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Lower Subase Remedial Investigation

for

Naval Submarine Base
New London
Groton, Connecticut

Volume I - Text

Northern Division
Naval Facilities Engineering Command
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FOR
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GROTON, CONNECTICUT

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ENVIRONMENTAL ACTION NAVY (CLEAN) CONTRACT

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ACRONYMS AND ABBREVIATIONS

4,4-DDT	1,1,1-trichloro-2,2-bis(4-chlorophenyl)ethane
4,4'-DDD	1,1-dichloro-2,2-bis(4-chlorophenyl)ethane
4,4'-DDE	1,1-dichloro-2,2-bis(4-chlorophenyl)ethene
ARARs	applicable, relevant, or appropriate requirements
AST	aboveground storage tank
ASTM	American Society for Testing of Materials
AVS/SEM	acid volatile sulfides/simultaneously extracted metals
AWQC	ambient water quality criterion
B&R	Brown & Root
BCF	bioconcentration factor
BEHP	bis(2-ethylhexyl)phthalate
BERA	baseline ecological risk assessment
bgs	below ground surface
BTEX	benzene, toluene, ethylbenzene, xylene
$CaCO_3$	calcium carbonate
CAWQC	chronic ambient water quality critierion
CDD	chlorinated dibenzo-p-dioxins
CERCLA	Comprehensive Response, Compensation and Liability Act
CFR	Code of Federal Regulations
CLEAN	Comprehensive Long-Term Environmental Action Navy
CLP	Contract Laboratory Program
CN	cyanide
COC	chemical of concern
CRDL	contract required detection limit
CRQL	contract required quantitation limit
CSF	cancer slope factor
CTDEP	Connecticut Department of Environmental Protection
CTE	central tendency exposure
CTO	Contract Task Order
DEIS	draft environmental impact statement
DO	dissolved oxygen
DQO	data quality objectives
DPT	direct push technique

DRMO	Defense Reutilization and Marketing Office
DTW	depth to water
EA	environmental assessment
Eh	oxidation/reduction potential
EIS	environmental impact statement
EPC	exposure point concentration
EqP	equilibrium partitioning
ERA	ecological risk assessment
ER-L	effects range - low
ER-M	effects range - medium
ESG	ecological screening guideline
FCV	final chronic value
FDA	Food and Drug Administration
FDEP	Florida Department of Environmental Protection
FEIS	final environmental impact statement
FFA	Federal Facilities Agreement
fpc	fraction of organic carbon
FS	feasibility study
ft^3/s	cubic feet per second
ft/s	feet per second
GPS	Global Positioning System
HEAST	Health Effects Assessment Summary Tables
HHRA	Human Health Risk Assessment
HI	Hazard Index
HNUS	Halliburton NUS Corporation
HQ	Hazard Quotient
HSA	hollow stem augering
HSWA	Hazardous and Solid Waste Amendment of 1984
IAS	initial assessment study
ICP	Inductively Coupled Plasma
ID	inside diameter
IDL	instrument detection limit
IEUBK	Integrated Exposure Uptake Biokinetic
ILCR	incremental lifetime cancer risk
IRIS	Integrated Risk Information System
IRP	Installation Restoration Program

K_d	distribution coefficient
K_{oc}	organic carbon partition coefficient
K_{ow}	octanol-water partition coefficient
LC_{so}	aqueous concentration of a contaminant lethal to 50% of the test population
LOAEL	lowest observed adverse effect level
MCL	maximum contaminant level
MCLG	maximum contaminant level goal
mlw	mean low water
MOE	Ontario Ministry of the Environment
msl	mean sea level
NACIP	Navy Assessments and Control of Installation Pollutants
NAVFAC	Naval Facilities Engineering Command
Navy	U.S. Department of the Navy
NCP	National Contingency Plan
NEESA	Naval Energy and Environmental Support Activity
NEPA	National Environmental Policy Act
NESO	Naval Environmental Support Office
NFEC	Naval Facilities Engineering Command
NFESC	Naval Facilities Engineering Service Center
NGVD	National Geodetic Vertical Datum
NLDS	New London Disposal Site
NOAA	National Oceanic and Atmospheric Administration
NOAEL	no observed adverse effect level
NPDES	National Pollutant Discharge Elimination System
NPL	National Priorities List
NSB-NLON	Naval Submarine Base - New London
NUWC	Naval Undersea Warfare Center
OBDA	over bank disposal area
OSHA	Occupational Safety and Health Administration
OSWER	Office of Solid Waste and Emergency Response
OVA	organic vapor analyzer
PAH	polycyclic aromatic hydrocarbon
PCBs	polychlorinated biphenyls
PEL	probable effects level
PID	photoionization detector
ppm	parts per million

ppt	parts per thousand
PVC	polyvinyl chloride
QAPP	quality assurance project plan
QA/QC	quality assurance/quality control
QSAR	quantitative structure-activity relationship
RBC	risk-based concentrations
RCRA	Resource Conservation and Recovery Act
RfC	reference concentration
RfD	reference dose
RI	remedial investigation
RME	reasonable maximum exposure
ROD	Record of Decision
RMS	root mean square
RPD	relative percent difference
RSE	removal site evaluation
RSR	Remediation Standard Regulations (State of Connecticut)
SARA	Superfund Amendments and Reauthorization Act
SCS	Soil Conservation Service
SECWA	Southeastern Connecticut Water Authority
SEL	severe effects level
SI	site investigation
SMDP	scientific management decision point
SOP	standard operating procedure
SOW	statement of work
SPLP	synthetic precipitation leaching procedure
SQB	sediment quality benchmark
SSL	soil screening level
SVOC	semivolatile organic compound
SWPC	Surface Water Protection Criteria (State of Connecticut)
TAL	Target Analyte List
TCDD	2,3,7,8-tetrachlorodibenzo-p-dioxin
TCL	Target Compound List
TCLP	toxicity characteristic leaching procedure
TEF	toxicity equivalence factor
TOC	total organic carbon
TPH	total petroleum hydrocarbons

TSCA	Toxic Substances Control Act
UCL	upper confidence limit
USCS	Unified Soil Classification System
USDA	United States Department of Agriculture
USEPA	United States Environmental Protection Agency
USFWS	United States Fish and Wildlife Service
USGS	United States Geologic Survey
UST	underground storage tank
VOC	volatile organic compounds
WPCA	Water Pollution Control Authority
WQS	water quality standards
WWTP	wastewater treatment plant

EXECUTIVE SUMMARY

This Lower Subase Remedial Investigation (RI) Report has been prepared for the Department of the Navy, Northern Division Naval Facilities Engineering Command by Brown & Root (B&R) Environmental under Contract Number N62472-90-D-1298, Contract Task Order 260. This report summarizes the results of the RI for seven distinct zones of the Lower Subase at the Naval Submarine Base - New London in Groton, Connecticut and the adjacent Thames River. The zones of investigation and the sites located within each zone are as follows:

- Zone 1: Site 10 - Fuel Storage Tanks and Tank 54-H; Site 11 - Power Plant Oil Tanks; Building 89 UST; and the Fuel Pipeline and Steam and Condensate Lines.

- Zone 2: Fuel Pipeline and Steam and Condensate Lines.

- Zone 3: Site 17 - Hazardous Materials/Solvent Storage Area (Building 31) and the Fuel Pipeline and Steam and Condensate Lines.

- Zone 4: Site 13 - Building 79 Waste Oil Pit; Site 19 - Solvent Storage Area (Building 316); the Quay Wall Study Area; and the Fuel Pipeline and Steam and Condensate Lines.

- Zone 5: Site 22 - Pier 33, Building 175 (Battery Acid Aboveground Storage Tanks), and adjacent property.

- Zone 6: Site 24 - Central Paint Accumulation Area (Building 174)

- Zone 7: Site 21 - Berth 16; Site 25 - Classified Materials Incinerator; Transformers at Building 157, Vault 31

- Thames River - Pier 2 to Pier 33

The remainder of this executive summary provides a synopsis of relevant background information for the RI and brief zone-specific summaries of nature and extent of contamination, contaminant fate and transport, baseline human health risk assessment, and recommendations (Sections ES.2 through ES.8). In addition, similar information, as well as the ecological risk assessment, are provided in this section for the Thames River (Section ES.9). An overall summary of recommendations is provided in Section ES.10.

ES.1 BACKGROUND INFORMATION

NSB-NLON is located along the Thames River and lies within the towns of Ledyard and Groton. The Lower Subase is a narrow strip of land that generally forms the western boundary of NSB-NLON and parallels the Thames River. Current and historic activities conducted within the Lower Subase include submarine docking and maintenance, power and heat generation for NSB-NLON, administration, and other miscellaneous activities. It was determined that past activities at the Lower Subase resulted in impacts to the environment. Because of these impacts, various potential sources of contamination that fall within the Lower Subase have been designated as sites and have been or are currently being investigated under the Navy's Installation Restoration Program (IRP). The IRP generally parallels the Comprehensive Environmental Response, Compensation, and Liability Act of 1980 (CERCLA) program.

Two base-wide RIs completed at NSB-NLON have included sample collection and analysis at the Lower Subase. A Phase I RI, which was performed by Atlantic Environmental in 1992, investigated several IRP sites at the Lower Subase as potential sources of fuel oil contamination. These sites included Site 10 - Fuel Oil Storage Tanks and Tank 54-H, Site 11 - Power Plant Oil Tanks, Site 13 - Building 79 Waste Oil Pit, and Site 17 - Hazardous/Flammable Materials Warehouse. The Phase I RI recommended further characterization of these sites. Subsequently, a Phase II RI was completed by B&R Environmental. The Phase II RI grouped the Lower Subase sites into four zones of investigation (Zones 1 through 4). Additional data gaps were identified in the Phase II RI and consequently, further characterization was again recommended for the Lower Subase sites and the adjacent Thames River.

The findings of these two RIs and other relevant investigations conducted at the Lower Subase and in the Thames River were summarized in the Existing Data Summary Report. The report was prepared and submitted by B&R Environmental on behalf of the Navy in March 1997. Three additional zones of investigation (Zones 5 through 7) within the Lower Subase that required further investigation were identified in the report. Five additional IRP sites (i.e., Site 19 - Solvent Storage Area, Site 21 - Berth 16 and Transformers at Building 157 Vault 31, Site 22 - Pier 33, Building 175, and Adjacent Property, Site 24 - Central Paint Accumulation Area, and Site 25 - Classified Materials Incinerator) are located within the boundaries of the three additional zones. The Existing Data Summary Report evaluated existing data for the Lower Subase and Thames River, identified remaining data gaps, and provided recommendations for filling the data gaps. The recommendations from the report were then used as the basis for developing the planning documents for this RI (i.e., Work Plan, Sampling and Analysis Plan, Quality Assurance Project Plan, and Health and Safety Plan).

The focus of the data collection activities of this RI is to characterize the subsurface conditions at the Lower Subase, to further characterize the quality of the sediment in the Thames River adjacent to the Lower Subase, and to provide data pertinent to identifying site-specific remedial alternatives. The data collected during this RI, in conjunction with data collected from previous investigations, are used for the following purposes:

- Identify the sources of soil and groundwater contamination.
- Define the major contaminant migration pathways.
- Define the nature and extent of contamination within the groundwater and soils at seven zones of investigation within the Lower Subase.
- Define the nature and extent of contamination in the sediments of the adjacent Thames River.
- Provide supplemental data to develop a revised human health risk assessment.
- Provide supplemental data to develop a revised ecological risk assessment for the Thames River.
- Provide sufficient information to identify proper recommendations for future action at each zone under the IRP.

ES.2 ZONE 1

This section presents a summary of major findings for Zone 1 of the Lower Subase. A summary of the nature and extent of contamination is provided in Section ES.2.1. Section ES.2.2 includes a summary of contaminant fate and transport information and Section ES.2.3 provides a synopsis of the baseline human health risk assessment for Zone 1. Section ES.2.4 provides recommendations regarding additional action and investigatory efforts for the soil and groundwater of Zone 1.

ES.2.1 Nature and Extent of Contamination

Metals, petroleum hydrocarbons, SVOCs, and VOCs were detected in Zone 1 soils. The types and concentrations of shallow and deep soil contaminants do not vary significantly. Maximum concentrations of a majority of deep soil metal contaminants were detected in the deep soil sample collected from well 13MW4, located northeast of Building 29 at the intersection of an existing fuel pipeline and a sanitary sewer line. Two areas of SVOC contamination exist within Zone 1. One area is located north of Site 11,

and the other is located west of Building 29. TPH contamination is widespread in both the shallow and deep soils and is most likely the result of leaking tanks in the areas of Sites 10 and 11.

Metals, petroleum hydrocarbons, SVOCs, and VOCs were also detected in the groundwater at Zone 1. The distribution of lead indicates that a small plume of lead contamination exists in the area between Building 89 and Site 11. VOCs and SVOCs were infrequently detected at low concentrations in the Zone 1 groundwater samples. The majority of SVOCs were detected in groundwater samples collected from well 13MW2, located east of Site 10. TPH and historical fluorescence data indicate that petroleum contamination exists in the groundwater beneath Sites 10 and 11, and the contamination may extend from the eastern side of Zone 1 to the Thames River. Free-phase product was detected in well 13MW18.

Storm sewer surface water samples, collected annually from Zone 1 as part of an NPDES monitoring program, were analyzed for copper, lead, zinc, oil and grease, and several miscellaneous parameters. The analyses shows a decrease in oil and grease concentrations over time. Copper, lead, and zinc were detected in all three surface water samples.

ES.2.2 Contaminant Fate and Transport

High concentrations of petroleum hydrocarbons and SVOCs, as well as inorganic concentrations in excess of background, have been detected in both the soil and the groundwater of Zone 1. Data from the Thames River, which is a downgradient receptor of Zone 1, indicates that mobile PAHs may have migrated from Zone 1 to the river. An evaluation of natural attenuation indicated that this process may be viable for the soil and groundwater because of the presence of biodegradable contaminants (i.e., petroleum hydrocarbons and SVOCs) and because key parameters indicate that the process is currently occurring in a portion of the groundwater. Therefore, a combination of monitored natural attenuation and a tiered groundwater monitoring program should be evaluated further as part of the remedial strategy for Zone 1.

The purpose of a tiered groundwater monitoring program is to monitor contaminant migration routes (e.g., the groundwater) from a site to determine if site-specific contaminants are impacting downgradient receptors via contaminant migration. A tiered groundwater monitoring program is typically implemented at a site, like Zone 1, that poses little risk to human health or the environment due to direct exposure, but has remaining source area concentrations that pose a potential contaminant migration problem. These programs have action levels, that if exceeded, trigger additional sampling activities in the media of downgradient areas (e.g., surface water and sediment of the Thames River) to verify if these media are being impacted by the site. The programs also include "decision trees" that provide the steps that will be

taken to evaluate monitoring data, to make changes to the monitoring program, and to modify the remedial strategy for the site. The end goal of a tiered groundwater monitoring program is to provide the long-term information that is necessary to determine if the selected remedial action for the site is acceptable.

ES.2.3 Baseline Human Health Risk Assessment

The baseline human health risk assessment for Zone 1 focused on three potential receptor groups: construction workers, full-time employees, and future residents. Noncarcinogenic risks for all receptor groups except one were less than the USEPA and CTDEP acceptable limit of one. The only noncarcinogenic risk exceedance was for the construction worker under the RME scenario, where the associated HI (1.5) slightly exceeded unity. However, based on an evaluation of target organ effects, toxic effects are not anticipated for the construction worker under the RME scenario. With the exception of the full-time employee and the future resident under the RME scenario, carcinogenic risks for all receptors were either less than 1E-6 or within the USEPA acceptable target risk range of 1E-4 to 1E-6. Cancer risks for the construction worker, full-time employee, and future resident under the RME scenario and future resident under the CTE scenario exceed the CTDEP acceptable cumulative risk level of 1E-5. PAHs and arsenic contribute significantly to the elevated cancer risks for these receptors. Benzo(a)pyrene and, to a lesser degree, dibenzo(a,h)anthracene are the major contributors to the elevated cancer risks.

Maximum detected concentrations of PAHs, metals, and TPH in soil exceeded their respective generic mobility criteria which indicates the potential exists for these chemicals to migrate from soil to groundwater. Although the maximum detected concentrations of benzo(a)anthracene, benzo(a)pyrene, benzo(b)fluoranthene, benzo(k)fluoranthene, and dibenzo(a,h)anthracene exceeded the generic mobility criteria, these chemicals were not detected in groundwater samples collected at Zone 1. The mobility of a few other PAHs and several inorganics may be supported by the groundwater data, but the SPLP results indicate that lead may not be mobile. The maximum detected concentration of chromium exceeded the generic mobility criteria but was within background levels.

Maximum concentrations in groundwater were compared to Connecticut salt water WQSs since Zone 1 borders the Thames River. Several migration COCs in groundwater were identified as exceeding the Connecticut salt water WQSs. Use of the Connecticut salt water WQSs to determine groundwater impacts on the Thames River is very conservative since the WQSs do not account for the dilutional effects of the groundwater mixing with the river. Appropriate alternative surface water protection criteria can be calculated by multiplying the lower of the human health or aquatic life criterion in the latest Connecticut WQSs by a site-specific dilution factor. Recently calculated site-specific dilution factors for the DRMO (Site 6) and Goss Cove Landfill (Site 8), other NSB-NLON IRP sites located along the Thames River, were

226 and 118, respectively. The maximum detected concentrations of most migration COCs (benzene, bis(2-ethylhexyl)phthalate, cadmium, lead, nickel, silver, thallium, and zinc) are within one order of magnitude of the Connecticut WQSs. Therefore, the actual impact on water quality in the Thames River is expected to be minimal because significant dilution is anticipated, thereby reducing chemical concentrations in the Thames River.

ES.2.4 Recommendations

It is recommended that this zone, which includes Site 10 - Fuel Storage Tanks and Tank 54-H and Site 11 - Power Plant Oil Tanks, proceed to a feasibility study for evaluation of appropriate remedial alternatives for the soil. Because of the extensive amount of underground utilities in Zone 1 and the nature of the activities conducted at this location (i.e., national security), the feasibility study for this zone should evaluate to the extent possible passive and/or in-situ remedial alternatives and the use of institutional controls. In addition, "hot spot" removal actions, in lieu of full-scale excavation, should also be considered in the Zone 1 Feasibility Study. It is also recommended that the feasibility study evaluate limited action scenarios for the groundwater and storm sewer system of Zone 1 in conjunction with the soil remedial alternatives. The scenarios evaluated for the groundwater should include free-phase product removal from monitoring well 13MW18 and a monitored natural attenuation/tiered groundwater monitoring program. The scenario for the storm sewer system should include cleaning and repair of the system. These recommendations are based on the following information:

- The nature and extent of organic and inorganic contamination in the soil is well defined to the extent practical considering infrastructure limitations.

- The baseline human health risk assessment indicates that noncarcinogenic risks for the construction worker under the RME scenario slightly exceed 1.0. The assessment also shows that the carcinogenic risks for the construction worker, full-time employee and the hypothetical future resident under the RME scenario and for the hypothetical future resident under the CTE scenario are in excess of the CTDEP cumulative target risk level. In addition, the carcinogenic risk for the full-time employee and hypothetical future resident under the RME scenario exceeds the USEPA target risk range.

- Based on a comparison of analytical results with conservative, generic mobility criteria, organic and inorganic contamination in the soil has the potential to migrate and impact the groundwater at this site. Groundwater analytical data confirm these screening results and indicate that limited migration is currently occurring.

- Monitored natural attenuation or bioremediation could be feasible alternatives for the petroleum contamination in the soil.

- Significant amounts of petroleum contamination remain in the soils of Zone 1; however, the historical source(s) of petroleum contamination have been eliminated (i.e., the leaking Site 10 and 11 USTs, the Building 89 UST, and the fuel distribution line have been removed and/or repaired). The Navy has implemented leak detection systems for all USTs and conducts regular pressure testing and repairs on the fuel distribution lines.

- The zone is generally covered with pavement or buildings, which minimizes direct exposure to the contaminated soil by human receptors.

- The groundwater at Zone 1 is not currently or anticipated to be used in the future as a potable water source because it is brackish; therefore, there is no imminent threat to human health.

- The ecological risk assessment for the Thames River adjacent to Zone 1 (see Section 11.0) and the baseline human health risk assessment for Zone 2 (see Section 5.0), which are both downgradient receptors of Zone 1, show that the risks to ecological and human receptors in these adjacent areas are currently minor. In addition, the Thames River provides significant dilution and mixing which minimizes the impact of any contaminant migration from Zone 1.

- Free-phase petroleum product was only detected in well 13MW18 during the latest round of sampling.

- Key parameters indicate that natural attenuation processes are at work in the groundwater of Zone 1 and these processes can reduce concentrations of petroleum contamination that reach the aquifer and convert the petroleum contamination to a less toxic form. Monitored natural attenuation should be further evaluated as part of the remedial strategy for the Zone 1 to confirm the effectiveness of these processes. The monitored natural attenuation program should include or be part of a tiered groundwater monitoring program, similar to the ones currently being implemented at other NSB-NLON IRP sites. These programs confirm or disprove that contamination present in the soil is mobile and impacting other media and allow for further actions to be completed if the results show significant impacts.

- The storm sewer system in Zone 1 may be acting as a migration pathway for contaminants present in the groundwater. Analytical results from one catch basin sampled as part of the NPDES permit indicate that several inorganics (i.e., copper, lead, and zinc) are frequently present in the surface

water discharged from Zone 1 and these three metals were identified as groundwater COCs for Zone 1. A limited evaluation of the invert elevations of the storm sewer system indicate that portions of the system are submerged by varying amounts during a given day or time of year. Because of the age of parts of the system (i.e., greater than 40 years) and the material that it was constructed with (i.e., vitrified clay), it is likely that the system is cracked and groundwater will infiltrate into the storm sewers.

ES.3 ZONE 2

This section presents a summary of major findings for Zone 2 of the Lower Subase. A summary of the nature and extent of contamination is provided in Section ES.3.1. Section ES.3.2 includes a summary of contaminant fate and transport information and Section ES.3.3 provides a synopsis of the baseline human health risk assessment for Zone 2. Section ES.3.4 provides recommendations regarding additional action and investigatory efforts for the soil and groundwater of Zone 2.

ES.3.1 Nature and Extent of Contamination

In summary, the analytical results indicate frequent detections of high molecular weight PAHs, TPH, and lead in Zone 2 shallow soil samples. The PAH and TPH data are suggestive of fuel oil contamination, perhaps from the fuel oil pipeline running through Zone 2 to Pier 8. Remediation of lead-contaminated soil was conducted at Building 31 (in Zone 3). It is likely that lead contamination in soil and groundwater in the southwestern corner of Zone 2 may be related to past lead contamination at Building 31. The infrequent detections and generally low concentrations of metals and SVOCs in groundwater samples collected from Zone 2 indicate that significant contamination of the groundwater system beneath Zone 2 has not occurred.

ES.3.2 Contaminant Fate and Transport

High concentrations of petroleum hydrocarbons and SVOCs, as well as inorganic concentrations in excess of background, have been detected in the soil of Zone 2. Analytical results from the groundwater sampling activities indicate that the contamination in the soil is generally not migrating to the groundwater. Data from adjacent zones (i.e., Zone 1 and Zone 3) suggest that Zone 2 may be the recipient of cross-contamination from these zones. Zone 1 may be contributing petroleum contamination to the northern end of Zone 2, and Zone 3 may be contributing lead contamination to the southern end of Zone 2. The Thames River, which is downgradient of Zone 2, showed some potential evidence of cross-contamination with some detections of inorganics and PAHs. An evaluation of natural attenuation indicated that this process may be viable for the soil because of the presence of biodegradable contaminants (i.e., petroleum

hydrocarbons and SVOCs). Key parameters indicate that natural attenuation is occurring in a limited portion of the groundwater of Zone 2; however, petroleum-related compounds were generally not detected in the groundwater. Therefore, a tiered groundwater monitoring program versus monitored natural attenuation may be an option that could be evaluated further as part of the remedial strategy for Zone 2.

ES.3.3 Baseline Human Health Risk Assessment

The baseline human health risk assessment for Zone 2 focused on three potential receptor groups: construction workers, full-time employees, and future residents. Noncarcinogenic risks for all receptor groups were less than the USEPA and CTDEP acceptable limit of one. Carcinogenic risks for all receptors were either less than or within the USEPA's acceptable target risk range of 1E-4 to 1E-6. With the exception of the future resident, all cancer risks were less than the CTDEP acceptable risk level of 1E-5. Benzo(a)pyrene, dibenzo(a,h)anthracene, and arsenic were the main contributors to the cancer risk for the full time employee and the future resident. The majority of the cumulative incremental cancer risks for the identified potential receptors were less than 1E-6. Only the cancer risk estimates developed for the full-time employee (RME case only) and the hypothetical future resident (RME case only) exceed 1E-6. Although the results of the risk assessment modeling for lead indicate that this chemical may be of concern for future construction workers, actual exposures for this receptor are not expected to be significant. Exposure to lead during construction activities is expected to be reduced via dust-control measures, personal protective equipment, etc.

