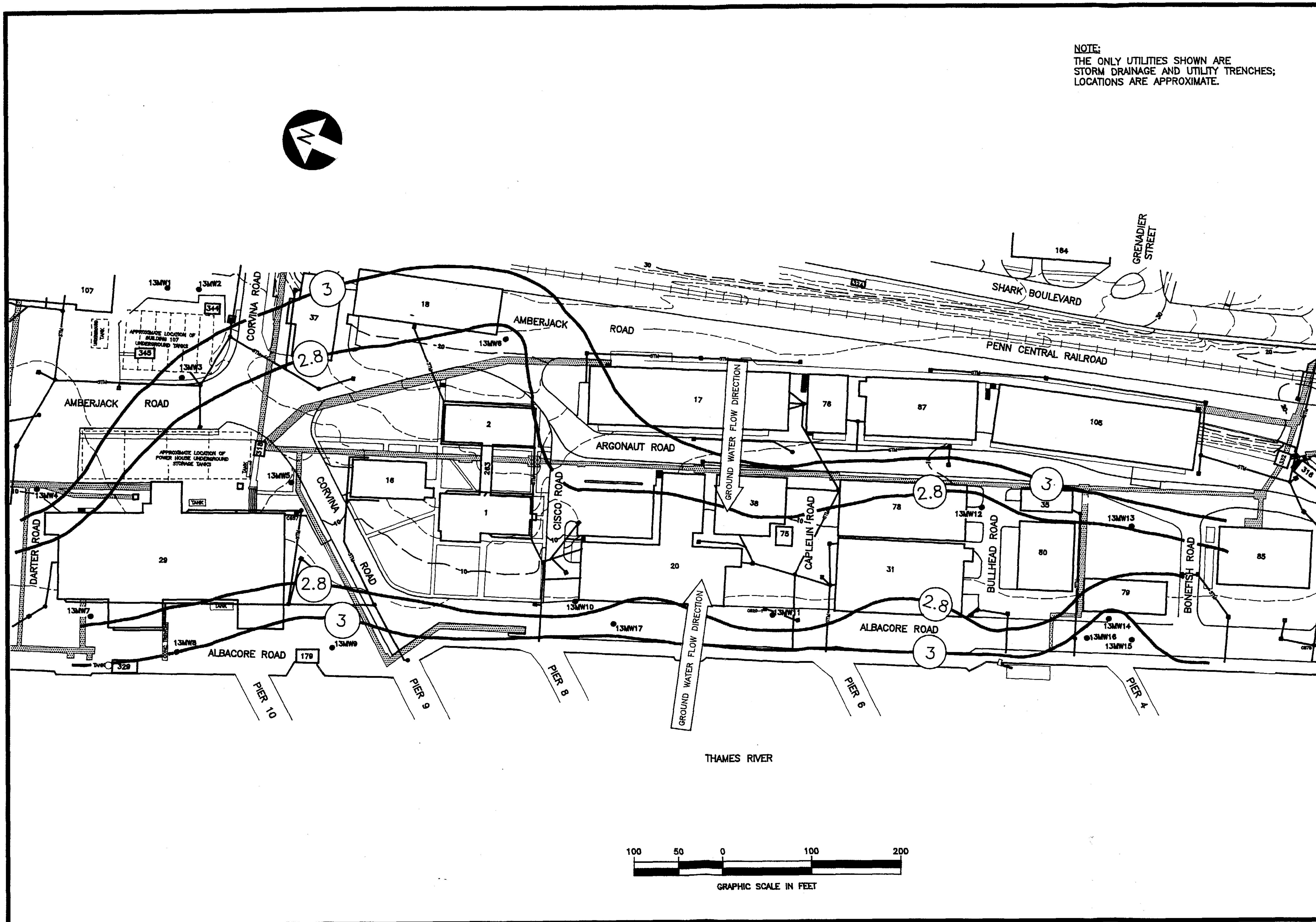

FIGURE 3-29
HIGH TIDE GROUND WATER
CONTOUR MAP
LOWER SUBASE

ATLANTIC ENVIRONMENTAL SERVICES, INC.