Maximum detected concentrations of methylene chloride, PAHs, metals, and TPH in soil exceeded their respective generic mobility criteria which indicates the potential exists for these chemicals to migrate from soil to groundwater. Although the maximum detected concentrations of methylene chloride and PAHs exceeded the generic mobility criteria, these chemicals were not detected in groundwater samples collected at Zone 2. The mobility of some of the inorganic COCs may be supported by the groundwater data and TCLP soil data. The maximum detected concentration of arsenic and chromium exceeded the generic mobility criteria but were within background levels.

Maximum concentrations in groundwater were compared to Connecticut salt water WQSs since Zone 2 borders the Thames River. Several migration COCs in groundwater were identified as exceeding the Connecticut salt water WQSs. Use of the Connecticut salt water WQSs to determine groundwater impacts on the Thames River is very conservative since the WQSs do not account for the dilutional effects of the groundwater mixing with the river. Appropriate alternative surface water protection criteria can be calculated by multiplying the lower of the human health or aquatic life criterion in the latest Connecticut WQSs by a site-specific dilution factor. Recently calculated site-specific dilution factors for the DRMO

(Stie 5) and Goss Cove Landfill (Site 8), other NSB-NLON IRP sites located along the Thames River, were 226 and 118, respectively. The maximum detected concentrations of most migration COCs (tetrachloroethene, antimony, lead, nickel, and zinc) are within one order of magnitude of the Connecticut WQSs. Therefore, the actual impact on water quality in the Thames River is expected to be minimal because significant dilution is anticipated, thereby reducing chemical concentrations in the Thames River.

ES.3.4 Recommendations

It is recommended that this zone, which includes only the fuel distribution pipeline as a potential source, proceed to a feasibility study. Because of the extensive amount of underground utilities in Zone 2 and the nature of the activities conducted at this location (i.e., national security), the feasibility study for this zone should evaluate to the extent possible alternatives that include institutional controls to limit exposure to contaminated soil and a tiered groundwater monitoring program to verify that significant contaminant migration is not occurring. Cleaning and repair of the Zone 2 storm sewer system should also be evaluated during the feasibility study. These recommendations are based on the following information:

- The nature and extent of organic and inorganic contamination in the soil and groundwater are well defined to the extent practical considering infrastructure limitations.

- The baseline human health risk assessment indicates that there are minimal risks to human receptors. There are no risks in excess of the USEPA acceptable risk range, and only the risk to the hypothetical future resident under the RME scenario slightly exceeds the CTDEP risk level. In addition, the modeling completed to evaluate the exposure to lead indicates that the exposure to lead from this site is not expected to be significant.

- Although reported concentrations of TPH in site soil samples exceeded the state RSRs for direct exposure and pollutant mobility, the chemical-specific risk assessment for those compounds assumed to be major constituents of the observed TPH contamination indicated minimal risks to potential receptors.

- The groundwater at Zone 2 is not currently or anticipated to be used in the future as a potable water source because it is brackish; therefore, there is no imminent threat to human health.

- Evidence suggests that organic contamination is generally not migrating from the site and that natural attenuation processes are at work in the southwestern portion of the Zone 2 aquifer. The data also indicates that limited inorganic contamination may be migrating from the site. Groundwater monitoring

will verify that natural attenuation processes are working to minimize the migration of organic contaminants and will confirm or disprove the potential inorganic contaminant migration problem.

- A tiered groundwater monitoring program will allow for further actions to be completed if the results show significant impacts.

- The ecological risk assessment for the Thames River adjacent to Zone 2 (See Section 11.0) shows that the risks to ecological receptors in this area are relatively low.

- The Thames River provides significant dilution and mixing which minimizes the impact of any contaminant migration from Zone 2.

- The Navy conducts regular pressure testing and repairs on the fuel distribution lines; therefore, the historical source of petroleum contamination has most likely been eliminated.

- A limited evaluation of the invert elevations of the storm sewer system indicate that portions of the system are submerged by varying amounts during a given day or time of year. Because of the age of parts of the system (i.e., greater than 40 years) and the material that it was constructed with (i.e., vitrified clay), it is likely that the system is cracked and groundwater will infiltrate into the storm sewers. Therefore, the storm sewer system may act as a contaminant migration pathway.

- The zone is generally covered with pavement or buildings, which minimizes direct exposure to the contaminated soil by human receptors.

ES.4 ZONE 3

This section presents a summary of major findings for Zone 3 of the Lower Subase. A summary of the nature and extent of contamination is provided in Section ES.4.1. Section ES.4.2 includes a summary of contaminant fate and transport information and Section ES.4.3 provides a synopsis of the baseline human health risk assessment for Zone 3. Section ES.4.4 provides recommendations regarding additional action and investigatory efforts for the soil and groundwater of Zone 3.

ES.4.1 Nature and Extent of Contamination

High concentrations of lead were detected in the shallow and deep soil samples collected from Zone 3. The high concentrations are most likely the result of historic operations at Building 31. Although a majority of soil under and adjacent to Building 31 has been remediated, some soils in the vicinity of Building 31 still

have elevated levels of lead. SVOCs, primarily PAHs, were also detected at relatively high concentrations in both shallow and deep soil samples collected from Zone 3. Based on the locations where the majority of maximum concentrations were detected, it appears that the SVOC contamination may be associated with the fuel pipeline that runs along the eastern side of Building 78. TPH was also detected in soil, with higher concentrations detected in soils along Bullhead Road from Argonaut to Albacore and along Albacore from Capelin to Bullhead Road. Sources of the petroleum contamination are likely pipeline leaks within Zones 3 and 4 and UST leaks within Zone 4. Based on the analytical data available for groundwater samples, it appears that neither SVOCs nor TPH have migrated to groundwater. Lead was detected at concentrations up to 392 µg/L in groundwater collected from beneath Building 31. This concentration was detected in an unfiltered sample taken from a temporary well installed inside of Building 31. Data from temporary wells are considered to be "screening" data. The maximum concentration of lead detected in groundwater samples collected outside of Building 31 was 10.5 µg/L (filtered sample from permanent well MW2-3RI, located on the western side of Building 31 along Albacore Road).

ES.4.2 Contaminant Fate and Transport

High concentrations of petroleum hydrocarbons and SVOCs, as well as inorganic concentrations in excess of background, have been detected in the soil of Zone 3. Analytical results from the groundwater sampling activities indicate that the petroleum hydrocarbons in the soil are generally not migrating to the groundwater but that the inorganic contamination (including lead) may be migrating to the groundwater and to downgradient locations. The data are inconclusive regarding lead cross-contamination from Zone 3 (Building 31) to Zone 2. It is likely that the lead contamination in both zones is the result of historical waste handling practices. It is possible that Zone 4 may be contributing petroleum contamination to the southern end of Zone 3. The Thames River, which is downgradient of Zone 3, showed some potential evidence of cross-contamination with some detections of inorganics and PAHs. An evaluation of natural attenuation indicated that this process may be viable for the soil because of the presence of biodegradable contaminants (i.e., petroleum hydrocarbons and SVOCs). Key parameters indicate that natural attenuation is occurring in a limited portion of the groundwater of Zone 3; however, petroleum-related compounds were generally not detected in the groundwater. Therefore, a tiered groundwater monitoring program versus monitored natural attenuation may be an option that could be evaluated further as part of the remedial strategy for Zone 3.

ES.4.3 Baseline Human Health Risk Assessment

The baseline human health risk assessment for Zone 3 focused on three potential receptor groups: construction workers, full-time employees, and future residents. Noncarcinogenic risks for all receptor groups were less than the USEPA and CTDEP acceptable limit of one. Carcinogenic risks for all

receptors at all zones were either less than or within USEPA's acceptable target risk range of 1E-4 to 1E-6. The cancer risk for future residents under the RME scenario slightly exceeded the CTDEP target risk level of 1E-5. Benzo(a)pyrene and arsenic are the major contributors to the cancer risk for this receptor. Chemical-specific cancer risks for these two chemicals plus dibenzo(a,h)anthracene, benzo(a)anthracene, benzo(b)fluoranthene, and indeno(1,2,3,cd)pyrene exceed 1E-6.

Lead was detected at concentrations exceeding the 400 mg/kg OSWER soil screening level for residential land use. Evaluation of lead using the IEUBK model for children and the interim slope-factor approach for adults indicates that adverse health effects are anticipated for small children and fetuses of female workers who maybe exposed to lead in shallow and subsurface soil at Zone 3.

Maximum detected concentrations of methylene chloride, PAHs, metals, and TPH in soil exceeded their respective generic mobility criteria which indicates the potential exists for these chemicals to migrate from soil to groundwater. Although the maximum detected concentrations of methylene chloride and PAHs exceeded the generic mobility criteria, these chemicals were not detected in groundwater samples collected at Zone 3. The mobility of some of the inorganic COCs may be supported by the groundwater data and TCLP/SPLP soil data. The maximum detected concentration of antimony and chromium exceeded the generic mobility criteria but were within background levels.

Maximum concentrations in groundwater were compared to Connecticut salt water WQSs since Zone 3 borders the Thames River. Several migration COCs in groundwater were identified as exceeding the Connecticut salt water WQSs. Use of the Connecticut salt water WQSs to determine groundwater impacts on the Thames River is very conservative since the WQSs do not account for the dilutional effects of the groundwater mixing with the river. Appropriate alternative surface water protection criteria can be calculated by multiplying the lower of the human health or aquatic life criterion in the latest Connecticut WQSs by a site-specific dilution factor. Recently calculated site-specific dilution factors for the DRMO (Site 6) and Goss Cove Landfill (Site 8), other NSB-NLON IRP sites located along the Thames River, were 226 and 118, respectively. The maximum detected concentrations of most migration COCs (lead, nickel, and zinc) are within one order of magnitude of the Connecticut WQSs. Therefore, the actual impact on water quality in the Thames River is expected to be minimal because significant dilution is anticipated, thereby reducing chemical concentrations in the Thames River.

ES.4.4 Recommendations

It is recommended that this zone, which includes Site 17 (Building 31) and the fuel distribution pipeline, proceed to a feasibility study. Because of the extensive amount of underground utilities in Zone 3 and the

nature of the activities conducted at this location (i.e., national security), the feasibility study for this zone should evaluate to the extent possible alternatives that include institutional controls to limit exposure to contaminated soil and a tiered groundwater monitoring program to verify that significant contaminant migration is not occurring. "Hot Spot" removal actions for the lead contamination and cleaning and repair of the Zone 3 storm sewer system should also be evaluated during the feasibility study. These recommendations are based on the following information:

- The nature and extent of organic and inorganic contamination in the soil and groundwater are well defined to the extent practical considering infrastructure limitations.

- The baseline human health risk assessment indicates that the risks associated with Zone 3 are within the USEPA acceptable risk range. There are carcinogenic risks in excess of the CTDEP target risk level to human receptors, but only under the hypothetical future resident scenario. In addition, modeling performed to evaluate exposure to lead showed that sensitive receptors to lead exposure (i.e., children and fetuses of pregnant women) are only at risk in Zone 3 under a future hypothetical scenario, which assumes that soils currently covered by pavement or buildings are available for exposure. Institutional controls and/or "hot spot" removal actions could be used to eliminate this exposure route.

- Although reported concentrations of TPH in site soil samples exceeded the state RSRs for direct exposure and pollutant mobility, the chemical-specific risk assessment for those compounds assumed to be major constituents of the observed TPH contamination indicated minimal risks to potential receptors.

- The groundwater at Zone 3 is not currently or anticipated to be used in the future as a potable water source because it is brackish; therefore, there is no imminent threat to human health.

- The data does not suggest that the petroleum contamination in the soil is significantly migrating to the groundwater. In addition, natural attenuation processes seem to be at work in the groundwater. These processes can reduce concentrations of petroleum contamination that reach the aquifer and convert the petroleum contamination to a less toxic form. Groundwater monitoring will confirm this information.

- Inorganics are potentially migrating from the Zone 3 to the Thames River. However, the ecological risk assessment for the Thames River adjacent to Zone 3 (See Section 11.0) shows that the risks to

ecological receptors in the sediment adjacent to Zone 3 are relatively low and that lead is not a significant threat to the ecological receptors. Groundwater monitoring will confirm this information.

- A tiered groundwater monitoring program will allow for further actions to be completed if the results show significant impacts.

- The Thames River provides significant dilution and mixing which minimizes the impact of any contaminant migration from Zone 3.

- The Navy completed a time-critical removal action on soil contaminated with lead underneath and adjacent to Building 31; therefore, a majority of the lead-contaminated soil that historically acted as a source of contamination to other media has been remediated.

- The Navy conducts regular pressure testing and repairs on the fuel distribution lines; therefore, the historical source of petroleum contamination has most likely been eliminated.

- The zone is covered with pavement or buildings, which minimizes direct exposure to the contaminated soil by human receptors.

ES.5 ZONE 4

This section presents a summary of major findings for Zone 4 of the Lower Subase. A summary of the nature and extent of contamination is provided in Section ES.5.1. Section ES.5.2 includes a summary of contaminant fate and transport information and Section ES.5.3 provides a synopsis of the baseline human health risk assessment for Zone 4. Section ES.5.4 provides recommendations regarding additional action and investigatory efforts for the soil and groundwater of Zone 4.

ES.5.1 Nature and Extent of Contamination

Two general areas of lead contamination in shallow soils were identified within Zone 4. These areas are in the northwestern corner of Zone 4 (west of Building 80) and in the north central portion of Zone 4 (east of Building 79). Concentrations of lead detected in the TCLP leachates of shallow soils collected from these two areas exceeded both the Federal toxicity characteristic regulatory level and the Connecticut remediation standard pollutant mobility criterion for lead. Lead contamination in deep soil samples within Zone 4 is less pervasive than lead contamination in Zone 4 shallow soils. Lead contamination is evident in Zone 4 deep soils in the northwestern corner of Zone 4 and north of Building 85. The maximum concentration of lead detected in Zone 4 deep soils is roughly five times less than the maximum concentration of lead detected in

Zone 4 shallow soils. The source(s) of lead contamination in Zone 4 may be the former waste oil pit at Building 79, Building 31 (the site of a lead removal action that was conducted in Zone 3), or historical waste disposal practices.

Little VOC contamination is evident in Zone 4 soils. An area of PAH contamination in the shallow soils south of Building 85 near the southern end of the quay wall is evident based on the results of the shallow soil sample collected from well MW1-4RI. However, concentrations of PAHs detected in the deep soil sample collected from well MW1-4RI are from 50 to 100 times less than respective PAH concentrations detected in the shallow soil sample from this well.

TPH contamination is evident in the shallow soils at the western edge of Zone 4 along the Thames River, with the greatest concentrations of TPH present in the shallow soils west of Building 80. TPH contamination in Zone 4 deep soils is more widespread, with high levels of TPH contamination in Zone 4 deep soils along Albacore Road and Bluefish Road. Sources of TPH contamination are likely to be fuel pipeline leaks and the pit at Building 79.

Three small areas of lead contamination were noted in the groundwater system beneath Zone 4, based on groundwater data collected during the Lower Subase RI. These areas are along the quay wall northwest of Building 85, at the northeastern corner of Building 85, and along the western side of Building 79. Very little VOC or SVOC contamination was noted in the groundwater samples collected from Zone 4. TPH was detected in historic groundwater samples collected from well 13MW16 (at concentrations decreasing from 5,400 µg/L to 700 µg/L over time) and in the groundwater sample collected from well WE1 at a concentration of 500 µg/L during Round 2 of the Phase II RI. A time-critical removal action was completed by the Navy in this zone in 1994. It was estimated that 800-gallons of petroleum product were removed from zone 4 during the action. TPH was not detected in any of the groundwater samples collected during the Lower Subase RI.

ES.5.2 Contaminant Fate and Transport

High concentrations of petroleum hydrocarbons and SVOCs, as well as inorganic concentrations in excess of background, have been detected in the soil of Zone 4. Analytical results from the groundwater sampling activities indicate that the petroleum hydrocarbons and inorganics (mainly lead) in the soil may be migrating to the groundwater and to downgradient locations. The analytical results for the storm sewer near Building 85 also indicate that lead is migrating via the storm sewer from Zone 4. Lead data from Zones 3 and 4 suggest that historical waste disposal practices at Building 31 in Zone 3 have contaminated the soil in both zones and that cross-contamination is probably not occurring. It is possible that Zone 4 may be contributing petroleum contamination to the southern end of Zone 3. The Thames River, which is

downgradient of Zone 4, showed some potential evidence of cross-contamination with some detections of inorganics and PAHs. An evaluation of natural attenuation indicated that this process is feasible for the soil because of the presence of biodegradable contaminants (i.e., petroleum hydrocarbons and SVOCs). Key parameters indicate that natural attenuation is occurring in a limited portion of the groundwater of Zone 4; however, petroleum-related compounds were generally not detected in the groundwater. Therefore, a tiered groundwater monitoring program versus monitored natural attenuation may be an option that could be evaluated further as part of the remedial strategy for Zone 4.

ES.5.3 Baseline Human Health Risk Assessment

The baseline human health risk assessment for Zone 4 focused on three potential receptor groups: construction workers, full-time employees, and future residents. Noncarcinogenic risks for all receptor groups were less than the USEPA and CTDEP acceptable limit of one. Carcinogenic risks for all receptors were either less than or within the USEPA's acceptable target risk range of 1E-4 to 1E-6 except for the future resident under the RME scenario. The cancer risk for the full-time employee and future resident under the RME scenario exceeded the CTDEP acceptable cumulative cancer risk level of 1E-5. PAHs and arsenic (via incidental ingestion and dermal contact with soil) are the main contributors to the cancer risk for these receptors.

Lead was identified as a COC for soil and groundwater at Zone 4. Evaluation of lead using the IEUBK model for children and the interim slope-factor approach for full-time employees indicates that adverse health effects are anticipated for these receptors from exposure to lead in Zone 4 soil.

The calculated risks for Zone 4 under current site conditions (full-time employees) are to some degree overestimated. Most of the soil samples collected from the site and used in the risk assessment were collected from locations beneath pavement. Currently, these soils are not exposed and available for human contact.

Maximum detected concentrations of PAHs, metals, and TPH in soil exceeded their respective generic mobility criteria which indicates the potential exists for these chemicals to migrate from soil to groundwater. Although the maximum detected concentrations of PAHs exceeded the generic mobility criteria, these chemicals were detected infrequently in groundwater samples (i.e., in less than 8 percent of the samples) collected at Zone 4. The mobility of lead may be supported by the groundwater data and TCLP soil data.

Maximum chemical concentrations in groundwater were compared to Connecticut salt water WQSs since Zone 4 borders the Thames River. Several migration COCs in groundwater were identified as exceeding the Connecticut salt water WQSs. Use of the Connecticut salt water WQSs to determine groundwater impacts on the Thames River is very conservative since the WQSs do not account for the dilutional effects of the groundwater mixing with the river. Appropriate alternative surface water protection criteria can be calculated by multiplying the lower of the human health or aquatic life criterion in the latest Connecticut WQSs by a site-specific dilution factor. Recently calculated site-specific dilution factors for the DRMO (Site 6) and Goss cove Landfill (Site 8), other NSB-NLON IRP sites located along the Thames River, were 226 and 118, respectively. The maximum detected concentrations of most migration COCs [1,1-dichloroethene, methylene chloride, vinyl chloride, bis(2-ethylhexyl)phthalate, antimony, cadmium, chromium, nickel, and thallium] are within one order of magnitude of the Connecticut WQSs. Therefore, the actual impact on water quality in the Thames River is expected to be minimal because significant dilution is anticipated, thereby reducing chemical concentrations in the Thames River.

ES.5.4 Recommendations

It is recommended that this zone, which includes Site 13 - Building 79 Waste Oil Pit, Site 19 - Solvent Storage Area (Building 316), the Quay Wall Study Area, and the fuel distribution pipeline, proceed to a feasibility study to evaluate appropriate remedial alternatives. Because of the extensive amount of underground utilities in Zone 4 and the nature of the activities conducted at this location (i.e., national security), the feasibility study for this zone should evaluate to the extent possible alternatives that include institutional controls to limit exposure to contaminated soil and passive and/or in-situ remedial alternatives. In addition, "hot spot" removal actions, in lieu of full-scale excavation, should be considered in the Zone 4 feasibility study. A tiered groundwater monitoring program and cleaning and repair of the Zone 4 storm sewer system should also be evaluated during the feasibility study. These recommendations are based on the following information:

- The nature and extent of organic and inorganic contamination in the soil and groundwater are well defined to the extent practical considering infrastructure limitations.

- The baseline human health risk assessment indicates that there are carcinogenic risks associated with Zone 4 that exceed the USEPA acceptable risk range (i.e., the hypothetical future resident RME scenario) and CTDEP target risk level (i.e., the full-time employee and hypothetical future resident RME scenarios). In addition, modeling performed to evaluate exposures to lead showed that sensitive receptors for lead exposure (i.e., small children and fetuses of pregnant working women) are at risk in Zone 4. All the elevated risks (for lead and other chemicals) were calculated for a future exposure

scenario where soils currently covered by pavement or buildings are available for human contact. Institutional controls and/or "hot spot" removal actions could be used to eliminate this exposure route.

- Evidence suggests that limited organic and inorganic contamination is migrating from the site. Natural attenuation seems to be occurring in the groundwater of Zone 4 and is most likely reducing the concentration and magnitude of petroleum hydrocarbons migrating from the site. Groundwater monitoring will confirm natural attenuation and potential inorganic migration.

- Natural attenuation or bioremediation could be feasible alternatives for the petroleum contamination in the soil.

- A tiered groundwater monitoring program will allow for further actions to be completed if the results show significant impacts.

- The ecological risk assessment for the Thames River adjacent to Zone 4 (see Section 11.0) shows that the risks to ecological receptors in this area are relatively low.

- The Thames River provides significant dilution and mixing which minimizes the impact of contaminant migration from Zone 4.

- The Navy removed the waste oil pit at Building 79 and filled the area in with concrete. A recovery well system was installed and operated for a short time in this area. In addition, approximately 800 gallons of petroleum product was removed via pumping from the quay wall area during a removal action in 1994.

- The Navy currently conducts regular pressure testing and repairs on the fuel distribution lines; therefore, the historical source of petroleum contamination has most likely been eliminated.

- The zone is covered with pavement or buildings, which minimizes the potential for direct exposure to the contaminated soil by human receptors.

- The groundwater at Zone 4 is not currently or anticipated to be used in the future as a potable water source because it is brackish; therefore, there is no imminent threat to human health.

- The storm sewer system in Zone 4 may be acting as a migration pathway for contaminants present in the groundwater. Analytical results from one catch basin sampled as part of the NPDES permit

indicate that lead has been detected at low concentrations in the surface water discharged from Zone 4 and lead was identified as a groundwater COC for Zone 4. A limited evaluation of the invert elevations of the storm sewer system indicate that portions of the system are submerged by varying amounts during a given day or time of year. Because of the age of parts of the system (i.e., greater than 40 years) and the material that it was constructed with (i.e., vitrified clay), it is likely that the system is cracked and groundwater will infiltrate into the storm sewers.

ES.6 ZONE 5

This section presents a summary of major findings for Zone 5 of the Lower Subase. A summary of the nature and extent of contamination is provided in Section ES.6.1. Section ES.6.2 includes a summary of contaminant fate and transport information and Section ES.6.3 provides a synopsis of the baseline human health risk assessment for Zone 5. Section ES.6.4 provides recommendations regarding additional action and investigatory efforts for the soil and groundwater of Zone 5.

ES.6.1 Nature and Extent of Contamination

Contamination originating from the tank on the southern side of Building 175 is evident at Zone 5. This contamination may be from a tank leak or from spillage during tank filling. TPH and SVOCs, primarily PAHs, are the predominant contaminants detected in this area. To a lesser degree, contamination originating from the tank adjacent to the north of Building 175 is also evident based on analytical results for SVOCs in soil samples. Lead was detected at concentrations exceeding the Connecticut remediation standard pollutant mobility criteria for GB classified groundwater in the TCLP leachates of samples collected near each of these two tanks (19SS1 and 19MW2). However, SPLP leachates of samples collected near these tanks (TB1-5RI and TB6-5RI) did not yield concentrations of lead exceeding Federal or state standards. Contaminated sediments collected from the storm sewers in this zone generally contained the highest concentrations of contaminants. Lead in particular was detected at concentrations as high as 85,600 mg/kg. Contamination in the storm sewers may be related to recent activities at the site. Groundwater results indicated that the soil contamination has only had minor impacts on groundwater quality.

ES.6.2 Contaminant Fate and Transport

VOCs, SVOCs, and petroleum hydrocarbons, as well as a few inorganic concentrations in excess of background, have been detected in the soil of Zone 5. Analytical results from the groundwater sampling activities indicate that the petroleum hydrocarbons in the soil have migrated to the groundwater. The Thames River, which is downgradient of Zone 5, showed some potential evidence of cross-contamination

from SVOCs. An evaluation of natural attenuation indicated that this process is viable for the soil because of the presence of biodegradable contaminants (i.e., petroleum hydrocarbons and SVOCs. Key parameters indicated that natural attenuation is occurring in a limited portion of the groundwater of Zone 5 and petroleum-related compounds were detected in the groundwater. Therefore, a combination of monitored natural attenuation and a tiered groundwater monitoring program should be evaluated further as part of the remedial strategy for Zone 5.

ES.6.3 Baseline Human Health Risk Assessment

The baseline human health risk assessment for Zone 5 focused on three potential receptor groups: construction workers, full-time employees, and future residents. Noncarcinogenic risks for all receptor groups were less than the USEPA and CTDEP acceptable limit of one. Carcinogenic risks for all receptors at all zones were either less than or within USEPA's acceptable target risk range (1E-4 to 1E-6). With the exception of the future resident under the RME scenario, all cancer risks were less than the CTDEP acceptable cumulative risk level of 1E-5. Benzo(a)pyrene, benzo(b)fluoranthene, dibenzo(a,h)anthraene, and arsenic were the main contributors to the cancer risk for the future resident.

Maximum detected concentrations of VOCs, PAHs, metals, and TPH in soil exceeded their respective generic mobility criteria which indicates the potential exists for chemicals to migrate form soil to groundwater. Although the maximum detected concentrations of methylene chloride, benzo(a)anthracene, benzo(a)pyrene, benzo(b)fluoranthene, carbazole, dibenzo(a,h)anthracene, indeno(1,2,3-cd)pyrene, chromium, and nickel exceeded the generic mobility criteria, these chemicals were not detected in groundwater samples collected at Zone 5. The mobility of naphthalene may be supported by the groundwater data. The maximum detected concentration of arsenic and chromium exceeded the generic mobility criteria but were within background levels.

Maximum concentrations in groundwater were compared to Connecticut salt water WQSs since Zone 5 borders the Thames River. Several migration COCs in groundwater were identified as exceeding the Connecticut salt water WQSs. Use of the Connecticut salt water WQSs to determine groundwater impacts on the Thames River is very conservative since the WQSs do not account for the dilutional effects of the groundwater mixing with the river. Appropriate alternative surface water protection criteria can be calculation by multiplying the lower of the human health or aquatic life criterion in the latest Connecticut WQSs by a site-specific dilution factor. Recently calculated site-specific dilution factors for the DRMO (Site 6) and Goss Cove Landfill (Site 8), other NSB-NLON IRP sites located along the Thames River, were 226 and 118, respectively. The maximum detected concentrations of some migration COCs (copper and zinc) are within one order of magnitude of the Connecticut WQSs. Therefore, the actual impact on water

quality in the Thames River is expected to be minimal because significant dilution is anticipated, thereby reducing chemical concentrations in the Thames River. In addition most migration COCs were detected infrequently in groundwater samples (i.e., one or two samples).

ES.6.4 Recommendations

It is recommended for this zone, which includes Site 22 - Pier 33, Building 175 and adjacent property, proceed to a feasibility study to evaluate appropriate remedial alternatives. Because of the extensive amount of underground utilities in Zone 5 and the nature of the activities conducted at this location (i.e., national security), the feasibility study for this zone should evaluate to the extent possible alternatives that include institutional controls to limit exposure to contaminated soil and passive and/or in-situ remedial alternatives. A "hot spot" removal action for the petroleum contamination in the soil of Zone 5 should also be included in one of the alternatives evaluated during the feasibility study. It is also recommended that the feasibility study evaluate limited action scenarios for the groundwater and storm sewer system of Zone 5 in conjunction with the soil remedial alternatives. A combination of monitored natural attenuation and a tiered groundwater monitoring program should be evaluated for the groundwater. Cleaning and repair of the Zone 5 storm sewer system should also be considered during the feasibility study. These recommendations are based on the following information:

- The nature and extent of organic and inorganic contamination in the soil and groundwater are well defined to the extent practical considering infrastructure limitations.

- The contamination detected at Zone 5 is related to the former UST used to store heating oil and not to the battery acid ASTs that were in Building 175. The UST has been replaced; therefore, the main source of the contamination has been eliminated.

- Monitored natural attenuation or bioremediation could be feasible alternatives for the petroleum contamination in the soil.

- Evidence suggests that limited organic contamination may be migrating from the site. Natural attenuation processes seem to be at work in the groundwater. These processes can reduce concentrations of petroleum contamination that reach the aquifer and convert the petroleum contamination to a less toxic form. Monitored natural attenuation should be further evaluated as part of the remedial strategy for the Zone 5 to confirm the effectiveness of these processes. The monitored natural attenuation program should include or be part of a tiered groundwater monitoring program, similar to the ones currently being implemented at other NSB-NLON IRP sites. These programs

confirm or disprove that contamination present in the soil is mobile and impacting other media and allow for further actions to be completed if the results show significant impacts.

- The baseline human health risk assessment indicates that there are minimal risks to human receptors. None of the risks were in excess of the USEPA acceptable risk range; but the risk to the hypothetical future resident under the RME scenario slightly exceeded the CTDEP risk level. In addition, lead was not a COC for this zone; therefore, modeling was not necessary to evaluate exposure to lead.

- Although reported concentrations of TPH in site soil samples exceeded the state RSRs for direct exposure and pollutant mobility, the chemical-specific risk assessment for those compounds, assumed to be the major constituents of the observed TPH contamination, indicated minimal risks to potential human receptors.

- The zone is generally covered with pavement and a building, which minimizes direct exposure to the contaminated soil by human receptors.

- Elevated levels of inorganics, particularly lead, were detected in the sediment collected from a catch basin between Zones 5 and 6. Both zones contribute surface water to this catch basin. Slightly elevated levels of inorganics were also detected in the surface water samples collected from the storm sewer system for the NPDES permit. Therefore, the storm sewer system in Zone 5 may be acting as a migration pathway for inorganic contaminants. The lead contamination is believed to be the result of storage of lead ballast in this area and surface water runoff. The Navy has eliminated the storage of ballast in this area.

- A limited evaluation of the invert elevations of the storm sewer system indicate that portions of the system are submerged by varying amounts during a given day or time of year. Because of the age of parts of the system (i.e., greater than 40 years) and the material that it was constructed with (i.e., vitrified clay), it is likely that the system is cracked and groundwater will infiltrate into the storm sewers.

- The ecological risk assessment for the Thames River adjacent to Zone 5 (See Section 11.0) shows that the risks to ecological receptors in this area are relatively low.

- The groundwater at Zone 5 is not currently or anticipated to be used in the future as a potable water source because it is brackish; therefore, there is no imminent threat to human health.

- The Thames River provides significant dilution and mixing which minimizes the impact of contaminant migration from Zone 5.

ES.7 ZONE 6

This section presents a summary of major findings for Zone 6 of the Lower Subase. A summary of the nature and extent of contamination is provided in Section ES.7.1. Section ES.7.2 includes a summary of contaminant fate and transport information and Section ES.7.3 provides a synopsis of the baseline human health risk assessment for Zone 6. Section ES.7.4 provides recommendations regarding additional action and investigatory efforts for the soil and groundwater of Zone 6.

ES.7.1 Nature and Extent of Contamination

Low levels of contamination are evident in Zone 6. TPH and SVOCs, primarily PAHs, were the primary contaminants detected in this area. The locations where the greatest concentrations of metals, SVOCs, and TPH were detected varied per analytical fraction among shallow soil samples. However, the greatest concentrations of SVOCs and TPH in deep soil samples and of SVOCs and metals in groundwater samples were reported for samples collected from well MW2-6RI, located south of Building 174.

ES.7.2 Contaminant Fate and Transport

Petroleum hydrocarbons and SVOCs, as well as a few inorganic concentrations in excess of background, have been detected in the soil of Zone 6. Analytical results from the groundwater sampling activities indicate that the petroleum hydrocarbons in the soil are generally not migrating to the groundwater but that inorganic contamination may be migrating to the groundwater and to downgradient locations. The Thames River, which is downgradient of Zone 6, showed some potential evidence of cross-contamination from inorganics. An evaluation of natural attenuation indicated that this process is viable for the soil because of the presence of biodegradable contaminants (i.e., petroleum hydrocarbons and SVOCs). Key parameters indicate that natural attenuation is occurring in a limited portion of the groundwater of Zone 6; however, petroleum-related compounds were detected infrequently and at low concentrations in the groundwater. Therefore, a tiered groundwater monitoring program versus monitored natural attenuation may be an option that could be evaluated further as part of the remedial strategy for Zone 6.

ES.7.3 Baseline Human Health Risk Assessment

The baseline human health risk assessment for Zone 6 focused on three potential receptor groups: construction workers, full-time employees, and future residents. Noncarcinogenic risks for all receptor

groups were less than the USEPA and CTDEP acceptable limit. Carcinogenic risks for all receptors were either less than or within USEPA's acceptable target risk range of 1E-4 to 1E-6. With the exception of the future resident under the RME scenario all cancer risks were less than CTDEP acceptable risk level of 1E-5. Benzo(a)pyrene and arsenic were the main contributors to the cancer risk for the future resident.

Maximum detected concentrations of PAHs, metals, and TPH in soil exceeded their respective generic mobility criteria which indicates the potential exists for these chemicals to migrate from soil to groundwater. Although the maximum detected concentrations of benzo(a)anthracene, benzo(a)pyrene, benzo(b)fluoranthene, dibenzo(a,h)anthracene, indeno(1,2,3-cd)pyrene, arsenic, and nickel exceeded the generic mobility criteria, these chemicals were not detected in groundwater samples collected at Zone 6. The mobility of chromium may be supported by the groundwater data. The maximum detected concentration of arsenic and chromium exceeded the generic mobility criteria but were within background levels.

Maximum concentrations in groundwater were compared to Connecticut salt water WQSs since Zone 6 borders the Thames River. Several migration COCs in groundwater were identified as exceeding the Connecticut salt water WQSs. Use of the Connecticut salt water WQSs to determine groundwater impacts on the Thames River is very conservative since the WQSs do not account for the dilutional effects of the groundwater mixing with the river. Appropriate alternative surface water protection criteria can be calculated by multiplying the lower of the human health or aquatic life criterion in the latest Connecticut WQSs by a site-specific dilution factor. Recently calculated site-specific dilution factors for the DRMO (Site 6) and Goss Cove Landfill (Site 8), other NSB-NLON IRP sites located along the Thames River, were 226 and 118, respectively. The maximum detected concentrations of some migration COCs (thallium and zinc) are within one order of magnitude of the Connecticut WQSs. Therefore, the actual impact on water quality in the Thames River is expected to be minimal because significant dilution is anticipated, thereby reducing chemical concentrations in the Thames River. In addition most migration COCs were detected infrequently in groundwater samples (i.e., one or two samples).

ES.7.4 Recommendations

It is recommended that this zone, which includes Site 24 - Central Paint Accumulation Area, proceed to a feasibility study to evaluate appropriate remedial alternatives. Because of the extensive amount of underground utilities in Zone 6 and the nature of the activities conducted at this location (i.e., national security), the feasibility study for this zone should evaluate to the extent possible alternatives that include institutional controls to limit exposure to contaminated soil and passive and/or in-situ remedial alternatives. It is also recommended that the feasibility study evaluate limited action scenarios for the groundwater and

storm sewer system of Zone 6 in conjunction with the soil remedial alternatives. A tiered groundwater monitoring program and cleaning and repair of the Zone 6 storm sewer system should be evaluated during the feasibility study. These recommendations are based on the following information:

- The nature and extent of organic and inorganic contamination in the soil are well defined to the extent practical considering infrastructure limitations. Organic and inorganic contamination was infrequently detected at low concentrations in the groundwater.

- The contaminants generally detected at Zone 6 are related to petroleum hydrocarbons and not to the historic operations at Site 24 - Central Paint Accumulation Area.

- The baseline human health risk assessment indicates that there are minimal risks to human receptors and they are not in excess of the USEPA acceptable risk range and only the hypothetical future resident under the RME scenario slightly exceeds the CTDEP risk level. In addition, lead was not a COC for this zone; therefore, modeling was not necessary to evaluate exposure to lead.

- Although reported concentrations of TPH in site soil samples exceeded the state RSRs for direct exposure and pollutant mobility, the chemical-specific risk assessment for those compounds assumed to be the major constituents of the observed TPH contamination (PAHs) indicated minimal risks to potential human receptors.

- Evidence suggests that organic contamination is generally not migrating from the site but that limited inorganic contamination may be migrating from the site. Natural attenuation processes seem to be at work in the groundwater. These processes can reduce concentrations of petroleum contamination that reaches the aquifer and convert the petroleum contamination to a less toxic form. Groundwater monitoring will confirm natural attenuation and the limited migration of inorganics.

- A tiered groundwater monitoring program will allow for further actions to be completed if the results show significant impacts.

- The ecological risk assessment for the Thames River adjacent to Zone 6 (see Section 11.0) shows that the risks to ecological receptors in this area are relatively low.

- The Thames River provides significant dilution and mixing which minimizes the impact of any contaminant migration from Zone 6.

- The zone is generally covered with pavement and a building, which minimizes direct exposure to the contaminated soil by human receptors.

- The groundwater at Zone 6 is not currently or anticipated to be used in the future as a potable water source because it is brackish; therefore, there is no imminent threat to human health.

- Elevated levels of inorganics, particularly lead, were detected in the sediment collected from a catch basin between Zones 5 and 6. Both zones contribute surface water to this catch basin. Slightly elevated levels of inorganics were also detected in the surface water samples collected from the storm sewer system for the NPDES permit. Therefore, the storm sewer system in Zone 6 may be acting as a migration pathway for inorganic contaminants. The lead contamination is believed to be the result of storage of lead ballast in this area and surface water runoff. The Navy has eliminated the storage of ballast in this area.

- A limited evaluation of the invert elevations of the storm sewer system indicate that portions of the system are submerged by varying amounts during a given day or time of year. Because of the age of parts of the system (i.e., greater than 40 years) and the material that it was constructed with (i.e., vitrified clay), it is likely that the system is cracked and groundwater will infiltrate into the storm sewers.

ES.8 ZONE 7

This section presents a summary of major findings for Zone 7 of the Lower Subase. A summary of the nature and extent of contamination is provided in Section ES.8.1. Section ES.8.2 includes a summary of contaminant fate and transport information and Section ES.8.3 provides a synopsis of the baseline human health risk assessment for Zone 7. Section ES.8.4 provides recommendations regarding additional action and investigatory efforts for the soil and groundwater of Zone 7.

ES.8.1 Nature and Extent of Contamination

A large area of lead contamination was identified based on analytical data for both shallow and deep soils collected within Zone 7. This area covers most of the eastern half of Zone 7. The greatest concentrations of lead in Zone 7 shallow soils were noted along the western side of Building 456 and the greatest concentrations of lead in Zone 7 deep soils were noted in the area surrounding the eastern side of Building 157. Concentrations of lead in the soils within this area of contamination are greater than lead concentrations detected in soils in all other zones of the Lower Subase. Lead contamination was also

noted in the groundwater samples collected from this area, particularly in the unfiltered groundwater samples collected along the western side of Building 456.

Two general areas of TPH contamination were identified in Zone 7 soils. These areas are in the northwestern corner of Zone 7 and in the southern third of Zone 7. TPH contamination in Zone 7 shallow soils is more widespread and is present at greater concentrations than TPH contamination in Zone 7 deep soils.

Several SVOCs, primarily PAHs, were detected in Zone 7 shallow and deep soil samples. Pesticides were also noted in shallow and deep soil samples collected from two borings located along the eastern boundary of Zone 7. Based on the analytical results of the off-site, upgradient shallow soil sample, it is likely that the source of pesticide contamination is from off-site activities. Dioxin was also detected in one Zone 7 shallow soil sample.

Little organic contamination was noted in Zone 7 groundwater samples. As previously noted, two areas of lead contamination were identified, based analytical data for groundwater samples collected from Zone 7.

Several inorganics, PAHs, and TPH were detected in the two sediment samples collected from the storm drains within Zone 7. The exact source of these contaminants is not known.

ES.8.2 Contaminant Fate and Transport

Petroleum hydrocarbons and SVOCs, as well as inorganic concentrations in excess of background (namely lead), have been detected in the soil of Zone 7. Geostatistical analysis of the soil data indicates that contamination in Zone 7 may be impacting regions outside the zone. Analytical results from the groundwater sampling activities indicate that the petroleum hydrocarbons in the soil are generally not migrating to the groundwater but that inorganics (namely lead) are migrating to the groundwater. The Thames River, which is downgradient of Zone 7, showed some potential evidence of cross-contamination from PAHs and inorganics. Lead, which was detected in the soil and groundwater of Zone 7, was not a contaminant of concern in the Thames River. An evaluation of natural attenuation indicated that this process is feasible for the soil because of the presence of biodegradable contaminants (i.e., petroleum hydrocarbons and SVOCs). Key parameters indicate that natural attenuation is occurring in limited portions of the groundwater of Zone 7; however, petroleum-related compounds were detected infrequently and at low concentrations in the groundwater. Therefore, a tiered groundwater monitoring program versus monitored natural attenuation may be an option that could be evaluated further as part of the remedial strategy for Zone 7.

ES.8.3 Baseline Human Health Risk Assessment

The baseline human health risk assessment for Zone 7 focused on three potential receptor groups: construction workers, full-time employees, and future residents. Noncarcinogenic risks for all receptor groups were less than the USEPA and CTDEP acceptable limit of one, except for the construction workers under the RME scenario. Although the RME HI for the construction workers slightly exceeded unity, adverse impacts are not anticipated since the major contributors (antimony and manganese) to the cumulative risk do not affect the same target organs. Cumulative risks to each individual target organ are expected to be less than unity. The cancer risk for the full-time employee and future resident under the RME scenario exceeded the USEPA target risk range of 1E-4 to 1E-6 and the CTDEP cumulative target risk level of 1E-5. Cancer risks for all other receptors were within or less than the USEPA and CTDEP target risk levels. The elevated risks are attributable to PAHs and arsenic in soil.

Lead was detected at concentrations exceeding the 400 mg/kg OSWER soil screening level for residential land use and the 15 µg/L federal drinking water Action Level. Evaluation of lead using the IEUBK model for children and the interim slope-factor approach for adult workers indicates that adverse health effects are anticipated for these receptors from exposure to lead in Zone 7 soil.

Calculated risks associated with current soil exposure (for full-time employees) are overestimated to some degree. Although the risk assessment was conducted using all soil data collected from Zone 7, most of the soil samples were obtained from locations beneath pavement. Under current site conditions, potential receptors would not be exposed to these soils.

Maximum detected concentrations of PAHs, metals, and TPH in soil exceeded their respective generic mobility criteria which indicates the potential exists for these chemicals to migrate from soil to groundwater. Although the maximum detected concentrations of methylene chloride, benzo(a)anthracene, benzo(a)pyrene, benzo(b)fluoranthene, benzo(k)fluoranthene, and indeno(1,2,3-cd)pyrene exceeded the generic mobility criteria, these chemicals were not detected in groundwater samples collected at Zone 7. The mobility of the remaining PAHs and the inorganics may be supported by the groundwater data.

Maximum concentrations in groundwater were compared to Connecticut salt water WQSs since Zone 7 borders the Thames River. Several migration COCs in groundwater were identified as exceeding the Connecticut salt water WQSs. Use of the Connecticut salt water WQSs to determine groundwater impacts on the Thames River is very conservative since the WQSs do not account for the dilutional effects

of the groundwater mixing with the river. Appropriate alternative surface water protection criteria can be calculated by multiplying the lower of the human health or aquatic life criterion in the latest Connecticut WQSs by a site-specific dilution factor. Recently calculated site-specific dilution factors for the DRMO (Site 6) and Goss Cove Landfill (Site 8), other NSB-NLON IRP sites located along the Thames River, were 226 and 118, respectively. The maximum detected concentrations of some migration COCs (antimony, copper, nickel, thallium, and zinc) are within one order of magnitude of the Connecticut WQSs. Therefore, the actual impact on water quality in the Thames River by these chemicals is expected to be minimal because significant dilution is anticipated, thereby reducing chemical concentrations in the Thames River. In addition organic migration COCs were detected infrequently in groundwater samples (i.e., less than 11 percent of the samples).

ES.8.4 Recommendations

It is recommended that this zone, which includes Site 21 - Berth 16, Site 25 - Classified Materials Incinerator, and Transformers at Building 157, Vault 31, proceed to a feasibility study for evaluation of appropriate remedial alternatives for the soil. Because of the extensive amount of underground utilities in Zone 7 and the nature of the activities conducted at this location (i.e., national security), the feasibility study for this zone should evaluate to the extent possible alternatives that include institutional controls to limit exposure to contaminated soil and passive and/or in-situ remedial alternatives. "Hot Spot" removal actions for the lead contamination should also be evaluated during the feasibility study. In addition, it is recommended that the feasibility study evaluate limited action scenarios for the groundwater and storm sewer system of Zone 7 in conjunction with the soil remedial alternatives. The scenarios should include a tiered groundwater monitoring program and cleaning and repair of the Zone 7 storm sewer system. These recommendations are based on the following information:

- The nature and extent of organic and inorganic contamination in the soil are well defined to the extent practical considering infrastructure limitations.

- The baseline human health risk assessment indicates that carcinogenic risks for full-time employees and hypothetical future residents under the RME scenario are in excess of the USEPA acceptable risk range and the CTDEP cumulative target cancer risk level. In addition, modeling performed to evaluate exposure to lead showed that all receptors (i.e., small children, fetuses of pregnant women, future employees, and construction workers) are at risk in Zone 7. These elevated risks (for lead, as well as other chemicals) assume that sometime in the future soils currently covered by pavement or buildings are exposed and available for human contact.

- Evidence suggests that inorganic contamination (mainly lead) is migrating from the soil to the groundwater.

- Natural attenuation or bioremediation could be feasible alternatives for the petroleum contamination in the soil.

- The Navy has decommissioned the fuel lines that were once within Zone 7. Therefore, the historic source of petroleum contamination has been eliminated.

- The zone is covered with pavement or buildings, which minimizes direct exposure to the contaminated soil by human receptors.

- The data do not suggest that the petroleum contamination in the soil is significantly migrating to the groundwater. In addition, natural attenuation processes seem to be at work in the groundwater. These processes can reduce concentrations of petroleum contamination that reach the aquifer and convert the petroleum contamination to a less toxic form. Groundwater monitoring will confirm this information.

- A tiered groundwater monitoring program will allow for further actions to be completed if the results show significant impacts.

- The source of the lead contamination in the groundwater is the unsaturated soil of Zone 7. Appropriate remedial alternatives for the Zone 7 soil will be evaluated in the feasibility study. Once the appropriate actions are taken, concentrations of lead in the groundwater will decrease. Furthermore, the ecological risk assessment for the Thames River adjacent to Zone 7 (see Section 11.0) shows that the risks to ecological receptors in the sediment adjacent to Zone 7 are relatively low and that lead is not a significant threat to ecological receptors. Groundwater monitoring will confirm this information.

- The groundwater at Zone 7 is not currently or anticipated to be used in the future as a potable water source because it is brackish; therefore, there is no imminent threat to human health.

- The Thames River provides significant dilution and mixing which minimizes the impact of any contaminant migration from Zone 7.

- A limited evaluation of the invert elevations of the storm sewer system indicate that portions of the system are submerged by varying amounts during a given day or time of year. Because of the age of parts of the system (i.e., greater than 40 years) and the material that it was constructed with (i.e., vitrified clay), it is likely that the system is cracked and groundwater will infiltrate into the storm sewers.

ES.9 THAMES RIVER

This section presents a summary of major findings for the Thames River. A summary of the nature and extent of contamination is provided in Section ES.9.1. Section ES.9.2 includes a summary of contaminant fate and transport information and Section ES.9.3 provides a synopsis of the baseline human health risk assessment. A brief summary of the ecological risk assessment is provided in Section ES.9.4 and Section ES.9.5 provides recommendations for the Thames River.

ES.9.1 Nature and Extent of Contamination

Little variation in the nature and extent of contamination was noted for surface water samples collected from upstream to downstream locations in the Thames River. Organic compounds (trichloroethene, butylbenzyl phthalate, di-n-butyl phthalate, and endrin aldehyde) were detected infrequently and at low concentrations (i.e., ranging from 0.14 µg/L to 3 µg/L). Several metals were detected in the surface water samples. However, with the possible exceptions of aluminum, iron, and manganese concentrations in surface water samples collected near the DRMO, the water quality near NSB-NLON does not appear to differ significantly from the water quality noted at locations distant from NSB-NLON.