INSTALLATION RESTORATION STUDY
NAVAL SUBMARINE BASE-NEW LONDON
GROTON, CONN.

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river in the western portion of the site and flows west toward the river in the eastern portion of the site. Thus, a small portion of the overburden aquifer at the Lower Subase ebbs and flows with the tide. This tidal effect appears to diminish with distance from the river, and therefore, it is likely that the reversal of ground water flow direction at high tide does not extend farther than 300 feet inland from the river.

Seven overburden wells were slug tested in the Lower Subase to evaluate *in situ* hydraulic conductivity of the overburden material. These wells were screened ten feet through various depths of medium- to coarse-grained sand and gravel and fine- to medium-grained sand with a trace of gravel. Review of the data indicates that the slug displacement test was ineffective in estimating the hydraulic conductivity of the material due to its high permeability. The hydraulic conductivity of the sediments is estimated to be 50 feet per day, based on published values (Freeze and Cherry, 1979). Based on a hydraulic conductivity of 50 feet per day, a porosity of 0.35 (Freeze and Cherry, 1979), and an average hydraulic gradient of 0.009 (Figure 3-28), the ground water flow velocity was calculated to be 1.3 feet per day. Assuming a saturated thickness of 50 feet, a flow velocity of 1.3 feet per day, and using the measured length of cross-sectional area of flow perpendicular to the flow direction, it was estimated that 88,000 cubic feet of water per day (658,240 gpd) discharges from the unconsolidated soils in the Lower Subase to the Thames River.

3.8 Climatology

Southeastern Connecticut has a variable climate that is defined by both continental and maritime air masses and modified by its proximity to the Atlantic Ocean. The region lies in the path of prevailing westerlies and cyclonic disturbances that cross the country from the west or southwest toward the east and northeast. The prevailing winds are southwesterly in the summer and northwesterly in the winter. The average wind speed is around ten miles per hour. The region is exposed to occasional storms that travel up the Atlantic coast. Storms in the region are laden with moisture from the ocean; in addition, some storms are tropical and occasional storms are of hurricane intensity.

According to data from New London, Connecticut, the average annual temperature is approximately 50°F. Average monthly temperatures vary from 58-72°F in July and August to 23-30°F in January and February.

Precipitation averages approximately 44 inches per year as measured at New London over an 81-year interval. Precipitation ranges from 32 to 65 inches per year. The greatest amount of precipitation occurs in the months of March and August and the least in June and September. Evaporation averages approximately 23 inches per year (NSB-NLON Master Plan, 1988).

3.9 Demography

Several communities are located within one mile of NSB-NLON. According to the U.S. Bureau of the Census, three neighborhoods in the Town of Groton lie adjacent to or within NSB-NLON. The neighborhood boundaries are described below.

North West - The community is located adjacent to NSB-NLON on the east side of Route 12 from the Groton - Ledyard town line to Walker Hill Road on the south. The neighborhood extends west to the Ledyard Reservoir.

Pleasant Valley - The Pleasant Valley Neighborhood borders the south boundary of NSB-NLON. On the east it is bounded by Connecticut Route 12 and on the west by the Thames River. The southern boundary of Pleasant Valley is Grove Street and Walker Hill Road.

Naval Submarine Base New London - NSB-NLON as described in Section 1.2.1 is considered a neighborhood in Groton although portions of it are located in Ledyard. Population data reported for this neighborhood is as of April 1, 1980.

The Gales Ferry section of Ledyard is also located adjacent to NSB-NLON to the north. Table 3-2 includes 1980 census information for the towns of Groton and Ledyard and shows the total population breakdown by age and sex. More recent data and population information for neighborhoods in the Town of Groton and for the Gales Ferry section of Ledyard are included where available.