The range of concentrations of most inorganics detected in sediments near the Lower Subase were similar to the range of concentrations of inorganics detected in other sections of the river, including the areas upstream and downstream of the Lower Subase. Maximum concentrations of some inorganics in a few zones were elevated relative to other sections of the river, including upstream of the base. Maximum concentrations of chromium (240 mg/kg), copper (1,570 mg/kg), lead (406 mg/kg), mercury (3.1 mg/kg), and zinc (1,150 mg/kg) detected in Zone 7 sediment samples were from three to 20 times greater than respective maximum concentrations detected in the upstream sediment samples. The maximum concentration of lead detected in sediment samples collected from Zone 3 was 1,380 mg/kg; lead contamination in this zone is most likely associated with Building 31 (a building located within Zone 3 of the Lower Subase where a lead removal action was conducted). In addition, chromium, lead, and zinc were detected in sediment samples collected from Zone 4 at concentrations of 400 mg/kg, 569 mg/kg, and 1,650 mg/kg, respectively. However, with the exception of lead and zinc (for which maximum concentrations detected in sediments collected from the downstream area were approximately two times

greater than respective concentrations in upstream sediment samples), concentrations of metals detected in sediment samples collected from the downstream area were similar to concentrations of metals detected in sediment samples collected from the upstream area.

Only three VOCs were detected in Thames River sediment samples. Acetone and 2-butanone, which are both common laboratory contaminants, were detected in sediment samples collected from more than half of the zones. Acetone (ranging from 18 µg/kg to 640 µg/kg) was detected in nine of 12 sediment samples analyzed for VOCs. These included samples from each location, with the lowest concentrations in the DRMO and upstream locations and the highest concentrations detected in the areas of Berth 16 and the Lower Subase. 2-Butanone was detected at concentrations ranging from 30 µg/kg to 190 µg/kg in sediment samples collected from several zones. The highest concentrations of 2-butanone were detected in sediment samples collected in the areas near Berth 16 and the Lower Subase. Carbon disulfide (0.007 mg/kg) was detected in sediment sample T3SD1 (collected near Goss Cove).

PAHs were by far the most prevalent organic compounds detected in Thames River sediment samples. Increases in the concentrations of PAHs detected in sediment samples were noted for samples collected from zones adjacent to the Lower Subase RI. In general, the maximum concentrations of PAHs were detected in the composite sample collected from location P2/P3, which is located adjacent to Lower Subase Zone 7. Phenanthrene was detected in this sample at a concentration of 25,000 µg/kg. Elevated concentrations of PAHs were also noted for samples collected from Zones 3 and 4. In general, fluoranthene and pyrene were detected at higher concentrations than all the other PAHs. However, no additional impact was observed downstream. Concentrations of PAHs detected in the sediment samples collected from near Goss Cove and the downstream area were similar to concentrations of PAHs detected in sediment samples collected from the upstream area. 4-Methylphenol, carbazole, dibenzofuran, phenol, and phthalate esters were also sporadically detected in sediment samples at concentrations ranging from concentration below the CRQL (330 µg/kg) to 11,000 µg/kg.

Analysis for TPH was not performed for a large number of Thames River sediment samples. TPH was detected in three of four sediment samples collected from Zone 5 at concentrations ranging from 1,420 mg/kg to 27,981 mg/kg. TPH was also detected in sediment samples collected from locations adjacent to the DRMO (103 mg/kg), Zone 6 (589 mg/kg), and Zone 4 (589 mg/kg).

Several pesticides, at concentrations ranging from 3.1 µg/kg to 110 µg/kg, were detected in Thames River sediment samples collected from a majority of the zones. However, the frequency of detection of pesticides in sediment samples was generally below 50 percent. 4,4'-DDT and related compounds were most frequently detected. The greatest concentrations of pesticides were detected in samples collected

from locations adjacent to the DRMO. As discussed in the Phase II RI report, 4,4'-DDT and related compounds were frequently detected in sediment samples collected from streams located within the Area A Downstream Site of NSB-NLON. Two streams that originate in the Area A Downstream Site discharge into the Thames River in the vicinity of the DRMO Zone and Zone 5. Therefore, the pesticides detected in Thames River sediment samples collected adjacent to the DRMO may have originated in the Area A Downstream Site.

PCBs (Aroclor 1248, Aroclor 1254, and Aroclor 1260) were detected at concentrations ranging from 12 to 170 µg/kg in samples collected from Zone 7 only. Building 157, Vault 31, located within Zone 7, was a transformer area.

Ribbed mussels were deployed in cages for 28 days. Although this period may have not have allowed tissue concentrations to reach equilibrium, this exposure period was long enough for these organisms to accumulate biologically available contaminants for comparison to control samples. Analyses of the mussels indicated that chemical constituents were present. However, those same constituents were also detected at relatively the same concentrations in the control mussel samples. Mercury detected in a sample collected near Goss Cove and semivolatile compounds detected in the caged mussel samples adjacent to the Lower Subase represent two exceptions.

Chemical contaminants were also detected in native shellfish samples. However, the results were generally inconclusive in establishing a link with contamination detected at NSB-NLON. PAHs were detected in one blue mussel sample located adjacent to the Lower Subase. This may be indicative of impacts from NSB-NLON. A majority of the native shellfish samples were collected from the commercial shellfish beds that were located either across the Thames River on the other side of NSB-NLON or somewhat upstream of NSB-NLON. No commercial shellfish beds are located near NSB-NLON for sampling and monitoring purposes.

ES.9.2 Contaminant Fate and Transport

Sediments in the Thames River in the vicinity of NSB-NLON located downgradient of Zones 1 through 7 showed some potential evidence of cross-contamination with detections of inorganics and PAHs. In general, concentrations of PAHs and inorganics detected in Thames River sediment samples did not differ significantly from upstream to downstream locations. Although the data indicate that site-related chemicals have migrated from the site to the Thames River, it does not appear that site-related chemicals have significantly impacted areas downstream of the site.

ES.9.3 Baseline Human Health Risk Assessment

The baseline human health risk assessment for Thames River focused on adult recreational users. Noncarcinogenic risks were greater than the USEPA and CTDEP acceptable level of one for ingestion of shellfish and finfish. Arsenic, cadmium, and zinc were the main contributors to the HI. The cancer risk for the adult recreational user under the RME scenario exceed the USEPA target range of 1E-4 to 1E-6 and the CTDEP acceptable target risk level of 1E-5. The cancer risk for the CTE scenario also exceeded the CTDEP target cancer level but was within the USEPA target risk range. Arsenic (via incidental ingestion of clams and oysters) was the main contributor to the cancer risk. Incremental cancer risks for this chemical exceeded target risk levels (i.e., the upper limit of the USEPA target risk range and the 1E-5 CTDEP cumulative target cancer level).

The estimated risks associated with shellfish (oysters and clams) ingestion are overestimated to some degree. For the purposes of this risk assessment, exposure to shellfish was assumed to occur. However, individuals are not permitted to harvest shellfish from the Thames River near the Lower Subase. Also, there are no licensed recreational shellfishing areas in the Thames River.

ES.9.4 Ecological Risk Assessment

Ecological risk assessments were performed for sediments in each of the seven zones near the Lower Subase. Maximum and average concentrations of contaminants detected in sediments from each zone were compared to both conservative and less conservative ecological guidelines. Historical ecological data from each zone, including toxicity testing, benthic macroinvertebrate analyses, and bioaccumulation studies, were also assessed, when available. A weight of evidence approach was used to assess potential risks that incorporated the results of the guideline screening and historical ecological analyses in each zone.

The weight of evidence indicated that potential risks to sediment-dwelling receptors were present from contaminants in Zones 1, 2, 3, 5, and 6 near the Lower Subase but were relatively low. Potential risks were present also in Zones 4 and 7 near the Lower Subase and were low to moderate. Potential risks in Zone 7 may have been ameliorated by recent dredging activities. For the most part, potential risks among all zones were confined to some metals, primarily arsenic, chromium, and mercury. Maximum and average acid-volatile sulfide (AVS) concentrations exceeded maximum and average semi-extractable metals (SEM) concentrations in all zones, suggesting that cadmium, copper, nickel, lead, and zinc were not bioavailable in sediments near the Lower Subase. The PAH compound benzo(a)pyrene was also determined to pose low to moderate risks among the zones.

Contaminant concentrations and the results of the ecological analyses conducted using sediments from the seven zones as a whole near the Lower Subase were compared to contaminant concentrations and ecological analyses conducted in other sections of the Thames River. The other sections of the Thames River that were investigated included upstream and downstream of NSB-NLON, near Goss Cove, and near the DRMO. The weight-of-evidence approach was used to determine whether the seven zones as a whole posed potential risks to sediment-dwelling receptors in the Thames River.

Similar to the Thames River sediments near the Lower Subase, AVS concentrations exceeded SEM concentrations at all locations in other sections of the Thames River where they were analyzed. In general, the range of contaminant concentrations in sediments near the Lower Subase was similar to the range of concentrations in other sections of the Thames River. Only some spotty elevated concentrations of a few metals and benzo(a)pyrene were present near the Lower Subase relative to other sections of the river. On the whole, the results of the benthic invertebrate analyses, shellfish bioaccumulation studies, and toxicity testing conducted using sediments near the Lower Subase were similar to those in other sections of the river, with a few exceptions. These included significant mortality in a toxicity test sample near Pier 17 (Zone 7) and Pier 33 (Zone 5), decreased benthic abundance near Pier 17, and elevated boron in two blue mussel samples collected near Zone 4. Again, potential risks near Pier 17 may have been reduced by recent dredging activities.

The weight of evidence suggests that potential risks are present in sediments near the Lower Subase as a whole. However, the risks are low to moderate and are generally similar to those in sections of the Thames River that do not appear to be influenced by NSB-NLON.

ES.9.5 Recommendations

It is recommended that the Thames River adjacent to the Lower Subase proceed to a Feasibility Study. A limited action scenario should be evaluated in the Feasibility Study for the river adjacent to Zones 1, 2, 3, 5, and 6. The limited action recommendation indicates that the river should be further evaluated only if the recommended zone-specific, tiered groundwater monitoring programs indicate potential migration problems. If migration problems are identified, further evaluation of the Thames River should include additional surface water and sediment sampling and testing. A Data Gap Investigation is recommended for the Thames River adjacent to Zones 4 and 7. The investigation should include additional sediment sampling and testing. The results of the investigation should be combined with the results of this RI to determine the overall risks to ecological receptors adjacent to Zones 4 and 7 and the appropriate remedial alternatives to be evaluated in the Feasibility Study. If risks are shown to be significant in a zone-specific segment of the river as a result of additional testing, an active remedial action such as "hot spot" removal

should be considered as an alternative for that segment of the river. These recommendations are based on the following information:

- The nature and extent of organic and inorganic contamination in the sediment adjacent to Zones 1, 2, 3, 5, and 6 is sufficiently characterized, but further characterization of the sediment adjacent to Zones 4 and 7 is required.

- The quality of the surface water near NSB-NLON does not appear to differ significantly from the water quality noted at locations distant from NSB-NLON.

- The baseline human health risk assessment for exposure to surface water in the Thames River indicates that noncarcinogenic risks could be greater than the USEPA and CTDEP acceptable level of one for ingestion of shellfish and finfish and that carcinogenic risks could be greater than the USEPA acceptable target risk range and the CTDEP acceptable target risk level for incidental ingestion of clams and oysters. These risks are generally overestimated because exposure to shellfish was assumed to occur; however, individuals are not permitted to harvest shellfish from the Thames River near the Lower Subase and there is no recreational shellfishing areas in the Thames River.

- The zone-specific ecological risk assessments, which considered only the Lower Subase RI data and the Phase II RI data, indicate that the risks to ecological receptors are low, with the exception of Zones 4 and 7, where the estimated risks are low to moderate. All calculated HQs were less than 12.0.

- The overall Thames River ecological risk assessment, which considered all data available from recent and historic sampling events, indicates that there are potential risks to sediment dwelling organisms near the Lower Subase but that most of the risks are low and are generally similar to those in sections of the river that do not appear to be influenced by NSB-NLON.

- There is some uncertainty associated with the estimated risks because there are other significant potential sources of contamination to the Thames River upstream and downstream of the Lower Subase and NSB-NLON. The Thames River is tidally influenced and these other sources may be contributing to the contamination detected near the Lower Subase.

- The depth of the Thames River within the navigational channel is maintained so that vessels can navigate the Thames River to various ports. The depth is maintained via dredging. Dredging activities are also completed along the piers of the Lower Subase to allow submarines to dock at the

piers. Dredging occurs approximately once every 10 to 15 years. It is likely that the recent dredging activities completed along the Lower Subase for the new class of submarine removed historically contaminated sediments.

ES.10 OVERALL SUMMARY AND CONCLUSIONS

This section presents an overall summary of the conclusions and recommendations that were reached for the 7 zones and the Thames River that were investigated as part of the Lower Subase RI. Table ES-1 provides a brief synopsis of the recommendations for each of the sites studied. The table identifies the sites, the recommendations for the sites, and provides the rationales for the recommendations.

As shown in Table ES-1, it is recommended that all zones proceed to feasibility studies to evaluate appropriate remedial alternatives for soil, groundwater, and storm sewer systems. For the soil of each zone, a combination of three alternatives is suggested for further evaluation in the feasibility study. The alternatives include institutional controls, passive or insitu technologies, and "hot spot" removal actions. Zone-specific information (i.e., magnitude of risks, type and distribution of contaminants, contaminant migration potential, infrastructure interferences, and nature of activities conducted at the zone) was used to select the appropriate combination of alternatives for each zone. Zone-specific recommendations are provided below:

- Feasibility studies for the soil of Zones 1, 3, 4, 5, and 7 should evaluate a combination of all three alternatives.

- Feasibility study for the soil of Zone 2 should evaluate only institutional controls.

- Feasibility study for the soil of Zone 6 should evaluate institutional controls and passive or insitu technologies.

A combination of three alternatives are recommended for further evaluation in the zone-specific feasibility studies for groundwater and they include free-phase product removal, tiered groundwater monitoring program, and monitored natural attenuation. These recommendations were made using zone-specific information such as the type and distribution of contamination in the groundwater, presence of free-phase product, contaminant migration potential, and the results of the natural attenuation evaluation. The groundwater monitoring program will be tiered and will provide specific criteria that will be used to trigger moving to the next tier. The second tier will include additional surface water and sediment sampling in the Thames River. If warranted, a subsequent tier would include evaluation of "hot spot" removal actions in

the Thames River. A similar tiered groundwater monitoring program is currently being enacted at another NSB-NLON IRP site (i.e., DRMO) along the Thames River. Zone-specific recommendations are provided below:

- Feasibility study for the groundwater of Zone 1 should evaluate all three alternatives.
- Feasibility study for the groundwater of Zones 2, 3, 4, 6 and 7 should evaluate a tiered groundwater monitoring program.
- Feasibility study for the groundwater of Zone 5 should evaluate monitored natural attenuation and tiered groundwater monitoring program.

Cleaning and repair of the storm sewer systems are recommended for each zone. This recommendation was made based on the following information:

- Elevated levels of inorganics were detected in the sediment of a catch basin between Zones 5 and 6.
- The analytical results from the NPDES permit sampling showed some elevated levels of inorganics and other contaminants in the surface water being discharged from the Lower Subase.
- The age and inverts of the storm sewer systems suggest that the system may act as a migration pathway for contaminated groundwater.

The Thames River adjacent to the Lower Subase should proceed to a Feasibility Study. A limited action scenario should be evaluated in the Feasibility Study for the Thames River adjacent to Zones 1, 2, 3, 5, and 6. For this scenario, no additional actions are recommended at the current time based on the results of the human health and ecological risk assessments, but additional surface water and sediment sampling or "hot spot" removal actions could be completed as part of the tiered groundwater sampling programs for the zones, if the data warrants. The human health risk assessment showed that there are elevated risks to human receptors from the Thames River surface water, but the risks are thought to be overestimated because the exposure route (i.e., ingestion of shellfish) that contributed significantly to the risks is considered to be hypothetical and overly conservative. The zone-specific and overall ecological risk assessments indicate that the current risks to sediment dwelling ecological receptors adjacent to Zones 1, 2, 3, 5, and 6 are low. A Data Gap Investigation is recommended for the Thames River adjacent to Zones 4 and 7. The investigation should include additional sediment sampling and testing. This recommendation is based on the results of the ecological risk assessment which indicates that the current

risks to sediment dwelling ecological receptors adjacent to Zones 4 and 7 are low to moderate. The results of the investigation should be combined with the results of this RI to determine the overall risks to ecological receptors adjacent to Zones 4 and 7 and the appropriate remedial alternatives to be evaluated in the Feasibility Study.

TABLE ES-1

SUMMARY OF RECOMMENDATIONS
LOWER SUBASE RI
NSB-NLON, GROTON, CONNECTICUT
PAGE 1 OF 2

Site	Recommended Action	Rationale
Zone 1	SO – FS (IC, PA/IN, HSRA) GW – FS (FP, MNA, LA) SS – FS (CR)	ARARs exceeded; elevated risks to human receptors; free-phase product in groundwater; groundwater is not used as a potable water source; contaminant migration occurring; and low risks to ecological receptors.
Zone 2	SO – FS (IC) GW – FS (LA) SS – FS (CR)	ARARs exceeded; risks to human receptors are minimal; groundwater is not used as a potable water source; potential contaminant migration; and low risks to ecological receptors.
Zone 3	SO – FS (IC, PA/IN, HSRA) GW – FS (LA) SS – FS (CR)	ARARs exceeded; risks to human receptors are minimal; groundwater is not used as a potable water source; time-critical removal action was completed to remediate lead contamination problem; remaining lead still poses risk to sensitive receptors; potential contaminant migration; and low risks to ecological receptors.
Zone 4	SO – FS (IC, PA/IN, HSRA) GW – FS (LA) SS – FS (CR)	ARARs exceeded; elevated risks to human receptors; groundwater is not used as a potable water source; limited contaminant migration; and low to moderate risks to ecological receptors.
Zone 5	SO – FS (IC, PA/IN, HSRA) GW – FS (MNA, LA) SS – FS (CR)	ARARs exceeded; risks to human receptors are minimal; groundwater is not used as a potable water source; petroleum contamination is localized; limited contaminant migration; elevated levels of inorganics in storm sewer system; and low risks to ecological receptors.
Zone 6	SO – FS (IC, PA/IN) GW – FS (LA) SS – FS (CR)	ARARs exceeded; risks to human receptors are minimal; groundwater is not used as a potable water source; potential contaminant migration; elevated levels of inorganics in storm sewer system; and low risks to ecological receptors.
Zone 7	SO – FS (IC, PA/IN, HSRA) GW – FS (LA) SS – FS (CR)	ARARs exceeded; elevated risks to human receptors; groundwater not used as a potable water source; contaminant migration occurring; and low to moderate risks to ecological receptors.
Thames River	Zone 1 - SW/SD - FS (LA) Zone 2 - SW/SD - FS (LA) Zone 3 - SW/SD - FS (LA) Zone 4 - SW/SD - FS (DG) Zone 5 - SW/SD - FS (LA) Zone 6 - SW/SD - FS (LA) Zone 7 - SW/SD - FS (DG)	Risks to human receptors from surface water are elevated only when a hypothetical exposure route (i.e., ingestion of shellfish) is considered. The weight-of-evidence approach used for the zone-specific ecological risk assessments and the overall Thames River ecological risk assessment indicates that there are potential risks to sediment dwelling ecological receptors, but they are generally low (Zones 1, 2, 3, 5, and 6) to moderate (Zones 4 and 7). All calculated HQs were less than 12.

TABLE ES-1

**SUMMARY OF RECOMMENDATIONS
LOWER SUBASE RI
NSB-NLON, GROTON, CONNECTICUT
PAGE 2 OF 2**

ARAR - Applicable, Relevant, or Appropriate Requirement
CR - Clean and Repair
DG - Data Gap Investigation
FS - Feasibility Study
FP - Free-Phase Product Removal
GW - Groundwater
HSRA - Hot Spot Removal Action
IC - Institutional Controls
LA - Limited Action - Includes a tiered Groundwater Monitoring Program with the second tier of the program including surface water and sediment sampling in the Thames River.
MNA - Monitored Natural Attenuation
PA/IN - Passive or Insitu Remedial Technologies
SO - Soil
SS - Storm Sewer System
SW/SD - Surface Water/Sediment

1.0 INTRODUCTION

This Remedial Investigation (RI) Report for the Lower Subase at Naval Submarine Base - New London (NSB-NLON), Groton, Connecticut, was prepared for the U.S. Department of the Navy (Navy) by Brown & Root Environmental (B&R Environmental), a division of Halliburton NUS Corporation (HNUS), under the Comprehensive Long-Term Environmental Action Navy (CLEAN), Contract Number N62472-90-D-1298, Contract Task Order (CTO) 0260.

1.1 PURPOSE OF THE REPORT

NSB-NLON is located along the Thames River and lies within the towns of Ledyard and Groton. The Lower Subase is a narrow strip of land that generally forms the western boundary of NSB-NLON and parallels the Thames River. Current and historic activities conducted within the Lower Subase include submarine docking and maintenance, power and heat generation for NSB-NLON, administration, and other miscellaneous activities. It was determined that past activities at the Lower Subase resulted in impacts to the environment. Because of these impacts, various potential sources of contamination that fall within the Lower Subase have been designated as sites and have been or are currently being investigated under the Navy's Installation Restoration Program (IRP). The IRP generally parallels the Comprehensive Environmental Response, Compensation, and Liability Act of 1980 (CERCLA) program.

Two base-wide RIs completed at NSB-NLON have included sample collection and analysis at the Lower Subase. A Phase I RI, which was performed by Atlantic Environmental in 1992, investigated several IRP sites at the Lower Subase as potential sources of fuel oil contamination. These sites included Site 10 - Fuel Oil Storage Tanks and Tank 54-H, Site 11 - Power Plant Oil Tanks, Site 13 - Building 79 Waste Oil Pit, and Site 17 - Hazardous/Flammable Materials Warehouse. The Phase I RI recommended further characterization of these sites. Subsequently, a Phase II RI was completed by B&R Environmental (1997b). The Phase II RI grouped the Lower Subase sites into four zones of investigation (Zones 1 through 4). Additional data gaps were identified in the Phase II RI and consequently, further characterization was again recommended for the Lower Subase sites and the adjacent Thames River.

The findings of these two RIs and other relevant investigations conducted at the Lower Subase and in the Thames River were summarized in the Existing Data Summary Report. The report was prepared and submitted by B&R Environmental on behalf of the Navy in March 1997. Three additional zones of investigation (Zones 5 through 7) within the Lower Subase that required further investigation were identified in the report. Five additional IRP sites (i.e., Site 19 - Solvent Storage Area, Site 21 - Berth 16 and Transformers at Building 157 Vault 31, Site 22 - Pier 33, Building 175, and Adjacent Property,

Site 24 - Central Paint Accumulation Area, and Site 25 - Classified Materials Incinerator) are located within the boundaries of the three additional zones. The Existing Data Summary Report evaluated existing data for the Lower Subase and Thames River, identified remaining data gaps, and provided recommendations for filling the data gaps. The recommendations from the report were then used as the basis for developing the planning documents for this RI (i.e., Work Plan, Sampling and Analysis Plan, Quality Assurance Project Plan, and Health and Safety Plan).

The focus of the data collection activities of this RI is to characterize the subsurface conditions at the Lower Subase, to further characterize the quality of the sediment in the Thames River adjacent to the Lower Subase, and to provide data pertinent to identifying site-specific remedial alternatives. The data collected during this RI, in conjunction with data collected from previous investigations, are used for the following purposes:

- Identify the sources of soil and groundwater contamination.
- Define the major contaminant migration pathways.
- Define the nature and extent of contamination within the groundwater and soils at seven zones of investigation within the Lower Subase.
- Define the nature and extent of contamination in the sediments of the adjacent Thames River
- Provide supplemental data to develop a revised human health risk assessment.
- Provide supplemental data to develop a revised ecological risk assessment for the Thames River.
- Provide sufficient information to identify proper recommendations for future action at each zone under the IRP.

1.2 BASE BACKGROUND

This section provides a description of base operations, a brief history of NSB-NLON and the Lower Subase, a summary of previous investigations at the Lower Subase, and a discussion of the contaminated areas and potential sources of contamination within the Lower Subase.

1.2.1 Base Description

NSB-NLON is located in southeastern Connecticut in the towns of Ledyard and Groton. Figure 1-1 illustrates the location of the Base. NSB-NLON is situated on the east bank of the Thames River, approximately 6 miles north of Long Island Sound. It is bordered 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 Thames River to Baldwin Hill.

NSB-NLON currently provides base command for naval submarine activities in the Atlantic Ocean. It also provides housing for Navy personnel and their families and supports submarine training facilities, military offices, medical facilities, and facilities for submarine maintenance, repair, and overhaul.