TABLE 3-2
BREAKDOWN OF POPULATION IN THE VICINIY OF NSB-NLON

	GROTON				LEDYARD	
	Town of Groton[1]	*Neighborhoods in the Vicinity of NSB-NLON*[2]			*Town of Ledyard*[1]	*Gales Ferry Section 3 of Ledyard*
		Northwest	Pleasant Valley	Naval Sub Base		
Total Population - 1980	41062	5520	4374	4099	13735	7473
Total Population - 1990	45144	NA	NA	NA	14913	*7802
Total Households - 1980	NA	1391	1216	63	---	2282
Median Age - 1980	25.5	19.9	23.5	21.4	27.4	27.1

Town of Groton	Male	Female	Town of Ledyard	Male	Female
Total	22473	18589	Total	6940	6795
0-4	1885	1699	0-4	549	515
5-9	1519	1532	5-9	585	555
10-14	1508	1395	10-14	752	727
15-19	2729	1432	15-19	742	709
20-24	4138	2120	20-24	623	547
25-29	2700	2002	25-29	598	572
30-34	1843	1534	30-34	611	635
34-39	1266	1085	34-39	621	642
40-44	789	804	40-44	470	457
45-49	715	762	45-49	382	371
50-54	814	845	50-54	346	324
55-59	805	863	55-59	261	262
60-64	631	667	60-64	179	186
65-69	450	582	65-69	101	117
70-74	289	428	70-74	67	86
75-79	163	351	75-79	30	40
80-84	142	254	80-84	16	28
85+	87	234	85+	7	22
Median Age	24.3	27.6	Median Age	26.8	28.1

NOTES

1) Source: U.S. Bureau of the Census, "1980 Census of Population, Volume 1, Characteristics of the Population", U.S. Government Printing Office, 1982.
2) Source: U.S. Bureau of the Census, "1980 Decennial Census Neighborhood Statistics Program, Groton, Connecticut".
3) Source: CACI, 1988 "The 1988 Sourcebook of Demographics and Buying Power for Every ZIP Code in the U.S.A.".
* Total Population - 1988
NA - Not Available