The Lower Subase is bordered on the west by the Thames River and on the east by the Providence and Worcester Railroad. A quay wall runs along the Thames River for the entire length of the NSB-NLON. The Lower Subase contains piers and berths for submarine docking, facilities for the submarine maintenance, repair, and overhaul, and administrative buildings.

For the purposes of this report, the Lower Subase study area extends to and includes Pier 2 to the south and Pier 33 to the north, as shown on Figure 1-2. Building 175, located just north of Pier 33, is included within the Lower Subase. The figure also shows the locations of other IRP sites at NSB-NLON. The Lower Subase is a secure, access-restricted portion of NSB-NLON. A more detailed depiction of the general configuration of the area is shown on Figure 1-3. As shown in Figure 1-3, the study area has been divided into seven zones that include nine IRP sites and the quay wall study area. These zones and sites are further discussed in Section 1.4 and Sections 4.0 through 10.0 of this report.

1.2.2 Base History

In 1867, the State of Connecticut donated a 112-acre parcel of land on the east bank of the Thames River to the Navy. In 1868, the Navy officially designated the property a Navy Yard. The site was used to moor small craft and obsolete warships and served as a coaling station for the Atlantic fleet. The Navy designated the site a submarine base in 1916. During World War I, facilities at the base were extensively expanded; 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 underwent another period of growth during World War II. Between 1935 and 1945, the Navy built more than 180 buildings and acquired land adjacent to NSB-NLON. The base expanded from

112 acres to 497 acres. The growth of NSB-NLON continued after World War II. In 1946, the Medical Research Laboratory was established.

In 1968, the status of the Submarine School was changed from an activity to a command, and the school 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. Currently, NSB-NLON consists of more than 300 buildings on 576 acres of land.

Because of the identification of significant, uncontrolled hazardous waste sites, NSB-NLON was placed on the National Priorities List (NPL) on August 28, 1991 by the United States Environmental Protection Agency (USEPA) pursuant to CERCLA and the Superfund Amendments and Reauthorization Act (SARA) of 1986. The NPL is a list of uncontrolled or abandoned hazardous waste sites identified by USEPA as requiring priority remedial actions.

In January 1995, the Navy, USEPA, and the State of Connecticut signed the USEPA Federal Facilities Agreement (FFA) for NSB-NLON. The agreement will be used to ensure that environmental impacts associated with past and present activities at NSB-NLON are thoroughly investigated and that the appropriate remedial action is pursued to protect human health and the environment. In addition, the FFA establishes a procedural framework and timetable for developing, implementing, and monitoring appropriate responses at NSB-NLON, in accordance with CERCLA (and SARA amendment of 1986), the National Contingency Plan (NCP), Resource Conservation and Recovery Act (RCRA) and Hazardous and Solid Waste Amendment (HSWA) of 1984, Executive Order 12580, and applicable state laws.

The Lower Subase is the original submarine base and, therefore, its use dates back to 1868. Most of the construction at the Lower Subase from approximately Pier 15 south took place in the early 1900s, with a major expansion from 1935 to 1940. In 1946, the waterfront north of Pier 15 was developed extensively to accommodate berthing of the reserve fleet. The area was dredged and filled, and bulkheads, piers, support buildings, and utilities were constructed.

Recently, dredging activities have occurred in the Thames River adjacent to the Lower Subase. The activities were conducted during 1995 and 1996 as part of the Pier 17 Replacement and Seawolf Class Submarine Homeporting projects. Dredged material was disposed at a designated open-water disposal site in Long Island Sound.

1.2.3 Previous and Ongoing Investigations and Related Documentation

Brief summaries of previous and ongoing investigations and activities associated with the areas addressed by this RI are presented in Table 1-1. The following investigations are included:

- Oil Contamination of the Groundwater at Subase New London [Naval Environmental Support Office (NESO), 1979]
- Final Initial Assessment Study (Envirodyne, 1983)
- Final Site Investigation - Subsurface Oil Contamination (Wehran, 1987)
- Hydrogeologic Investigation UST OT-4, OT-7, OT-8, OT-9, and Tank 54-H (Fuss & O'Neill, 1989)
- Multimedia Inspection (USEPA, 1991b)
- Phase I Remedial Investigation (Atlantic, 1992)
- Action Memorandum for Building 31 (HNUS, 1993a)
- Remedial Design for Building 31 (HNUS, 1993b)
- Environmental Assessment for Pier 17 Replacement (Maguire, 1994)
- Post-Removal Action Report for Building 31 (HNUS, 1995a)
- Final Site Inspection Report, Pier 33 and Berth 16/Former Incinerator (Atlantic, 1995a)
- Site Characterization Report for OT-10, Building 325 and Building 89 (B&R Environmental, 1996)
- Background Soil Investigation (Atlantic, 1995b)
- Preliminary Assessment/Supplement to Initial Assessment Study (NFESC, 1995)
- Removal Site Evaluation for Quay Wall (HNUS, 1995b)

- Final Environmental Impact Statement for Seawolf Class Submarine Homeporting on East Coast of the United States (Maguire, 1995)
- Leak Testing Investigation for Fuel Oil Distribution System (Heitkamp, 1996)
- Existing Data Summary Investigation for Lower Subase (B&R Environmental, 1997a)
- Phase II Remedial Investigation (B&R Environmental, 1997b)
- Site Investigation Report for Tank Farm Investigation (B&R Environmental, 1997c)
- Annual NPDES Stormwater Monitoring Program (Navy, 1997)

The analytical data from these investigations that were determined to be applicable to the study area were evaluated and included in a database for use in the nature and extent of contamination and data evaluations for this Lower Subase RI. The results of these investigations are summarized in Table 1-1. Further discussion of the database is provided in Section 3.0.

1.3 GENERAL CHARACTERISTICS OF NSB-NLON AND THE LOWER SUBASE

This section provides a summary of the general physical characteristics of NSB-NLON, including topography and surface features, climate and meteorology, surface water quality and hydrology, soil characteristics, geology, hydrogeology, etc. This section has been designed to discuss both "macroscopic" aspects of the facility in general and specific physical features of the Lower Subase study area. Details for each zone and the Thames River are discussed in Sections 4.0 through 11.0.

1.3.1 Topography and Surface Features

The topography of NSB-NLON, depicted on Figure 1-1, consists of irregular, hilly upland areas with poorly drained valleys between them. In addition, glacial terraces and river alluvium flank the Thames River valley. Hills and ridges in the area generally have a north-south orientation, as modified during the Wisconian glaciation (USGS, 1967).

Bedrock outcrops are prevalent along steep topographic slopes. Four bedrock highs form the topographic upland areas at the NSB-NLON and surrounding area. In the northern, central, and southern portions of the facility, elevations of the bedrock highs exceed 200 feet above mean sea level (msl); east of the facility, Baldwin Hill has a maximum elevation of 245 feet above msl. In addition to the large bedrock

highs, there are several small sub-ridges that are visible as bedrock outcrops at the facility. Two primary sub-ridges include one east of the Defense Reutilization and Marketing Office (DRMO) and one northeast of the Goss Cove Landfill, with elevations of approximately 80 and 60 feet, respectively.

The bedrock high in the center of the facility divides drainage from the facility into northern and southern valleys, both draining westward to the Thames River. In the northern valley, the ground elevation ranges from approximately 80 feet above msl in the east to near sea-level along the Thames River. The eastern (upper) portion of the northern valley contains the Area A Wetland, which drains through an earthen dike into the Area A Downstream Watercourses. The ground surface drops steeply across the dike to 30 to 40 feet below the elevation of the wetland. Historically, the ground surface decreased more uniformly toward the Thames River (USGS, 1960). The current steep drop in the ground elevation was created by the construction of the dike and subsequent filling of the wetlands area with dredge spoils from the Thames River. The southern valley has no surface water bodies and is drained by a storm sewer system. The ground elevation in the southern valley slopes gently from approximately 50 feet msl in the eastern portion to near sea level along the Thames River. Historically, Crystal Lake existed between Tang and Crystal Lake Road. The lake was drained and filled with quarried till from Bailey Hill, south of the facility (USGS, 1960), during the installation of the tank farm along Crystal Lake Road.

As shown on Figure 1-2, NSB-NLON consists of over 300 buildings on 547 acres of land (Atlantic, 1992). High densities of buildings exist across the central bedrock high, in the southern valley, and along the Thames River. The northern bedrock high is largely undeveloped, except along its southern face where the Area A Weapons Center and the Torpedo Shops are located. The upper elevations and northern face of the northern ridge are wooded and undeveloped.

The Lower Subase is relatively level, sloping gradually from the Providence and Worcester Railroad bed along its eastern boundary toward the piers and the Thames River along its western edge. Elevations range from approximately 22 feet msl along the eastern edge of the Lower Subase to 8 feet msl along the piers. The ground surface elevation increases sharply east of the Lower Subase to the central bedrock high and the 20- and 30-foot glacial terraces in the northern and southern sections of the Lower Subase.

The topography along the Lower Subase has been modified extensively by cut-and-fill practices. The land surface in the southern section of the Lower Subase has been extended beyond the historical shoreline of the Thames River with artificial fill, consisting typically of till quarried from surrounding areas (USGS, 1960). The northern section of the Lower Subase has been built on glacial terrace deposits with minimal backfilling. The golf course east of the northern Lower Subase is built on terrace deposits.

Except for a few isolated grassy areas, the Lower Subase is completely paved and has a high density of buildings, promoting surface water runoff. Numerous catch basins and storm sewers collect runoff from around buildings and convey it to the Thames River.

1.3.2 Climate and Meteorology

Southeastern Connecticut is in the northern temperate zone. The climate is influenced by cold and dry continental-polar air during the winter and warm, humid maritime air during the summer. During the winter, this region is located near the Polar Front boundary, which separates regions of cold, dry continental-polar air and warm, moist tropical air. The area experiences extensive winter storm activity and variable daily temperatures. During the summer, the Polar Front boundary is located farther north, and the region experiences warm weather.

The prevailing winds are southwesterly from the continent and bring most of the weather into the region. Land-sea breezes are also present in the region. Occasional storms moving northward along the mid-Atlantic coast provide strong northeasterly winds and storms, commonly known as "coastals" or "northeasters." Storms are extensive, with heavy rainfall, and are occasionally of hurricane intensity. Dense fog is frequently advected onshore from the Atlantic Ocean from the spring through the fall (NOAA, 1988).

The average annual temperature at New London, Connecticut, is approximately 50°F. Average monthly temperatures vary from 58 to 72°F in July and August to 23 to 30°F in January and February. The average wind speed is approximately 10 miles per hour. Precipitation ranges from 32 to 65 inches of water per year and averages approximately 44 inches per year, as measured at New London over an 81-year period. The greatest amount of precipitation generally occurs in March and August and the least in June and September. Evaporation averages approximately 23 inches per year (NFEC, 1988).

1.3.3 Surface Water Hydrology and Quality

This section summarizes available information regarding surface water hydrology and surface water quality in the vicinity of NSB-NLON. The primary focus of this section is the Thames River, which is the major receiving surface water body proximate to the facility. Surface water and sediment samples were collected from the Thames River and analyzed by the USGS and NOAA, respectively, resulting in the background concentrations for inorganics as presented in Tables 1-2 and 1-3.

1.3.3.1 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 1,500 square miles of eastern Connecticut, western Rhode Island, and south-central Massachusetts. The Thames River originates in the City of Norwich Harbor, at the confluence of the Shetucket and Yantic Rivers, and discharges into Long Island Sound approximately 6 miles south of NSB-NLON. The Thames River estuary extends northward from Long Island Sound to Norwich (16 miles). Widths of the river vary from 1.5 miles at New London Harbor to approximately 500 feet at Norwich Harbor. A dredged channel runs north to south in the river. Depths in the dredged channel are approximately 40 feet below msl between Long Island Sound and the Subase and about 25 feet farther upstream. At NSB-NLON, the width of the channel is approximately 600 to 900 feet. However, the channel is narrower upstream and downstream of NSB-NLON. Outside the channel, depths are relatively shallow (2 to 10 feet). Upstream of NSB-NLON, there are shallow coves that empty into the river. Most of the coves are at least partially cut off from the river by a rail bed.

The two rivers that join to form the Thames River are the Shetucket and Yantic Rivers. The Yantic River has a drainage basin of 88 square miles. Average, minimum, and maximum flows in the Yantic have been reported at 170, 3.5, and 13,400 cubic feet per second (ft^3/s), respectively. The Shetucket, which has a 1,390-square-mile drainage basin, has reported average, minimum, and maximum flows of 2,000, 14, and 52,300 ft^3/s, respectively. According to an engineering study (LMS Engineers, 1992), other sources of inflow to the Thames River are minor in comparison to these flows and to the volume of tidal exchange. Other sources of inflow include wastewater treatment facilities in Norwich, Montville, New London, the City of Groton, and the Town of Groton, as well as combined sewer overflows in Norwich, industrial discharges, and several small streams.

The Thames River is a salt wedge estuary that is highly stratified with fresher water on the surface and denser saline water on the bottom. Very little vertical mixing occurs in the Thames River. The north-south alignment, steep banks, and narrow channel do not permit much wind-induced mixing. Therefore, the freshwater outflows reach Long Island Sound in a well-defined surface layer. The river is tidally influenced with a mean tidal range at the New London State Pier of 2.6 feet (LMS Engineers, 1992). A freshwater flushing time of 0.5 to 2 days from Norwich to Long Island Sound has been estimated (Welsh and Stewart, 1984). In comparison, a bottom water flushing time of greater than 19 days was estimated. The average freshwater flow discharging to Long Island Sound from the Thames River has been estimated as 222 million cubic feet per day (Soderberg and Bruno, 1971). However, streamflow in the Thames River is small in comparison to intertidal volume and exchange (Bohlen and Tramontano, 1977).

As previously discussed, the Thames River estuary is stratified with relatively fresh water on the surface and saline water on the bottom. Historical records show that the salinity in the water at the bottom of the river is relatively constant at 30 parts per thousand (ppt). Salinity measurements taken in the Thames River adjacent to NSB-NLON in May 1995 for the Supplemental Ecological Investigation confirmed the constant 30 ppt salinity level. Measurements taken near the bottom of the channel of the Thames River ranged from 29.4 to 30.0 ppt. The salinity of the water at the surface of the river is more variable, with the salinity ranging from 28 ppt at the mouth of the river to 2 ppt at the upstream end of the estuary at Norwich.

Surface water from NSB-NLON drains west toward the Thames River via streams and storm sewers. The off-site 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.

Significant on-site drainage features include several streams (perennial and intermittent), ponds, Rock Lake, North Lake, and a large wetland (Area A Wetland). The majority of these surface water features are located in the north-central section of NSB-NLON. These water courses drain to the Thames River through discharge points located at the DRMO, the Lower Subase north of Pier 33, and the Goss Cove Landfill.

More specific information regarding the watercourse and drainage features associated with each zone investigated is provided in subsequent Sections 4.0 through 11.0.

1.3.3.2 Surface Water Quality and Designation

The Connecticut Department of Environmental Protection (CTDEP) has classified the Thames River quality as SC/SB. This classification designates the water for marine fish, shellfish, and wildlife habitat, certain aquaculture operations, recreational uses, and industrial and other legitimate use and indicates that the waters presently are not meeting water quality criteria or are not supporting one or more designated uses as a result of pollution (CTDEP, 1992).

The quality of the surface water in the Thames River has been measured by the USGS upstream of NSB-NLON at Mohegan, Connecticut (USGS, 1993). Many depth-specific water quality parameters are measured by USGS, including pH, dissolved oxygen, hardness as $CaCO_3$, and dissolved metals (e.g., iron, manganese, and lead). Parameters such as pH, dissolved oxygen, and total hardness varied depending on the time of year when the sample was collected and the depth from which it was collected.

The pH of shallow surface water (1 foot) ranged from 6.3 (November 16, 1990) to 8.5 (July 9, 1991), and the pH of deep surface water (20 feet) ranged from 6.5 (November 16, 1990) to 7.9 (May 8, 1991). Dissolved oxygen in shallow surface water of the Thames River ranged from 13.2 mg/L (January 10, 1991) to 8.7 mg/L (September 9, 1991) and, for deep surface water, it ranged from 8.8 mg/L (January 10, 1991) to 1.7 mg/L (July 9, 1991). The total hardness of shallow surface water ranged from 340 mg/L (May 8, 1991) to 1,000 mg/L (July 9, 1991), while the total hardness of deep surface water ranged from 5,000 mg/L (November 16, 1990) to 2,300 mg/L (January 10, 1991).

Concentrations of dissolved metals in the surface water of the Thames River remained relatively constant over the sampling period (i.e., November 16, 1990; January 10, 1991; May 8, 1991; and July 9, 1991) but varied with depth. The average concentration of dissolved iron in shallow surface water was 84 µg/L and in deep surface water it was 25 µg/L. Average dissolved manganese concentrations ranged from 28 µg/L (shallow surface water) to 61 µg/L (deep surface water). The average concentration of dissolved lead in shallow surface water was 7.1 µg/L. This average is skewed due to a single high detection (27 µg/L) measured on July 9, 1991. In deep surface water, lead was not detected above method detection limits; therefore, an average was not calculated.

1.3.4 Soil Characteristics

According to the Soil Conservation Service (SCS) Soil Survey of New London County, Connecticut (USDA, 1983), the predominant soil series at NSB-NLON are Canton, Charlton, Hollis, Udorthents-Urban Land Complex, and Urban Land. Canton soils develop in sandy glacial till on hills, ridges, and glacial till upland. Hollis and Charlton soils develop in loamy glacial till on hills, ridges, and glacial plains. The Canton, Charlton, and Hollis are generally dark in color, nonstony to stony, and excessively to well drained. Stones, boulders, and bedrock outcrops are prevalent on hills and ridges. Additional soils with limited extent include the Hinkley Loam, consisting of dark, gravelly, sandy loam and associated with stream terrace and outwash plain deposits, in the far northwestern corner of the facility, and the Narragansett Silt Loam, consisting of an extremely stony silt loam, in the southeastern corner of the facility.

Altered soils at NSB-NLON are classified as either Urdothents-Urban land or Urban land. The Urdothents-Urban Land Complex includes excessively to moderately drained soils that have been disturbed by cutting and filling. This soil is mapped in the northern portion of NSB-NLON in the Area A Downstream Watercourses and the northern section of the Lower Subase and in the area of the former location of Crystal Lake in the southern portion of the facility. Urban land is defined as areas where more than

85 percent of the surface is covered by streets, parking lots, and buildings. Urban land has been mapped in the southern portion of NSB-NLON and the southern section of the Lower Subase.

All soil types at NSB-NLON have moderate to moderately high permeabilities (USDA, 1983). Available water capacity is moderate to low. The soils are well drained, and runoff is rapid. The pH of the soils is strongly to moderately acidic, and the erosion hazard is severe.

Atlantic completed background soil sampling at NSB-NLON in April 1995 to characterize the concentrations of naturally occurring inorganics and anthropogenic compounds (organics) to support site data evaluation and risk assessment. The results of the background information for soil are listed in Table 1-4. No volatile or semivolatile compounds were detected in the background samples.

The manganese content of area soils was reviewed as this constituent emerged as a potential concern during the Phase II RI risk assessment. Nationwide, USGS reports background levels of manganese occurring at levels from less than 2 mg/kg to 7,000 mg/kg (Shacklette and Boerngen, 1984). In Connecticut, the USGS reports that manganese occurs in soils at levels from 150 to 700 mg/kg (Shacklette and Boerngen, 1984). More specific information regarding the soil characteristics associated with each zone investigated is provided in Sections 4.0 through 10.0.

1.3.5 Geology

Detailed descriptions of the regional geology are provided in the Phase I RI Report (Atlantic, 1992) and the Initial Assessment Study Report (NEESA, 1983). The following discussion summarizes the geology of NSB-NLON. Specific geological descriptions associated with each zone in the study area are provided in Sections 4.0 through 10.0.

NSB-NLON is situated in the Eastern Uplands region of Connecticut. The area has irregular hills of exposed bedrock with poorly drained, uneven valleys between them. The bedrock is metamorphosed rocks of sedimentary and igneous origin and is faulted and folded. The major low-angle fault in the area is the Honey Hill Fault, which trends east to west and is located approximately 6 miles north of NSB-NLON. It does not cross the facility boundary.

According to the USGS bedrock map (USGS, 1967) for the area, five bedrock formations underlie NSB-NLON: Alaskite Gneiss, Granitic Gneiss, Mamacoke Formation, Plainfield Formation, and Westerly Granite. The Alaskite Gneiss and Granitic Gneiss are orange-pink to light gray, medium-grained granitic gneisses; the Mamacoke Formation is a light to dark gray, medium-grained biotite-quartz-feldspar gneiss;

the Plainfield Formation is a dark green hornblende-biotite-quartz-plagioclase gneiss; and the Westerly Granite consists of gray, fine- to medium-grained equigranular granite.

The Mamacoke Formation, the Alaskite Gneiss, and the Granite Gneiss are the only formations underlying the Lower Subase. Only borings in Zones 5 and 7, completed during the Pier 33 and Berth 16 Investigation (Atlantic, 1995a), have been advanced to bedrock along the Lower Subase. In these zones, bedrock was encountered between 5 and 21 feet below grade at locations along the Thames River. The deepest boring in Zones 1, 2, 3, and 4 was 13MW7 with a total depth of 35 feet below grade. Bedrock was not encountered.

The surficial geology of NSB-NLON consists of unconsolidated glacial materials deposited during the Wisconsian Glaciation (USGS, 1960). Two types of glacial deposits exist at the facility: stratified drift and glacial till. Stratified drift consists of stratified deposits of sorted silt, sand, and gravel that were deposited by glacial meltwater streams. Glacial till consists of a nonstratified, dense, heterogeneous mixture of clay, silt, sand, and rock fragments laid down directly by glacial ice. Stratified drift at NSB-NLON is mapped as terraces flanking the Thames River valley (USGS, 1960). The 20- and 30-foot elevation terraces border the eastern edge of the Lower Subase. A thin blanket of glacial till covers most of the bedrock in the area. Till is exposed only on bedrock highs and probably underlies outwash materials in valleys. The till thickness varies considerably but averages less than 10 feet (USGS, 1960).

Other surficial deposits are post-glacial river and floodplain deposits (alluvium), backfill material of reworked and quarried till, and debris fill. Quaternary alluvium, consisting of sand, silt, and gravel, is limited to the Area A Downstream Watercourses (USGS, 1960). Fill material is mapped in the former location of Crystal Lake, along the southern half of the Lower Subase, at the DRMO along the Thames River, and in an area east of the Torpedo Shops. Generally, fill material underlying the southern half of the Lower Subase thickens from 5 feet along its eastern edge to approximately 20 feet along the Thames River. The fill material is primarily sand and gravel with isolated areas of wood, fly ash, brick and concrete fragments, and metal fragments.

A silty sand layer underlies the sand and gravel backfill and debris fill in the southern half of the Lower Subase (Zones 1, 2, 3, 4, and 7). In Zones 1 and 2, a medium-coarse sand layer underlies the sand and gravel backfill and overlies the silty sand. The silty sand layer contains shell and wood fragments and varying amounts of clay. The sand and silty sand units are interpreted as natural deposits of stratified drift. The bottom of the silty sand unit in Zones 1, 2, 3, 4, and 7, with a maximum depth of approximately 34 feet, was not encountered during this or previous investigations.

In Zones 5 and 6, sand and gravel backfill overlies sand of stratified drift deposits. Most of the soil borings completed in the Lower Subase did not exceed 30 feet and many were 20 feet in depth or less. Therefore, the bottom of the silt and sand layer was not always encountered. However, borings in Zone 5 extended to greater depths. According to geologic information provided during investigations at Zone 5, the sand and silt layers are underlain by approximately 10 feet of gravel, which overlies bedrock (Atlantic, 1995a).

A wooden platform and quay wall were constructed in the southern portion of the Lower Subase in 1940. The wooden platform is believed to be in place between Pier 2 and Pier 15. The presence of the wooden platform has been confirmed by borings and excavations between Piers 2 and 6 and at Pier 10. The wooden platform is 4 inches thick and supported by 10- to 12-inch-square wooden joists and 8-inch timber pilings. A steel bulkhead along the Thames River was erected in 1952 and constructed of steel sheet piling and supports. A typical cross-section showing the wooden structure and steel bulkhead is provided on Figure 1-4. During construction of the bulkhead, the quay wall and wooden platform were covered with approximately 6 to 7 feet of sand and gravel fill, and the area was paved for vehicular access along Albacore Road. The quay wall is located approximately 4 feet east of the steel bulkhead, immediately beneath the paved surface. Fill soil below the wooden platform and quay wall may periodically wash out. Void spaces of 3 to 8 feet exist discontinuously beneath the wooden platform. Sand and gravel fill separate the void spaces and can be replaced with sand poured into a series of manholes along the length of Albacore Road. Natural river deposits of silt and sand underlie the void spaces and sand fill.