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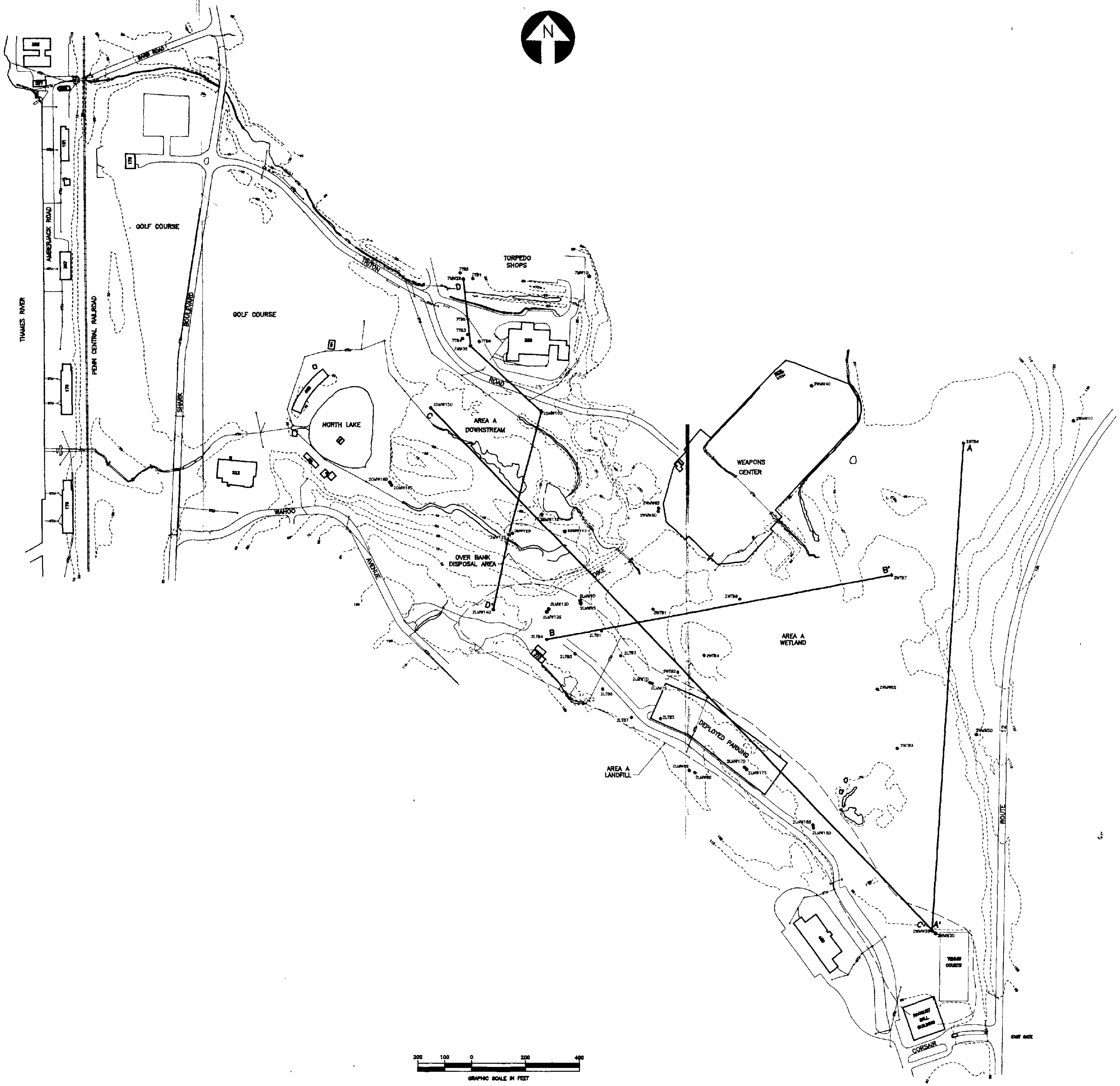

NOTE:
THE ONLY UTILITIES SHOWN ARE STORM DRAINAGE;
LOCATIONS ARE APPROXIMATE.

INSTALLATION RESTORATION STUDY NAVAL SUBMARINE BASE–NEW LONDON GROTON, CONN.	LEGEND		PLATE 3–1 GEOLOGIC CROSS–SECTION LOCATIONS AREA A
	CROSS–SECTION	EXISTING CONTOUR	
	MONITORING WELL	BUILDING NUMBER	
	TEST BORING	WATERCOURSE	
		STORM SEWER	ATLANTIC ENVIRONMENTAL SERVICES, INC.