1.3.6 Hydrogeology

This section provides a summary of hydrogeologic conditions at NSB-NLON. Brief discussions of groundwater quality and designations, aquifer characteristics, and groundwater flow are provided.

1.3.6.1 Area Hydrogeology

For the State of Connecticut, the USGS National Water Summary (USGS, 1986) reports that "... groundwater beneath more than 90 percent of the land in the state is considered to be suitable for drinking without treatment ... ." Saltwater intrusion impacts groundwater in coastal areas. The groundwater is hard to very hard in 70 percent of the wells in the state's carbonate rock aquifer, in 40 percent of the wells in the state's sedimentary rock aquifer, and in 15 percent of the wells in the stratified drift and crystalline bedrock aquifers, the latter of which NSB-NLON overlies. The report also states that "large concentrations of iron (as large as 40,000 µg/L) and manganese (as large as 14,000 µg/L) are a common natural groundwater-quality problem in Connecticut."

Several well water users exist in the vicinity of NSB-NLON. These include the Groton Water Department, the Southeastern Connecticut Water Authority (SECWA), the Town of Ledyard, and a limited number of private residences adjacent to the facility. Because of recent improvements, most residences adjacent to the facility are currently supplied with potable water from the Groton Water Department, which also supplies potable water to the facility. The primary source of the Groton water supply is reservoirs, supplemented with water wells. The water supplies are located within the Poquonock River Watershed, east of NSB-NLON and not within the NSB-NLON watershed.

1.3.6.2 Groundwater Quality

The following three subsections describe the CTDEP groundwater classifications for NSB-NLON, as well as the quality of local background groundwater and the quality of groundwater beneath NSB-NLON.

CTDEP Groundwater Classifications

The Navy recently applied to CTDEP to have all groundwater beneath NSB-NLON reclassified to GB. The GB classification indicates that the area has been used for long-term intense industrial or commercial development and the groundwater is not used as a drinking water source. Remediation standards for GB areas are typically lower than those for GA areas. A reclassification application was submitted by the Navy to CTDEP on August 12, 1996. A public hearing was conducted on the issue on December 13, 1996, and formal notification from the CTDEP regarding successful reclassification was received on March 5, 1997. The groundwater for all of NSB-NLON, except for a small northern portion of the site, is now classified as GB. The small northern portion, which is the portion north of Perimeter Road, will remain classified as GA. The GA classification signifies groundwaters presumed suitable for direct human consumption without the need for treatment. All the Lower Subase groundwater is now classified as GB.

Local Background Groundwater Quality

SECWA uses groundwater to provide potable water to residents in areas north, east, and northwest of NSB-NLON. Water quality data collected in 1991 and 1994 from 16 SECWA divisions were obtained from the water authority. The data indicated that barium, sodium, chloride, fluoride, sulfate, nitrates, and nitrites were detected in the groundwater. These results are summarized in the Phase II RI Report (B&R Environmental, 1997b).

The Town of Ledyard also uses groundwater to provide potable water to its residents. The Ledyard Water Pollution Control Authority (WPCA) monitors groundwater constituents. Concentrations of iron and manganese measured in Well #1 in the Highland Well Field were obtained by NSB-NLON from WPCA. This well is approximately 6 miles northeast of NSB-NLON. The data obtained included seven sampling rounds, all from July and August 1995. The concentrations of iron ranged from 2,170 µg/L to 2,780 µg/L. The concentrations of manganese ranged from 1,100 µg/L to 1,400 µg/L. The analytical results did not indicate whether samples were filtered prior to sample analysis.

Previously, homes on Route 12 adjacent to the northeastern portion of the site had private drinking water wells, as did homes north of NSB-NLON on Sleepy Hollow Road, Long Cove Road, and Military Highway. The quality of the groundwater in these areas was measured by Atlantic and is summarized in the Off-Site Residential Well Water Data Evaluation Report (Atlantic, 1994d). Manganese concentrations measured in these residential wells ranged from less than 0.7 µg/L to 2,130 µg/L, and iron concentrations ranged from less than 4.8µg/L to 21,800 µg/L. Two trailer parks near the site have wells classified as public water supply wells. The Colonel Ledyard Mobile Home Park, located on Sleepy Hollow Road 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. Several irrigation wells on site at the golf course have not been used for several years.

NSB-NLON Groundwater Quality

Manganese concentrations in off-site residential wells located upgradient of NSB-NLON ranged as high as 2130 µg/L. These levels are typical of most wells on the base. Maximum concentrations of manganese in groundwater at several sites at NSB-NLON exceed the off-site concentrations by less than one order of magnitude. Data collected during previous investigations indicate that the manganese is dissolved in the groundwater. In general, the maximum concentrations of manganese were detected in the Area A Wetland, the Area A Downstream Watercourses/OBDA near Streams 1 and 5, and the Torpedo Shops in the vicinity of the former Otto Fuel UST. Many other areas of NSB-NLON had limited or no data available and conclusions could not be drawn about the concentration of manganese in groundwater for those areas.

The maximum concentrations of iron detected in the shallow overburden and bedrock groundwater were 141,000 µg/L (Goss Cove Landfill) and 108,000 µg/L (Area A Wetland), respectively. Areas of NSB-NLON that had high concentrations of manganese typically also had high concentrations of iron. These areas included the Area A Wetland, Area A Downstream Watercourses/OBDA, and the Torpedo Shops.

The groundwater pH was measured in the field during Round 2 of the Phase II RI. The pH of the shallow and deep groundwater ranged from approximately 5 to 9. Higher pHs (greater than 9) were only detected in the shallow overburden groundwater (Lower Subase and Area A Downstream Watercourses), and lower pHs (less than 5) were detected in both the shallow and the deep groundwater (Spent Acid Storage and Disposal Area and Area A Downstream Watercourses). The pH of the shallow and deep groundwater in the Area A Landfill and Wetland ranged from 6 to 8. The pH of 8 was measured in a deep well along the upgradient edge of the NSB-NLON. The pH of the deep groundwater in the area upgradient of the Torpedo Shops and Area A Weapons Center was approximately 8. The pH of groundwater in the vicinity of the Rubble Fill Area at Bunker A86, which is upgradient of the Area A Landfill and Wetland, is approximately 6.

Previous studies indicate that there is not a clear relationship between low pH and high dissolved metal concentrations. The occurrence of manganese and iron in the groundwater may be due to either natural sources (i.e., local geologic units) or man-made sources such as dredge spoils from the Thames River or leachate from the municipal solid waste ash placed in the Area A Landfill. Both scenarios fit the available data and background information.

1.3.6.3 Comprehensive Water-Level Investigation

The following two subsections are general descriptions of groundwater flow and vertical components of groundwater flow at NSB-NLON, excerpted from the Phase II RI report (B&R Environmental, 1997b). Site-specific discussions of groundwater flow within each zone are provided in Sections 4.0 through 10.0.

General Discussion of Groundwater Flow

The general direction of groundwater flow at NSB-NLON is from Baldwin Hill across the facility toward the Thames River, with the water-table surface following the topography and bedrock surface locally. High hydraulic potentials develop within the three bedrock highs in the northern, central, and southern areas of the facility. Precipitation infiltrates into the overburden and bedrock and flows radially from the areas of high elevation toward areas of low elevation. Groundwater flows toward the two valleys and ultimately toward the Thames River or directly from the western edges of the three hills toward the Thames River.

Based on three comprehensive rounds of water-level measurements that were completed in 1994 and 1995, saturated overburden materials were encountered within and along the valley margins at the Subase. In areas of higher ground surface (and bedrock surface) elevation, the overburden materials were typically not saturated.

In most cases, the groundwater elevations at NSB-NLON well clusters are similar in the bedrock and overburden. This suggests that the bedrock and overburden are hydraulically connected and that the groundwater flow directions are similar in both. At a few well clusters, the difference in groundwater elevations between the bedrock and overburden is greater than several feet. In these areas, the bedrock and overburden have a weak hydraulic connection, and local groundwater flow directions may vary.

Limited water-level data obtained in November 1995 from off-site wells showed that groundwater in areas east of NSB-NLON is at higher elevations than along the eastern boundary of NSB-NLON, indicating that groundwater at NSB-NLON does not migrate off-site to the east. To the north, off-site wells have relatively low water levels; however, they are located in a valley on the opposite side of a large ridge that separates the waste disposal areas at NSB-NLON from these wells. The ridge acts as a local groundwater divide, preventing migration of groundwater from the northern waste disposal areas at NSB-NLON to these off-site wells.

A drainage basin map of Connecticut in the Geological and Natural History Survey, (Connecticut 1974) shows that a major basin divide occurs along the ridges of Baldwin Hill. To the east of Baldwin Hill, water (both surface and subsurface) is part of the Southeast Coast Major Basin. Water from this basin is not expected to travel toward the facility. To the west of Baldwin Hill, water is part of the Thames Major Basin. Surface and groundwaters ultimately discharge into the Thames River.

Hydraulic gradients in the bedrock are greatest where the bedrock surface slope is steepest and decrease where the bedrock slope is milder. Typically, the hydraulic gradient decreases as the bedrock slope decreases.

Vertical Components of Groundwater Flow

The vertical component of groundwater flow is predominantly downward in upland areas of NSB-NLON. However, at the base of the hills, the bedrock surface flattens and the overburden thickens. In these areas, upward gradients may occur, resulting in shallow bedrock groundwater discharge into the overburden. Near the Thames River, upward gradients exist, as is typical for groundwater in major stream valleys. Whether an upward or downward gradient develops depends on factors such as the bedrock configuration, depth of the overburden, topographic features, permeability, distance to the river, and the tides.

Vertical gradient data, calculated at select well cluster locations, show an upward vertical gradient at the majority of the Area A landfill and wetland well clusters. Presumably, the Area A Wetland acts as the discharge point for groundwater in this area. This is supported by the observed upward groundwater flow potential from the bedrock, through the overburden, discharging to the Area A Wetland.

1.3.6.4 Groundwater Discharge and Tidal Influence

Based on studies conducted during the Phase I RI (Atlantic, 1992), the Phase II RI (B&R Environmental, 1997b), an investigation at Building 31 (HNUS, 1993a), the Quay Wall Removal Site Evaluation (HNUS, 1995b), and this RI, the groundwater potentiometric surface has been shown to vary as a result of tidal and seasonal influences. Specific information regarding tidal and seasonal influences is provided in the remainder of this section.

Tidal Influences on Groundwater Discharge

The tides of the Thames River influence the discharge of groundwater from NSB-NLON on a daily basis. Under normal flow conditions in the river, the discharge of groundwater to the Thames River is greatest at low tide, because the hydraulic gradient along the river will be steepest during low tide. During high-tide conditions, the elevation of the river is higher than the groundwater elevations observed along the western perimeter of the facility, which creates localized reversed gradients and consequently reverses flows. Two small studies, both in the vicinity of the Lower Subase, have been completed that verify this pattern of water-level changes.

The first tidal study was conducted on April 18, 1991 during the Phase I RI (Atlantic, 1992). Water levels in 16 Lower Subase wells and points on the river were monitored hourly during a 12-hour tidal cycle to determine the effects of the tide on groundwater discharge at this site. Groundwater elevations under low and high tide were contoured to determine the flow trend. The contours showed that at low tide, groundwater flows west toward the Thames River. They also indicated that at high tide, groundwater flows east from the river in the western portion of the Lower Subase and flows west toward the river in the eastern portion of the Lower Subase, with a low groundwater elevation occurring in the center of the site where the opposing gradients meet. The study demonstrated that the tidal effects diminish with distance from the river. The reversal of groundwater flow direction at high tide did not extend farther than 300 feet inland of the river.

The second tidal study was completed in February 1993 as part of a larger investigation at Building 31 by Halliburton NUS under a separate contract (Contract Task Order 112). Two data loggers and two

transducers were installed, one in a temporary well and the other in the Thames River, to complete the 40-hour study. The two monitoring points were approximately 105 feet apart. The study showed that tidal changes of approximately 2.22 feet occurred in the Thames River, creating reversals in groundwater flow directions within the Lower Subase every tidal cycle. Water levels in the monitoring well fluctuated by 1.19 feet during the same time frame.

Based on the information discussed above, the following conclusions were reached regarding tidal influences of groundwater discharge from NSB-NLON: (1) During low tide, the hydraulic gradient of the groundwater table at NSB-NLON is toward the Thames River and will result in the highest discharge rate of groundwater to the river; (2) During high tide, the hydraulic gradient of the groundwater at NSB-NLON along the Thames River is reversed and flow occurs from the river to the site, temporarily halting the discharge of groundwater from the base to the river; (3) The reversal in hydraulic gradient resulting from tidal influences occurs only near the river, generally within 300 feet, and does not seem to significantly alter groundwater flow in other areas of NSB-NLON.

Influence of Seasonal Variations on Groundwater Discharge

During the Phase II RI, seasonal variations of the groundwater table across the site were recorded during monthly groundwater-level measurements at monitoring wells. Generally, the variations of the monthly water-level measurements correlate with the months with lower and higher precipitation and recharge. In addition, the smallest standard deviations in water levels were noted in wells installed in the valleys, where the overburden thickens and groundwater recharge from upland areas moderates water-level variations.

Hydrographs developed from the groundwater-level measurements also showed that, in the upgradient areas of the northern valley, the aquifer dewaters during the summer months and tends to recharge during the fall and winter months. The aquifer does not show any real trend of dewatering during the summer months or recharge during the fall and winter months in the portion of the valley closer to the Thames River. This difference in trends can be explained by the storativity of the aquifer material and the hydraulic gradient in the two regions. The upgradient wells are located along the bedrock highs where the overburden is relatively thin. Because the storativity of the bedrock is low and the hydraulic gradient is relatively steep, the groundwater potentials are more sensitive to seasonal changes. The downgradient wells are located where the bedrock slope is milder and the overburden is thicker. Because the storativity of the overburden is relatively high and the hydraulic gradient is mild, the groundwater potentials are less sensitive to seasonal changes. The hydrographs for the wells near the Thames River show more pronounced tidal effects than the well selected from the northern region of the site. The difference is attributable to the proximity of the southern wells to the river. Variations in the hydraulic gradients are

most pronounced along the bedrock highs and least evident in the valleys (with the exception of those attributable to tidal influences).

Based on the evaluation of the monthly water-level data, the following conclusions may be reached regarding seasonal influences on groundwater discharge from NSB-NLON: (1) During periods of limited recharge (i.e., summer and early fall), the hydraulic gradients along the bedrock highs (where there is limited overburden thickness) decrease and the groundwater discharge from these areas decreases; conversely, during periods of significant recharge (late fall and spring), the hydraulic gradients in these areas and groundwater discharge increases; and (2) Hydraulic gradients in the portions of the site where there is significant overburden (i.e., the valleys and floodplain) remain relatively constant (with the exception of tidal-related variations) throughout the year as does the groundwater discharge.

1.3.7 Demography and Land Use

The information compiled from the Phase I RI report (Atlantic, 1992) indicates that several communities are located within 1 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 with the population figures that are based on data from the 1980 census:

- North West - This community of 5,520 people is located adjacent to NSB-NLON on the eastern side of Route 12 from the Groton - Ledyard town line to Walker Hill Road on the south. The neighborhood extends westward to the Ledyard Reservoir.

- Pleasant Valley - The Pleasant Valley neighborhood, population 4,374, borders the southern 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. A population of 4,099 was reported for this neighborhood in the 1980 census data.

The Gales Ferry section of Ledyard is also located adjacent to NSB-NLON to the north. The town of Groton and NSB-NLON are on the east bank of the Thames River, approximately 6 miles north of Long Island Sound. The city of New London is located on the west bank of the river. Chemical companies, oil terminals, power plants, and wastewater treatment plants occupy both banks of the river. Pfizer

Pharmaceutical, Hess Oil, Electric Boat, City Coal, NUWC, and city and state piers are located in the vicinity of NSB-NLON on both sides of the river.

1.3.8 Ecology

The New London/Groton area lies in the Central Hardwoods zone, which covers a large portion of the northeastern United States. Virgin forests in this area have been replaced by second- or third-growth stands as a result of development. Many wetland areas have been filled to support development. Although the Thames River has been dredged and its banks have been stabilized, the course of the river is unchanged and the river still supports a variety of indigenous species of flora and fauna.

1.3.8.1 Lower Subase Ecology

The Lower Subase is located in a highly industrialized portion of NSB/NLON and is characterized by large industrial buildings, a substantial amount of paved area, and very little maintained lawn. The area is characterized by heavy human activity and does not provide suitable habitat for wildlife. The only potential ecological habitat near the Lower Subase is the Thames River (described below), which represents the Lower Subase's western border. This portion of the Thames River is dominated by piers and serves as a docking and repair facility. Based on previous investigations, contamination resulting from activities at the Lower Subase has potentially impacted the Thames River sediments.

1.3.8.2 Thames River Ecology

Plankton

Very little information exists on the phytoplankton species in the Thames River (ASA, 1989). Most studies have focused on *chlorophyll a* concentrations as a surrogate for phytoplankton densities. *Chlorophyll a* concentrations ranging from 1 to 250 mg/m^3 have been reported for the Thames River. In August 1975, *chlorophyll a* ranged from 40 to 90 mg/m^3 in the reaches of the river downstream of Montville in both surface and bottom waters. Results of studies in 1974 and 1986 reported lower concentrations ranging from 0 to 41 mg/m^3 along the length of river.

In 1989, Project Oceanology measured *chlorophyll* a concentrations above and below the pycnocline to assess the contribution of phytoplankton to hypoxic conditions in bottom water of the estuary. The results of the study showed higher *chlorophyll* a concentrations in the surface layer (3 to 15 mg/m^3) than in the more saline bottom water (1 to 10 mg/m^3).

Phytoplankton/Zooplankton tows were conducted in September 1972 to determine the density and diversity of phytoplankton in the Thames River. The collection was performed with a #25 Standard Mesh Plankton net. Although the exact density was not recorded, the total number of cells was reported to be low. Zooplankton were almost completely absent. The few phytoplankters present were members of the Bacillariophyceae and included *Ditylum brightwelli. Coscinodiscus spp.*, *Gyrosiama spp.*, and *Glenodinium spp. Ditylum brightwelli* was the only species that was uniformly present in the samples, although density was very low.

A zooplankton study was performed in the Montville area (approximately 2 miles upstream of NSB-NLON) in spring, summer, and autumn 1987 (ASA, 1989). This study identified adult copepods as the dominant species of zooplankton in the river during that time. In the spring, the dominant species were *Acartia hudsonica*, *Eurytemora hirundoides*, *Temora longicornis*, and *Centropages sp.* In the summer and autumn, *Acartia tonsa* were dominant. Other zooplankton groups included larval forms of barnacles and crabs. In late summer, the presence of a zooplankton predator, the ctenophore *Mnemiopsis leidyi,* reduced copepod densities.

A study of ichthyoplankton performed in 1988 (ASA, 1989) identified bay anchovy and winter flounder eggs and larvae, tautog eggs, and rainbow smelt larvae.

A low diatom population was also found in the Thames River. This was probably due to the time of collection. Nutrient levels were not excessively high because thorough mixing had not released nutrients from the bottom sediments. Thus, a dense population of diatoms was not likely. Low temperatures, along with winds and wave action in the fall, will result in a mixing and release of bottom nutrients, subsequently producing a diatom "bloom."

Marine Algae

Thirteen species of algae were collected from the Thames River during the 1973 studies (Navy, 1973): seven Rhodophyta, two Phaeophyta, and four Chlorophyta. The Rhodophyta included *Chondrus crispus*, *Dosya pedicellata*, *Grinnellia americana*, *Agardhiella tenera*, *Chondria tenuissima*, *Rhodymenia palmata*, and *Gracilaria folifera*. Phaeophyta were *Laminaria* sp. and *Fucus vesiculosus* var. *sphaerocarpus*. Chlorophyta consisted of *Corium fragile* ssp. *tomentosoides*, *Ulva lactuca, Protoderma marinum* and *Ulthrix flacca*. The majority of the species were collected by dredging and Eckman sampler in the sublittoral zone, and one scuba dive was also made for collecting purposes. The eulittoral zone is narrow, with little substrate for the attachment of algae. Only two species were collected in the eulittoral zone.

The marine algae forms collected were sporadic in distribution. The greatest number of species were collected near the mouth of the river, where a total of seven different species were found. *Fucus sp.* and *Ulothrix* lacea were collected at a few locations in the eulittoral zone and from the pier pilings at the NSB-NLON marina. At no station was the density of algae very great.

A 1983 study of macroalgae in the river summarized by Applied Sciences Associates (ASA, 1989) described the non-industrial portions of the Thames River as having a typical northeastern rocky coastline. The macroalgae in these areas consist of *Enteromorpha sp., Fucus sp., Chondrus sp.*, and *Lamineria sp.* with *Ascophyllum sp.* in protected areas in shallow areas reached by light. In the industrial areas, the algal zone was narrow and sparse or dominated by *Ulva sp., Cladophora sp., Enteromorpha sp.*, and *Vaucheria sp.* The depth of the river in the dredged industrial areas and the lack of appropriate substrate preclude the growth of macroalgae in these areas. During sampling conducted in 1993, dense *Ulva sp.* were observed in Mamacoke Cove across the river from the NSB-NLON.

The lack of species diversity and density of algae in the Thames River is probably due to the lack of suitable substrate. Algae growth was largely confined to large *Venus mercenarca* shells and submerged objects such as lobster traps and other debris. Few rocks were present. Small rocks and larger outcroppings were present along one area of the shore, where *Fucus sp.* and *Ulothrix sp.* were found.

Marine algae are important in the food chain of Thames River marine organisms. *Laminaria sp., Chondrus sp., Ulva sp.,* and *Rhodymenia sp.* are utilized by such forms as herbivorous gastropods, crustaceans, and fishes. These organisms are then eaten by carnivorous forms and so on up the food chain. In addition to being important as a food source, attached marine algae also provide a substrate for the attachment of such invertebrates as hydrozoans, bryozoans, and the polychaete, *Spiroobis sp.* Starfish, polychaetes, and molluscs are also found entangled in the holdfasts of *Laminaria sp.* Despite low numbers and diversity, the importance of the algae in the river should not be minimized.

Species of benthic algae found in this area, of which Ulva sp. was the most prevalent, are

- *Agardhiella tenera*
- *Chondri tenuissima*
- *Chondrus crispus*
- *Gracilaria folifera*
- *Grinnellia americana*
- *Protoderma marimum*
- *Ulotrhix flacca*

- *Ulva lactuca*
- *Fucus vesiculosis var. sphaerocarpus*

One species of vascular plant (*Potamogeton pectinatus*) was found floating throughout the region. No rooted plants of this species were located, however.

Benthic Invertebrates

Much of the existing data on the benthic invertebrates in the Thames River were collected in support of proposed dredging projects. The most comprehensive study was performed for the draft Environmental Impact Statement (EIS) for the Seawolf project (Navy, 1991). The draft EIS document compared data collected during that survey with previous benthic surveys performed in the Thames River. Applied Science Associates (ASA, 1989) also provided a comprehensive summary of benthic data from the Thames River.

Benthic communities in the Thames River differ from south to north and between channel and non-channel areas. Since most of the benthic surveys of the Thames River have been performed in anticipation of dredging, the work has focused on the channel. The benthic communities south of the I-95 bridge (2 miles south of NSB-NLON) are more representative of Long Island Sound. As is expected in an estuary (Maguire, 1990), benthic abundance and species richness decreased from the mouth of the river north to NSB-NLON. Species composition is similar north of the I-95 bridge, but abundances are lower, probably due to the shallower, less saline water in this area.

The channel is dominated by several taxa, including the bivalves *Mulinia lateralis* (the opportunistic coot clam) and *Nucula proxima*, and the polychaetes *Nephtys incisa* and *Mediomastus ambiseta*. Welsh and Stewart also found differences in benthic communities in the channel north and south of the I-95 bridge (Welsh and Stewart, 1984). North of the bridge, they found that *Nephtys ceaca, Potamilla reniformis, Pectinaria gouldii,* and *Yoldia limatula* predominated. They also found invertebrate species such as the hardshell clam (*Mercenaria mercenaria*), the shrimp (*Crangon septemspinosus*), and a starfish (*Asterias forbesii*). This is similar to what Tolderlund reported (Tolderlund, 1975).

In the summer of 1989, Project Oceanology identified *Nucula proxima, Yoldia limatula, Nephtys incisa*, and *Mulinia lateralis* as the most common and abundant species in areas of the estuary where the sand content of the sediments was less than 40 percent.

Predominant species found by Welsh and Stewart outside the channel in 1984 differed from those found in the channel. Outside the channel, they reported the presence of the polychaetes *Scoloplos robustus, Pectinaria gouldii*, and *Sabellaria vulgaris*, softshell clams (*Mya arenaria*), hardshell clams, the amphipod *Gammarus oceanis*, the gastropod *Illyanassa obsoleta*, shrimps *Paleomonetes pugio* and *Crangon septemspinosus*, blue crab (*Callinectes sapidus*), and starfish (*Asteria forbesii*).

Taxa identified in the Thames River benthic samples collected in November 1993 during studies conducted in support of the Phase II RI included nemertean, turbellarian, and annelid worms, gastropods, bivalves, crustaceans, and a few species of other phyla. A few species of annelid worms were dominant at most of the Thames River benthic stations. These included *Mediomastus ambiseta, Cossura longocirrata*, and *Streblospio benedicti*. *M. ambiseta* accounted for 12 to 55 percent of individuals at each station. This species has been identified as "opportunistic" (Dauer, 1993.) These are short-lived species that frequently dominate disturbed or distressed habitats. *C. longocirrata* was most notably dominant near shore at the Lower Base and north of Pier 33 where it accounted for 63 and 69 percent of all individuals, respectively. In contrast, *C. longocirrata* accounted for less than 1 percent of all individuals on the western shore of the river opposite the DRMO. S. *benedicti* generally accounted for between 5 and 30 percent of all individuals. Like M. *ambiseta, S. benedicti* has been classified as "opportunistic" (Dauer, 1993). Other annelids commonly present but less abundant were *Polycirrus spp.*, Aricidea *(Acmira)catherinae, Leitoscoloplos sp., Tharyx sp. A. Polydora cornuta, Clymenalla torquata, Hypereteone heteropoda, Steptosyllis pettiboneae*, and *Nephtys incisa* and oligochaete worms. The mollusks *Mulinia lateralis*, *Yoldia limatula, Tellina agilis, Mya arenaria* (softshell clam), and *Nucula annulata* were relatively abundant at some stations. The only crustacean observed at most stations was the amphipod *Ampelisca abdita*.

The mean number of individuals per station in the Phase II RI samples (represented by the mean of the three replicate 0.05 m^2 samples) ranged from 178 to 1,242. The total number of taxa per station (i.e., the number of taxa observed at a station in at least one of three replicate samples) ranged from 18 to 55.

The benthic invertebrate species identified as dominant or observed during the Phase II RI studies were similar to those reported by others for the Thames River. The results were also similar to those reported for the Pier 15 station (Maguire, 1994).

The environmental assessment conducted as part of the April 1994 study for the Pier 17 replacement (Maguire Group, 1994) included the collection of three samples for benthic analysis. One sample was collected from the vicinity of Pier 15 and two samples were collected from the vicinity of Pier 17. Results indicated that the two samples from near Pier 17 had low numbers of benthic invertebrates (15 and 17

individuals) and low numbers of species (five and six) per sample (0.09 m^2). The sample from near Pier 15 had 303 individuals per sample and a total of 16 infaunal species. The polychaete worms *Mediomastus ambiseta* and *Cossura longocirrata* and the *bivalves Mulina lateralis, Yoldia limatula*, and *Nucula annulata* were the most common in the samples.

Shellfish

Most of the Thames River is closed to recreational shellfishing due to contamination by fecal bacteria (Citak, 1991). Shellfish beds in a few areas of the Thames River are open to commercial shellfishing on a conditionally restricted basis. Conditional restriction means that shellfish from these areas must be relayed to and held in approved waters for 45 days. Shellfish in these beds are hardshell clams (*Mercenaria mercenaria*) and oysters (*Crassostrea virginica*). The conditionally restricted shellfish beds are in Waterford and Ledyard waters.

Some commercial lobstering occurs in the river. Most of the commercial lobstering occurs south of the I-95 bridge, over 1.5 miles downstream of NSB-NLON. Recreational fishing for blue crab also occurs in the river. The blue crabs move into the shallower waters of the coves in the summer months. Recreational crabbing usually occurs in July, August, and September (McLeod, 1993). When the water gets colder, blue crabs move into deeper water and south toward Long Island Sound.

Finfish

Abundant fish species in the Thames River include winter flounder, tomcod, and window pane flounder in the deeper channel areas and mummichog and striped killifish near shore.

The Thames River also serves as a feeding area for long-range coastal migrants such as menhaden, bluefish, striped bass, and mackerel, and seasonal migrants such as tautog, weakfish, porgy, and whiting. Striped bass also overwinter in the estuarine portion of the Thames River. An important recreational fishery in this area is based on striped bass (Minta, 1992).

Historically, the construction of dams on the Shetucket and Yantic Rivers has limited anadromous fish runs in the Thames River to species who could spawn and survive below these dams (Minta, 1992). Prior to construction of the dams in the 1800s, the river supported many anadromous species including Atlantic salmon and Atlantic sturgeon. Currently, the only anadromous species known to spawn in the vicinity of Norwich are alewife, blueblack herring, and rainbow smelt. A small recreational fishery for American shad exists in the Shetucket River upstream of the Thames River estuary. The CTDEP has a goal to restore

the anadromous fishery to the Thames River by encouraging the construction of fish passage facilities on the upstream dams (Minta, 1992).

Birds

Species observed frequently on the river include herring gulls, great black-backed gulls, cormorants, and mute swans. Many duck species, in particular mallards, are observed on the river and overwinter in the coves around Mamacoke Island, opposite the river from NSB-NLON (Askins, 1994). During summer, 10 to 12 mallards and black ducks are normally present in this area; however, during the winter, up to 1,000 ducks have been observed. These include large numbers of canvasback ducks, hooded mergansers, mallards, black ducks, gadwalls, and redhead ducks. Greater scaup and common goldeneye use the area temporarily.

1.3.8.3 Threatened and Endangered Species

Two state endangered and one state threatened species have been sighted in the NSB-NLON area (CTDEP, 1994). The state endangered species include the Golden Alexander (*Zizia aptera*) and the Seaside Crowfoot (*Ranunculus cymbalacia*), and the state threatened species is the Atlantic Sturgeon (*Acipenser oxyrhynchus*).

1.4 DESCRIPTION OF THE LOWER SUBASE STUDY AREA

This section provides a summary of the description of the Lower Subase study area of NSB-NLON. It covers contaminated areas and sources of contamination, including the seven zones of contamination, the Thames River, the fuel oil distribution system, and the steam, condensate and electrical ducts.

1.4.1 Contaminated Areas and Sources of Contamination within Lower Subase

Within the Lower Subase, several potential contaminated areas and sources of contamination have been identified and include Site 10, Site 11, Site 13, Site 17, Site 19, Site 21, Site 22, Site 24, Site 25; the Thames River; the fuel oil distribution system; and steam, condensate, and electrical ducts. The sites, fuel distribution system, and the steam, condensate and electrical ducts have been grouped into zones of investigation. These areas and sources are discussed in the following subsections. Previous investigations identified the Lower Subase as the area occupied by Zones 1 through 4. However, for the purposes of this RI, the Lower Subase is the area occupied by Zones 1 through 7 (See Figures 1-2 and 1-3). The investigation area was increased to include Zones 5 through 7 (from Pier 33 to Berth 16) at the

request of the regulators to provide a cohesive and thorough evaluation of all potential Lower Subase source areas along the Thames River.

1.4.1.1 Zone Boundaries

Seven separate zones of investigation have been identified in the Lower Subase, and the discussion in this report centers on these particular zones. Zones 1 through 4 were delineated in the Phase II RI and were accepted by the regulators for the development of the Phase II RI Report (B&R Environmental, 1997b). These same zones were carried through into the Existing Data Summary Report for the Lower Subase RI (B&R Environmental, 1997a) and into this Lower Subase RI Report. This report also includes Zones 5 through 7.

The Lower Subase includes numerous buildings and potential sources of contamination. The zones were delineated to encompass specific, potential sources and to focus the preparation of reports. The Navy and regulators previously identified potential source areas at NSB-NLON that require investigation under the Navy's IRP and CERCLA. Each of the potential source areas was given a unique site number and specific sites fall within each zone. Portions of the fuel oil distribution lines and steam, condensate, and electrical ducts may also be included in each of the zones. The fuel oil distribution system and the steam, condensate, and electrical ducts are discussed in Sections 1.4.1.3 and 1.4.1.4, respectively. The subdivision of the Lower Subase into zones has also made report preparation easier, focused the nature and extent of contamination discussions and allowed the human health risk assessment to be linked to specific sources.

Site-specific hydrogeology and surface water hydrology information was also used to delineate the zones. The information was used to determine potential contaminant migration pathways from these potential source areas and zone boundaries were generally chosen so that contamination from one zone would not migrate into another. The approach used to delineate Zones 1 through 4 was also used to delineate Zones 5 through 7. The seven zones are shown on Figure 1-3.

Zone 1 extends from Darter Road (just south of Building 89) to the south side of Corvina Road and includes the following IRP sites: Site 10 - Fuel Storage Tanks and Tank 54-H; Site 11 - Power Plant Oil Tanks; and Building 89 Underground Storage Tank (UST).

Zone 2 extends from the southern boundary of Zone 1 (i.e., Corvina Road, which is north of Pier 8) to Capelin Road (just north of Building 31 and Pier 6). No IRP sites have been identified within Zone 2. Approximately 10 buildings are located within Zone 2. Most of the buildings within this zone have been

historically and are currently used for administrative activities. Other buildings within the zone are currently used to house a carpenter's shop, a sanitary sewer pump station/emergency generator, and utilities.

Zone 3 extends from the southern end of Zone 2 (Capelin Road) to the south side of Bullhead Road and includes IRP Site 17 - Hazardous Materials/Solvent Storage Area (Building 31).

Zone 4 extends from the south side of Bullhead Road to the southern boundary of the Lower Subase and includes the following IRP sites: Site 13 - Building 79 Waste Oil Pit; Site 19 - Solvent Storage Area (Building 316); and the Quay Wall Study Area.

Zone 5 consists of Pier 33, Building 175, approximately 800 feet of additional property adjacent to these two structures and the storm sewer conveying Stream 6 from the Area A Downstream. Zone 5 includes IRP Site 22 - Pier 33.

Zone 6 consists of Building 174, which is identified as the following IRP site: Site 24 - Central Paint Accumulation Area (Building 174).

Zone 7 extends from just north of Building 478 to the southern side of Dorado Road and includes the following IRP sites: Site 21 - Berth 16 and Transformers at Building 157 Vault 31; and Site 25 - Classified Materials Incinerator.

1.4.1.2 Thames River

The Thames River forms the western boundary of the Lower Subase. All the zones and sites being evaluated as part of the RI are within several hundred feet of the river. In addition, both groundwater and surface water runoff from the Lower Subase discharge to the Thames River. Therefore, the Thames River may have been adversely impacted by activities at the Lower Subase.

1.4.1.3 Fuel Oil Distribution System

Distribution systems for No. 6 fuel oil and No. 2 diesel fuel have existed within the Lower Subase. The pipelines were historically used to convey fuel to the Power Plant (Building 29), to the underground storage tanks at the fuel farm, and to fuel ships at the piers (see zone-specific figures in Sections 4.0 through 10.0). Recent changes have significantly modified the distribution systems at the Lower Subase. Historical and current information on the distribution systems is provided below.

The No. 6 fuel oil distribution system is no longer in use and has been decommissioned. The system previously included three USTs (OT-1, OT-2 and OT-3) at the Tank Farm, two USTs (54 A and B) near the Power Plant in the Lower Subase, and approximately 3,700 linear feet of 12-inch line. The No. 6 fuel oil line along Argonaut Road from the valve house at the gate of the Lower Subase to the Power Plant (Building 29) was replaced in the late 1980s. Fuel lines along Corvina Road to the piers were also replaced. The No. 6 fuel oil line was contained in concrete-lined trenches shared with other utilities, including steam and condensate lines.

USTs OT-1, OT-2, and OT-3 were removed from service in the summer of 1991 and have subsequently been demolished and closed in place. Tanks 54A and B were emptied, cleaned, and repaired and are now used as containment structures for new, 150,000-gallon, steel tanks. Fuel oil for the Power House, which is stored in these new steel tanks, is brought in by tanker trucks.

The No. 2 diesel fuel oil distribution system included five USTs at the Tank Farm (OT-5, OT-6, OT-7, OT-8, and OT-9) and five USTs (C, D, E, F and G) at the Lower Subase. The system also included approximately 11,000 linear feet of 6-inch pipeline. Portions of the distribution system are still active. The active and inactive underground transfer lines are contained in concrete tunnels that are generally located adjacent to the concrete utility trenches. The concrete tunnels can be accessed through several manholes located throughout the Lower Subase.

A reduced demand for diesel in the mid-1970s led to the modification of Tank OT-5 for waste oil storage purpose and the decommissioning and demolition of Tank OT-6. Tank OT-5 was later decommissioned in 1990. Tanks OT-7, OT-8, and OT-9 were decommissioned in the summer of 1990. Tanks C and D were emptied, cleaned, and repaired and are now used as containment structures for steel tanks. Tanks 54E, F, and G have also been decommissioned by filling them with sand.

Both of the fuel distribution systems may be sources of petroleum contamination within the Lower Subase. An investigation along the active and inactive fuel lines located in the Lower Subase was conducted as part of the Phase II RI (B&R Environmental, 1997b) and the Tank Farm Site Investigation (B&R Environmental, 1997c). Soil sampling and analysis for total petroleum hydrocarbons (TPH) were conducted along new and old diesel underground pipelines in Zones 1 through 4. Soil samples were collected at intervals of approximately 100 feet along the underground lines. Elevated TPH concentrations were found at several soil sample locations. Based on the results of the investigations, new integrity inspections and a review of previously performed integrity inspections were recommended for the fuel lines to identify current and previous sources of petroleum contamination present in the Lower Subase. A leak test investigation was also performed along the active fuel lines by Heitkamp in 1996.

1.4.1.4 Steam, Condensate, and Electrical Ducts

The Power Plant, Building 29, is the producer of steam on the base. Three distribution systems, including the north, east, and pier systems, distribute steam to various portions of the NSB-NLON (see zone-specific figures in Sections 4.0 through 10.0). The north steam distribution system serves the zones located north of the Power Plant, the east steam distribution system serves buildings up to the gate valve house (Building 318), and the pier steam distribution system serves all the piers south of Pier 15. Generally, the steam is used for building heating and for domestic hot water supply. Steam supplied to the piers is used for the various valve stations and for protecting pier water lines against freezing. All steam condensate is returned to the power plant condensate receiver tank, with the exception of that supplied to the piers and oil tank heating coils, which is not recovered. Generally, the condensate return piping parallels the steam distribution piping. The steam distribution and condensate return piping are installed mainly in concrete tunnels, trenches, or above grade. A small portion of the piping system is buried. The tunnels have manholes for access, and the trenches have removable concrete covers at grade level. Electrical lines are also present in the trenches. The subgrade utility ducts may act as preferential flow pathways for contamination in the area. Previous investigations have identified petroleum contamination in the ducts.

1.5 REPORT ORGANIZATION

Section 1.0 is this introduction. Section 2.0 discusses the sample nomenclature and the general investigative procedures of the study area. Section 3.0 covers the general data evaluation procedures including data quality, chemical fate and transport analysis, human health risk assessment, and ecological risk assessment. Sections 4.0 through 11.0 discuss the seven zones within the Lower Subase and the Thames River. Each section includes a site description and discussions of the site investigations; site-specific physical characteristics; nature and extent of contamination; contaminant fate and transport, baseline human health risk assessment, and ecological risk assessment; and summary and conclusions. Section 12.0 of this report provides a summary of conclusions and recommendations for Zones 1 through 7 and the Thames River.

TABLE 1-1

SUMMARY OF PREVIOUS AND ONGOING INVESTIGATIONS AT THE LOWER SUBASE AND RELATED DOCUMENTATION
LOWER SUBASE
NSB-NLON, GROTON, CONNECTICUT
PAGE 1 OF 11

Report	Area Investigated	Associated NSB-NLON Site	Media Investigated	Number of Analytical Samples	Analytical Parameters	Summary of Findings	Historical Recommendations	Analytical Data Included in the Database
NESO 1-026 "Oil Contamination of the Groundwater At Subase New London, CT" Naval Environmental Support Office February 11, 1979	Building 29 (Power Plant Oil Tanks, Area 1)	Lower Subase, Site 11	Soil Groundwater	38 16	Oil/Grease	Source of contamination at Site 11 is the heated day storage tanks and the reclamation tank behind the power plant.	Inspection of tanks and storm sewers and repair as necessary.	No
	Building 107/345 (Oil Storage Tanks, Area 2)	Lower Subase, Site 10				Site 10 poses no environmental threat.	Monitor adjacent well regularly.	
	Building 79 (Waste Oil Pit, Area 3)	Lower Subase, Site 13				Site 13 contaminated with oil originating from abandoned exfiltration well or basin.	Install well system to remove oil from the soil.	
Final Initial Assessment Study of Naval Submarine Base New London, CT NEESA 13-025 Envirodyne Engineers, Inc. March, 1983	Building 79 (Waste Oil Pit, Site 13)	Lower Subase, Site 13	Visual investigation and research of site history	None	NA	Low potential for contributing contaminants to the environment because source of contamination has been filled with concrete and closed to all drainage.	No further action.	NA
	Building 107/345 (Oil Storage Tanks, Site 10)	Lower Subase, Site 10						
	Building 29 (Power Plant Oil Tanks, Site 11)	Lower Subase, Site 11						

TABLE 1-1

SUMMARY OF PREVIOUS AND ONGOING INVESTIGATIONS AT THE LOWER SUBASE AND RELATED DOCUMENTATION
LOWER SUBASE
NSB-NLON, GROTON, CONNECTICUT
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Report	Area Investigated	Associated NSB-NLON Site	Media Investigated	Number of Analytical Samples	Analytical Parameters	Summary of Findings	Historical Recommendations	Analytical Data Included in the Database
Final Site Investigation Subsurface Oil Contamination - Lower Subase Naval Submarine Base - New London, Groton, Connecticut Wehran Engineering Corporation November 1987	Building 29 (Power Plant Oil Tanks, Area 1)	Lower Subase, Site 11	Soil Oil Groundwater	10 9 7	Oil/PCBs[1]	Soluble constituents of oil are present throughout the study area: • Manholes and groundwater in the vicinity of Building 29 and 345 contaminated with #6 and #5 fuel oil.	Additional study of oil distribution in Building 29 and of electrical conduits/ manholes along Corvina Road.	Yes
	Building 107/345 (Oil Storage Tanks, Area 2)	Lower Subase, Site 10				• Manholes, soils, and groundwater in the vicinity of Building 79 contaminated with #6 fuel oil. Likely caused by old undocumented spills.	Mopping sludge oil or excavation of oil-laden soils.	
	Building 79 (Waste Oil Pit, Area 3)	Lower Subase, Site 13				• Utility trench from Building #85 to #78 contaminated with #6 fuel oil. Leak suspected in #6 fuel line within trench.	Inspection of the #6 fuel oil line and cleaning of trench.	
Hydrogeologic Investigation Underground Storage Tanks OT-4, OT-7, OT-8, OT-9, and 54-H U.S. Naval Submarine Base New London Groton, Connecticut Fuss & O'Neill, Inc. September 1989	Lower Subase, Tank 54-H	Lower Subase, Site 10	Groundwater	4	Volatile organics, Petroleum Scan (Coast Guard Method)	• Impacts have occurred as a result of petroleum handling at the site. • No. 2 fuel oil found in groundwater monitoring wells. • Volatile organics found in groundwater monitoring wells.	With data available, cannot determine if tanks or the associated piping and appurtenances are leaking.	Yes

TABLE 1-1

SUMMARY OF PREVIOUS AND ONGOING INVESTIGATIONS AT THE LOWER SUBASE AND RELATED DOCUMENTATION
LOWER SUBASE
NSB-NLON, GROTON, CONNECTICUT
PAGE 3 OF 11

Report	Area Investigated	Associated NSB-NLON Site	Media Investigated	Number of Analytical Samples	Analytical Parameters	Summary of Findings	Historical Recommendations	Analytical Data Included in the Database
Multi-media Inspection, Naval Submarine Base-New London, Groton, Connecticut USEPA, Region I, August 8, 1991	Various locations for Clean Water Action inspection	Lower Subase	Sediment Surface Water Industrial/ Sanitary Discharge	3 1 3	Unknown Oil/Grease VOC[2], Metals	Certain accessible sampling locations and flow measurement devices will be necessary to comply with future self monitoring requirements.	To be provided.	No
	Various locations for TSCA[3] inspection	Lower Subase	None	NA	NA	Various PCB spills and storage problems.	Correct problems.	NA
	Various locations for RCRA[4] inspection	Lower Subase	None	NA	NA	Various deficiencies in container storage area, inspections, documentation, waste manifests, contingency plan, and spill prevention, control, and counter measures.	Correct problems.	NA

TABLE 1-1

SUMMARY OF PREVIOUS AND ONGOING INVESTIGATIONS AT THE LOWER SUBASE AND RELATED DOCUMENTATION
LOWER SUBASE
NSB-NLON, GROTON, CONNECTICUT
PAGE 4 OF 11

Report	Area Investigated	Associated NSB-NLON Site	Media Investigated	Number of Analytical Samples	Analytical Parameters	Summary of Findings	Historical Recommendations	Analytical Data Included in the Database
Phase I Remedial Investigation Naval Submarine Base New London Atlantic Environmental Services, Inc. August 1992	Lower Subase, Site 13	Lower Subase, Site 13	Soil Groundwater	17 24	TCL[5] VOC TAL Metals/CN[6] TCLP[7] Metals TPH[3] Fluorescence TCL VOC TAL Metals/CN[6] TPH[8] Fluorescence pH	Nature and Extent of Contamination • Groundwater slightly exceeds drinking water standards. • No oil releases along Thames River. • Groundwater near Building 29 had high pH. • Former onsite oil pit in Building 79 is source of subsurface soil contamination. • Elevated lead levels detected in soil but not in groundwater. • Subsurface free product detected in previous studies is no longer present. • Low levels of Thallium detected in two monitoring wells. Human Health Risk Assessment • Negligible risks calculated for several exposure pathways.	Proceed to a Feasibility Study with additional data requirements.	Yes

TABLE 1-1

SUMMARY OF PREVIOUS AND ONGOING INVESTIGATIONS AT THE LOWER SUBASE AND RELATED DOCUMENTATION
LOWER SUBASE
NSB-NLON, GROTON, CONNECTICUT
PAGE 5 OF 11

Report	Area Investigated	Associated NSB-NLON Site	Media Investigated	Number of Analytical Samples	Analytical Parameters	Summary of Findings	Historical Recommendations	Analytical Data Included in the Database
Action Memorandum for Building 31 Naval Submarine Base - New London Groton, Connecticut Halliburton NUS Corporation May, 1993	Building 31	Lower Subase, Site 17	Subsurface Soil Surface Soil Groundwater	101 28 9 5 4 20	pH, Lead TCLP Lead Metals Organics Lead Metals	• Soil at the site contaminated primarily with metals. • Other contaminants include PAHs, phthalate esters, chlorinated phenolics and pesticides.	Excavation, onsite solidification, and offsite solidification of soil contaminated with lead.	Yes
Remedial Design for Building 31 Naval Submarine Base - New London Groton, Connecticut Halliburton NUS Corporation May, 1993	Building 31	Lower Subase, Site 17	Design Report			Design for removal actions documented.	Proceed to removal action.	NA
Environmental Assessment for Pier 17 Replacement, Naval Submarine Base New London, Groton Connecticut, Prepared for: Department of the Navy, Commander-In-Chief, U.S. Atlantic Fleet, Norfolk, Virginia, Prepared by: Maguire Group Inc. September 1994	Pier 15 Pier 17	Thames River	Sediment Surface Water Fish and Benthic Species	24 3 5	Metals, PAHs Elutriate Test Toxicity test and Taxonomy study	• Higher concentrations of metals and PAHs[9] in upper sediment strata than lower strata. • Pesticides and PCBs detected in low levels in upper sediment strata. • Mercury and nickel exceeded marine USEPA water quality criteria.	The proposed action will have short-term effects on Thames River water quality, no effects on navigation, and minimal effects on fish and benthic species.	Yes

TABLE 1-1

SUMMARY OF PREVIOUS AND ONGOING INVESTIGATIONS AT THE LOWER SUBASE AND RELATED DOCUMENTATION
LOWER SUBASE
NSB-NLON, GROTON, CONNECTICUT
PAGE 6 OF 11