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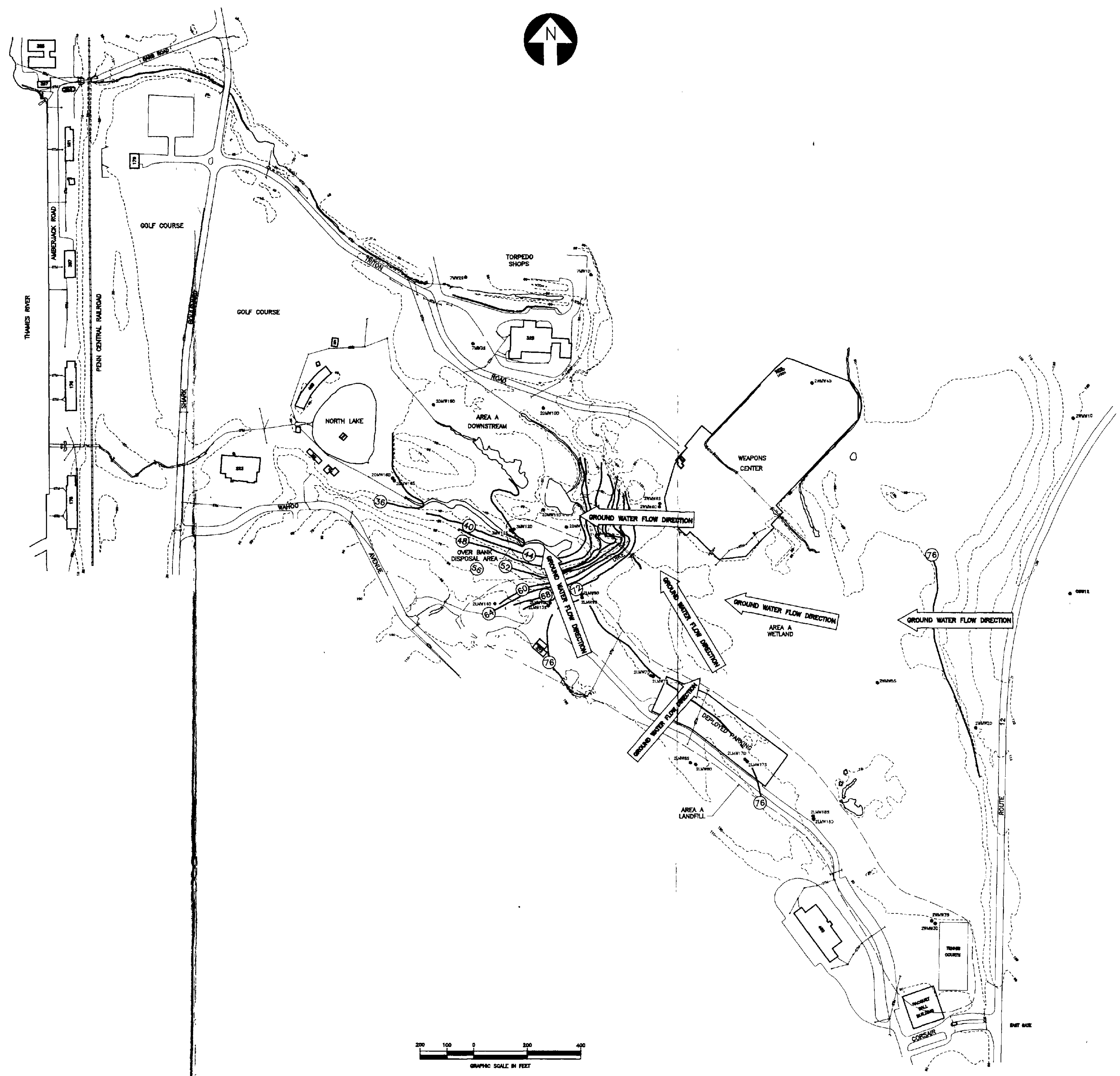

NOTE:
THE ONLY UTILITIES SHOWN ARE STORM DRAINAGE;
LOCATIONS ARE APPROXIMATE.

INSTALLATION RESTORATION STUDY
NAVAL SUBMARINE BASE—NEW LONDON
GROTON, CONN.

LEGEND

GROUND WATER CONTOUR	EXISTING CONTOUR
MONITORING WELL	BUILDING NUMBER
OFFSITE RESIDENTIAL WELL	WATERCOURSE
	STORM SEWER

PLATE 3-2
GROUND WATER CONTOUR MAP
OVERBURDEN AQUIFER
AREA A

ATLANTIC ENVIRONMENTAL SERVICES, INC.

06751306X

INSTALLATION RESTORATION STUDY NAVAL SUBMARINE BASE—NEW LONDON GROTON, CONN.	LEGEND GROUND WATER CONTOUR MONITORING WELL OFFSITE RESIDENTIAL WELL --10-- EXISTING CONTOUR 123 BUILDING NUMBER WATERCOURSE STM STORM SEWER	PLATE 3–3 GROUND WATER CONTOUR MAP BEDROCK AQUIFER AREA A LANDFILL ATLANTIC ENVIRONMENTAL SERVICES, INC.

0675 1307X