Report	Area Investigated	Associated NSB-NLON Site	Media Investigated	Number of Analytical Samples	Analytical Parameters	Summary of Findings	Historical Recommendations	Analytical Data Included in the Database
Post-Removal Action Report for Building 31 Lead Remediation Naval Submarine Base - New London Groton, Connecticut Halliburton NUS Corporation January, 1995	Building 31	Lower Subase, Site 17	Excavated Soil Solidified Soil Wipe Samples	57 54 27	Total Lead TCLP Lead Total Lead	The final sample results showed that the walls of the excavation were no longer contaminated or the excavation reached the mean low tide elevation (maximum excavation depth). Albacore Road could not be completely excavated due to operational concerns of the Base. The sampled concrete surfaces were either not contaminated or were adequately decontaminated.	No further excavation was required for most areas of site. Navy to defer continued remediation at Albacore Road.	Yes
Final Site Inspection Report Pier 33 and Berth 16/Former Incinerator Installation Restoration Study Naval Submarine Base - New London Groton, Connecticut Atlantic Environmental Services, Inc. February, 1995	Pier 33 and Berth 16/ Former Incinerator	Portions of the Pier 33 Study Areas are located near Lower Subase Site 22 Berth 16 is not located in the formal boundaries of the Lower Subase site used in the RI, however, Berth 16 is proximate to Site 13	Soil Sediment Groundwater	43 4 9	TAL/TCL Parameters TPH TCLP Metals Dioxin	• VOCs concentrations detected in the soils are not considered to be significant. • Elevated concentrations of TPH were detected. • No significant concentrations of pesticides or PCBs were detected. • Groundwater quality at the site is generally good and does not exceed ARARs[10] except for lead in one well. • Dioxin was detected in one location.	Remedial Investigation is recommended for both Pier 33 and Berth 16.	Yes

TABLE 1-1

SUMMARY OF PREVIOUS AND ONGOING INVESTIGATIONS AT THE LOWER SUBASE AND RELATED DOCUMENTATION
LOWER SUBASE
NSB-NLON, GROTON, CONNECTICUT
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Report	Area Investigated	Associated NSB-NLON Site	Media Investigated	Number of Analytical Samples	Analytical Parameters	Summary of Findings	Historical Recommendations	Analytical Data Included in the Database
Background Soil Investigation Naval Submarine Base - New London Groton, Connecticut Atlantic Environmental Services, Inc. April, 1995	Undisturbed Areas of NSB-NLON	None	Soil	18	TCL VOC TCL SVOC[11] TCL Pest/PCB TAL Metals Cyanide Boron	• All site-derived background levels are within the ranges published by the USGS[12] for background levels for the eastern United States. • Based on the organic compounds detected, it is concluded that all samples locations are representative of native background conditions.	Background levels of inorganics were established to screen site analytical data to identify areas where releases of pollutants may have occurred.	Yes
Site Characterization Report for OT-10, Building 325, and Building 89 Naval Submarine Base - New London Groton, Connecticut Halliburton NUS Corporation April 1995	Building 89, Tank Z01	Site is not located in the formal boundaries of the Lower Subase site used in the RI; however, Building 89 is proximate to the Lower Subase site	Soil	3 1	BTEX[13], TPH Lead, TPH, Volatile Aromatics	Analytical results indicate soils in the vicinity of tank Z01 have detected contaminants below state cleanup levels. Groundwater has been impacted by a petroleum related source.	Due to the possibility of the groundwater contamination originating from another source, and because the Lower Subase is being investigated as part of the RI, no further action is recommended.	Yes

TABLE 1-1

SUMMARY OF PREVIOUS AND ONGOING INVESTIGATIONS AT THE LOWER SUBASE AND RELATED DOCUMENTATION
LOWER SUBASE
NSB-NLON, GROTON, CONNECTICUT
PAGE 8 OF 11

Report	Area Investigated	Associated NSB-NLON Site	Media Investigated	Number of Analytical Samples	Analytical Parameters	Summary of Findings	Historical Recommendations	Analytical Data Included in the Database
Preliminary Assessment, Draft Final PA-13-025A-ENV Supplement to Initial Assessment Study NEESA 13-025, Naval Facilities Engineering Service Center, Naval Submarine Base New London Groton, Connecticut April, 1995	Transformer at Building 157, Vault 31	Lower Subase, Zone 7	Visual Investigation and Research of Site History			Oil on concrete pad surface, potential for PCBs.	No further action under the cleanup recommended under the spill contingency plan.	NA
	Hazardous Waste Accumulation Areas	Various				No evidence of releases found.	No further action.	
Removal Site Evaluation for Quay Wall for Naval Submarine Base New London Halliburton NUS Corporation May 1995	Quay Wall	Lower Subase	Soil	5	BTEX TCLP Metals TCL VOC TCLP VOC TCL SVOC Total PCB TAL Metals Cyanide TPH	• Lead and arsenic detected above CTDEP regulatory standard. • VOC, SVOC, and pesticides below regulatory CTDEP standards. • No PCBs detected. • TPH detected in all soils but not in exceedance of CTDEP standards.	No further removal actions are recommended but further study needed.	Yes

TABLE 1-1

SUMMARY OF PREVIOUS AND ONGOING INVESTIGATIONS AT THE LOWER SUBASE AND RELATED DOCUMENTATION
LOWER SUBASE
NSB-NLON, GROTON, CONNECTICUT
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Report	Area Investigated	Associated NSB-NLON Site	Media Investigated	Number of Analytical Samples	Analytical Parameters	Summary of Findings	Historical Recommendations	Analytical Data Included in the Database
Final Environmental Impact Statement for Seawolf Class Submarine Homeporting on East Coast of the United States, Prepared for: Department of the Navy Commander-In-Chief, U.S. Atlantic Fleet, Norfolk, Virginia. Prepared by: Maguire Group Inc. August 1995	Pier 8 Pier 10	Thames River	Sediment Fish and Benthic Species	27 10	Metals PAHs PCBs Pesticides Toxicity	• Sediments to be dredged are similar to previously dredged material. • Sediments in the channel tend to be cleaner than those near the pier areas.	Sediments to be dredged are not toxic to bottom dwellers. Channel sediments near the subase piers could cause accumulation of organic contaminants in tissues of benthic organisms.	Yes
Site Investigation Report for Tank Farm Investigation Naval Submarine Base - New London Groton, Connecticut Brown & Root Environmental September, 1997	Tank Farm	The Investigation of the pipelines from the Tank Farm include a portion of the Lower Subase Site	Soil	29	TPH	Petroleum hydrocarbons found in soil along the fuel pipeline in the Lower Subase Area.	Further assess pipelines under the upcoming Lower Subase RI.	Yes
Leak Testing Investigation for Fuel Oil Distribution System Naval Submarine Base New London Groton, Connecticut Heitkamp April, 1996	Lower Subase	Pressure testing of various fuel oil distribution lines within the Lower Subase Site				One section of fuel line in the vicinity of Pier 12 failed the test. Two valves in the diesel fuel lines in the vicinity of Building 332 do not seal tightly.	Replacement of the two valves and section of fuel line.	No
Annual NPDES Storm-Water Monitoring Program October, 1996	Lower Subase	Building 85, Building 89 and Between Zones 5 and 6 (NOVA)	Stormwater	3	pH, DO[14], Solids Oil/Grease Inorganics Coliform Zinc, Copper, Lead Toxicity	Stipulated annual monitoring in accordance with General Stormwater Permit.		Yes

TABLE 1-1

SUMMARY OF PREVIOUS AND ONGOING INVESTIGATIONS AT THE LOWER SUBASE AND RELATED DOCUMENTATION
LOWER SUBASE
NSB-NLON, GROTON, CONNECTICUT
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Report	Area Investigated	Associated NSB-NLON Site	Media Investigated	Number of Analytical Samples	Analytical Parameters	Summary of Findings	Historical Recommendations	Analytical Data Included in the Database
Phase II Remedial Investigation for Naval Submarine Base - New London Groton, Connecticut Brown & Root Environmental March, 1997	Lower Subase	Lower Subase	Soil Groundwater	22 23 2 52 2	Lead TPH, TCLP Metals TCLP VOC, SVOC TCLP Herb/Pest TCL VOC TCL SVOC TAL Metals TAL Metals (dis.) TPH Eng. Parameters	• It appears that the lower Subase may have impacted the Thames River due to elevated contamination in the sediment adjacent to the Lower Subase. • Elevated human health risks for Construction Worker in Zones 1 and 2 (non-carcinogenic). • It is unlikely that the Lower Subase represents a risk to ecological receptors.	Further characterization of the Lower Subase should be performed.	Yes
	Thames River	Thames River	Sediment Surface Water Biota	2 18 16 15 6 11 25	TCL VOC TCL SVOC TCL Pest TCL PCBs TAL Metals Taxonomy Engr. Char. TCL VOC TCL SVOC TCL Pest TCL PCBs TAL Metals TAL Metals (dis.) TCL VOC TCL SVOC TCL Pest TCL PCBs TAL Metals	• Nature and extent of contamination in surface water and sediment of Thames River is not indicative of releases from NSB-NLON except possibly the Lower Subase. • Carcinogenic risks associated with ingestion of finfish/shellfish. • Thames River presents minimal risks to potential ecological receptors.	Perform additional characterization of the Thames River in the vicinity of the Lower Subase.	Yes

TABLE 1-1

SUMMARY OF PREVIOUS AND ONGOING INVESTIGATIONS AT THE LOWER SUBASE AND RELATED DOCUMENTATION
LOWER SUBASE
NSB-NLON, GROTON, CONNECTICUT
PAGE 11 OF 11

Report	Area Investigated	Associated NSB-NLON Site	Media Investigated	Number of Analytical Samples	Analytical Parameters	Summary of Findings	Historical Recommendations	Analytical Data Included in the Database
Existing Data Summary Report for Lower Subase Remedial Investigation Naval Submarine Base New London, Groton, Connecticut Brown & Root Environmental March, 1997	Lower Subase, Thames River	Lower Subase, Thames River	Evaluate adequacy of existing data			• Activities and contamination at the Lower Subase have impacted the Thames River but have minimal impact on the groundwater. • USTs and leaking fuel lines result in potential contaminant sources throughout the Lower Subase.	Perform additional characterization of the Thames River in the vicinity of the Lower Subase. Also identify and remove and monitor sources of contamination in the Lower Subase. Identify and repair fuel line leaks. Perform additional characterization at all contaminant zones in the Lower Subase.	NA

NA: Not Applicable
1 PCBs: Polychlorinated biphenyls
2 VOC: Volatile organic compounds
3 TSCA: Toxic Substances Control Act
4 RCRA: Resource Conservation and Recovery Act
5 TCL: Target Compound List
6 TAL: Target Analyte List
CN: Cyanide
7 TCLP: Toxicity Characteristic Leaching Procedure
8 TPH: Total Petroleum Hydrocarbons
9 PAHs: Polycyclic aromatic hydrocarbons
10 ARARs: Applicable Relevant or Appropriate Requirements
11 SVOC: Semivolatile organic compounds
12 USGS: United States Geological Survey
13 BTEX: Benzene, Toluene, Ethylbenzene, Xylene
14 DO: Dissolved oxygen

TABLE 1-2

BACKGROUND CONCENTRATIONS - SURFACE WATER[1] - THAMES RIVER
LOWER SUBASE
NSB-NLON, GROTON, CONNECTICUT

Analyte	Background Concentration (µg/L)
Aluminum	1
Barium	20
Boron	4,500
Cadmium	0.11
Calcium	410,000
Chromium	0.05
Iron	3
Lead	0.03
Magnesium	1,350,000
Manganese	2
Mercury	0.2
Potassium	390,000
Sodium	10,500,000
Vanadium	2
Zinc	10

1 Background concentrations established using data taken from USGS Water-Supply Paper 2254 "Study and Interpretation of the Chemical Characteristics of Natural Water" (Hem, 1985).

TABLE 1-3

BACKGROUND CONCENTRATIONS - SEDIMENT[1] - THAMES RIVER
LOWER SUBASE
NSB-NLON, GROTON, CONNECTICUT

Analyte	Background Concentration (mg/kg)
Aluminum	54,500
Antimony	0.405
Arsenic	6.75
Barium	NA
Beryllium	NA
Boron	NA
Cadmium	0.39
Calcium	NA
Chromium	73
Cobalt	NA
Copper	36.8
Iron	29,250
Lead	42.15
Magnesium	NA
Manganese	486
Mercury	0.169
Nickel	34.5
Potassium	NA
Selenium	0.32
Silver	0.615
Sodium	NA
Thallium	NA
Vanadium	NA
Zinc	112.45

1 Background concentrations established using NOAA Technical Memorandum NOS ORCA 80, "Biological Effects of Toxic Contaminants in Sediments from Long Island Sound and Environs" (NOAA, 1994).

NA - Not Available.

TABLE 1-4

BACKGROUND SOIL CONCENTRATIONS[1]
LOWER SUBASE
NSB-NLON, GROTON, CONNECTICUT

Parameter	Naval Submarine Base Site-Specific Background[2] (mg/kg)	
	(0-2 feet)	(0-4 feet)
Aluminum	17,600	17,600
Arsenic	3.6	3.6
Antimony	2.05[3]	2.05[3]
Barium	39	57.2
Beryllium	0.72	0.72
Boron	3.1[3]	3.1[3]
Cadmium	0.24[3]	0.24[3]
Calcium	314	499
Chromium	19.3	21.5
Cobalt	7	8
Copper	17.9	25.6
Iron	16,800	17,200
Lead	17.5	17.5
Magnesium	2,460	3,650
Manganese	172	188
Mercury	0.055[3]	0.05
Nickel	5.0[3]	5.95[3]
Potassium	669	2,580
Selenium	0.445[3]	0.445[3]
Silver	0.385[3]	0.385[3]
Sodium	16.5[3]	20.5[3]
Thallium	0.105[3]	0.29
Vanadium	33.3	35.1
Zinc	25.6	31.3

1 All data taken from Atlantic, 1995b.
2 The site-specific background value is the highest value detected from among all the background soil samples collected in April 1995.
3 Value based on one-half of the highest detection level from among all the background soil samples collected in April 1995.

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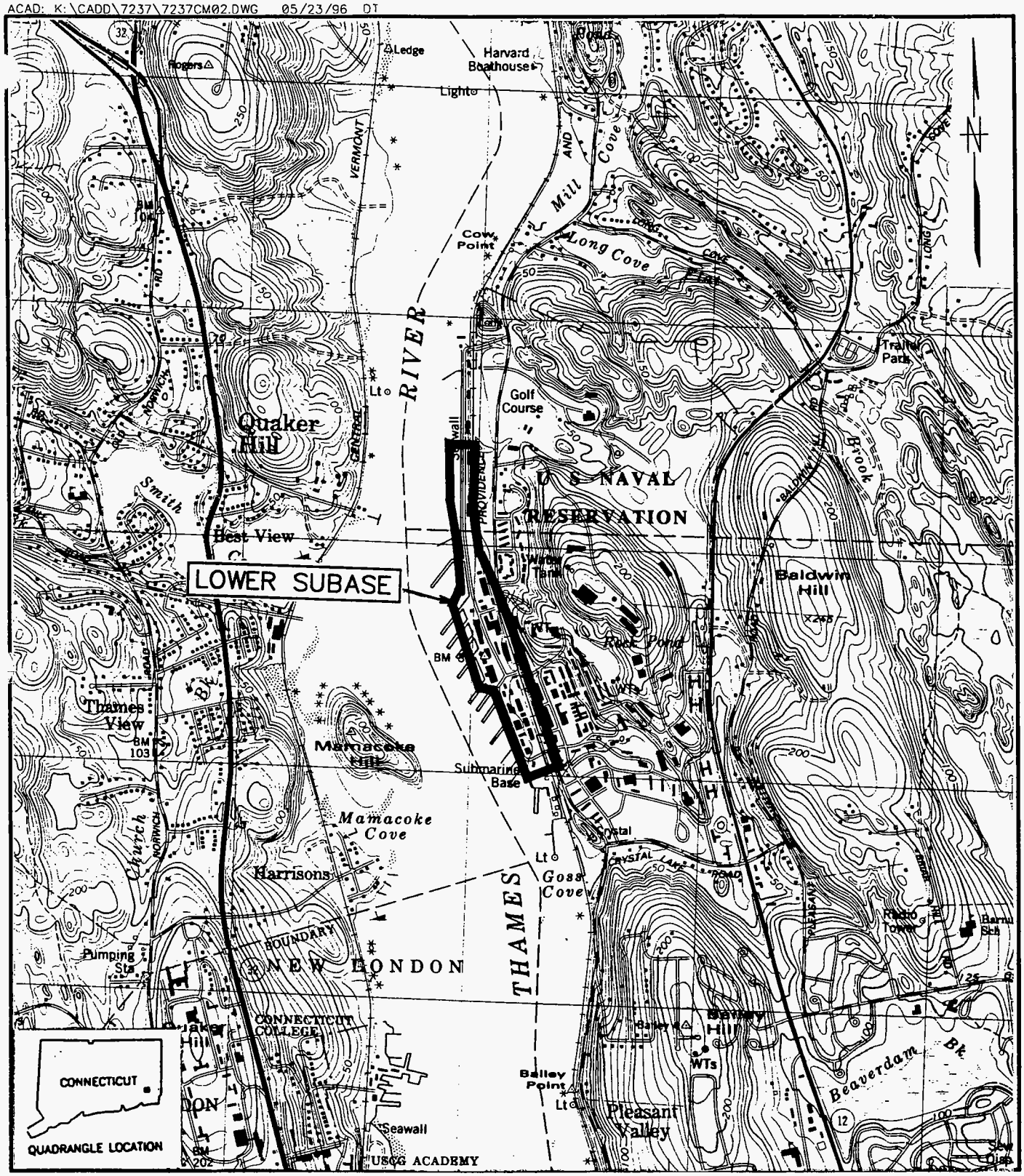

BASED ON USGS UNCASVILLE, CT AND NEW LONDON, CT-NY QUADRANGLE MAPS, 1984. 1"=2000

FIGURE 1-1

SITE LOCATION MAP
NSB-NLON, GROTON, CONNECTICUT

0 2000 4000
SCALE IN FEET

Brown & Root Environmental

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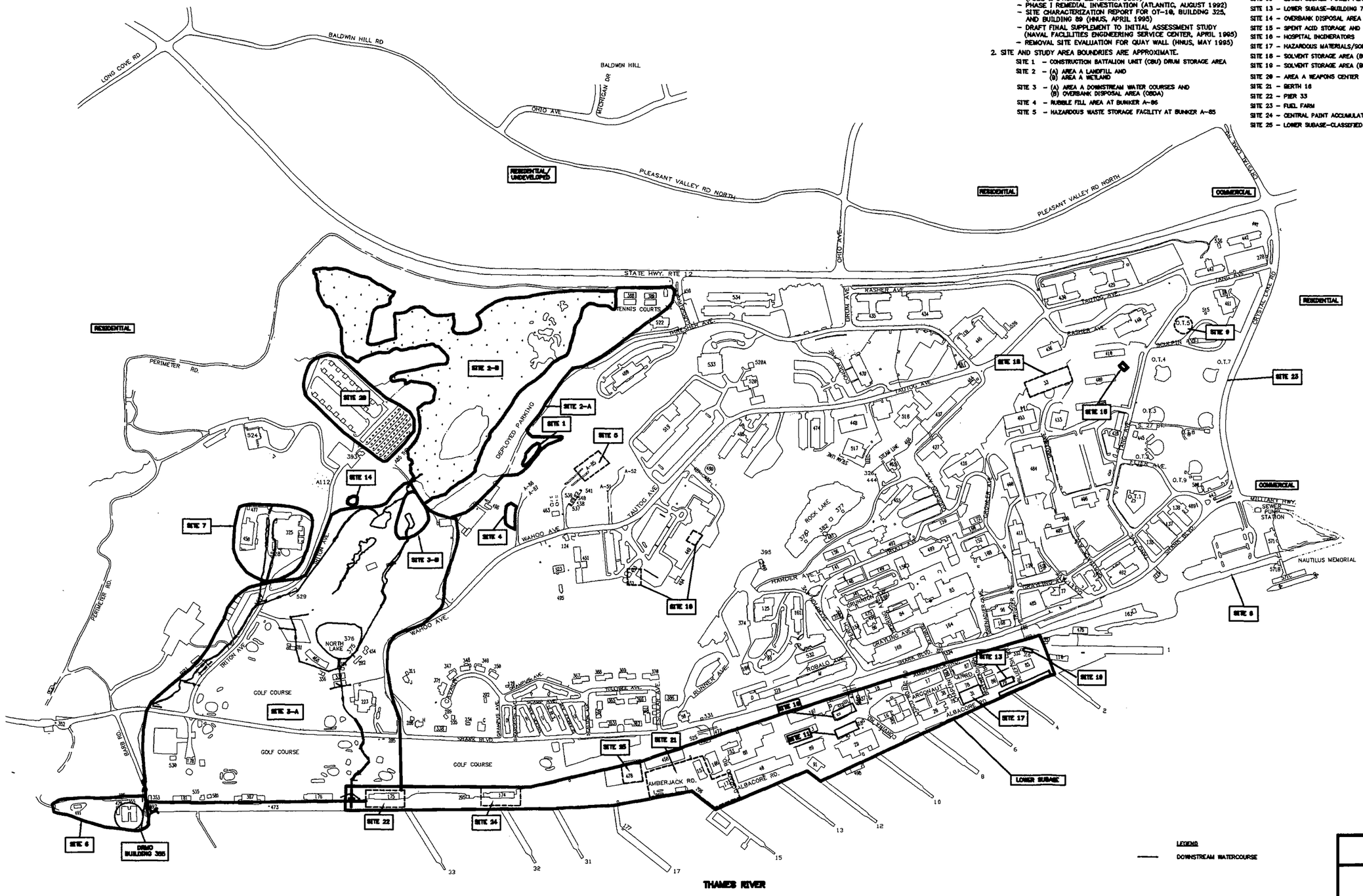
REVISION 1
OCTOBER 1998

NOTES:
1. SITE AND STUDY AREA LOCATIONS WERE TAKEN FROM THE FOLLOWING REPORTS:
   - FEDERAL FACILITY AGREEMENT UNDER CERCLA 120, NAVAL SUBMARINE BASE, NEW LONDON, CONNECTICUT
   - FINAL INITIAL ASSESSMENT STUDY (ENVIRODYNE, MARCH 1983)
   - HYDROGEOLOGIC INVESTIGATION UNDERGROUND STORAGE TANKS OT-4, OT-7, OT-8, OT-9, AND 54-H (FUSS & O'NEILL, SEPTEMBER 1989)
   - PHASE I REMEDIAL INVESTIGATION (ATLANTIC, AUGUST 1992)
   - SITE CHARACTERIZATION REPORT FOR OT-10, BUILDING 325, AND BUILDING 89 (HNUS, APRIL 1995)
   - DRAFT FINAL SUPPLEMENT TO INITIAL ASSESSMENT STUDY (NAVAL FACILITIES ENGINEERING SERVICE CENTER, APRIL 1995)
   - REMOVAL SITE EVALUATION FOR QUAY WALL (HNUS, MAY 1995)
2. SITE AND STUDY AREA BOUNDRIES ARE APPROXIMATE.

SITE 1 – CONSTRUCTION BATTALION UNIT (CBU) DRUM STORAGE AREA
SITE 2 – (A) AREA A LANDFILL AND (B) AREA A WETLAND
SITE 3 – (A) AREA A DOWNSTREAM WATER COURSES AND (B) OVERBANK DISPOSAL AREA (OBDA)
SITE 4 – RUBBLE FILL AREA AT BUNKER A-86
SITE 5 – HAZARDOUS WASTE STORAGE FACILITY AT BUNKER A-85
SITE 6 – DEFENSE REUTILIZATION AND MARKETING OFFICE (DRMO)
SITE 7 – TORPEDO SHOPS
SITE 8 – GOSS COVE LANDFILL
SITE 9 – OILY WASTEWATER TANK (OT-5)
SITE 10 – LOWER SUBASE-FUEL STORAGE TANKS AND TANK 54-H
SITE 11 – LOWER SUBASE-POWER PLANT OIL TANKS
SITE 13 – LOWER SUBASE-BUILDING 78 WASTE OIL PIT
SITE 14 – OVERBANK DISPOSAL AREA NORTHEAST (OBDANE)
SITE 15 – SPENT ACID STORAGE AND DISPOSAL AREA (SASDA)
SITE 16 – HOSPITAL INCINERATORS
SITE 17 – HAZARDOUS MATERIALS/SOLVENT STORAGE AREA (BUILDING 31)
SITE 18 – SOLVENT STORAGE AREA (BUILDING 33)
SITE 19 – SOLVENT STORAGE AREA (BUILDING 38)
SITE 20 – AREA A WEAPONS CENTER
SITE 21 – BERTH 16
SITE 22 – PIER 33
SITE 23 – FUEL FARM
SITE 24 – CENTRAL PAINT ACCUMULATION AREA (BUILDING 174)
SITE 25 – LOWER SUBASE-CLASSIFIED MATERIALS INCINERATOR



LEGEND
DOWNSTREAM WATERCOURSE

NOT TO SCALE

FIGURE 1-2

LOWER SUBASE RI
IRP SITE LOCATION MAP
NSB-NLON
GROTON, CONNECTICUT

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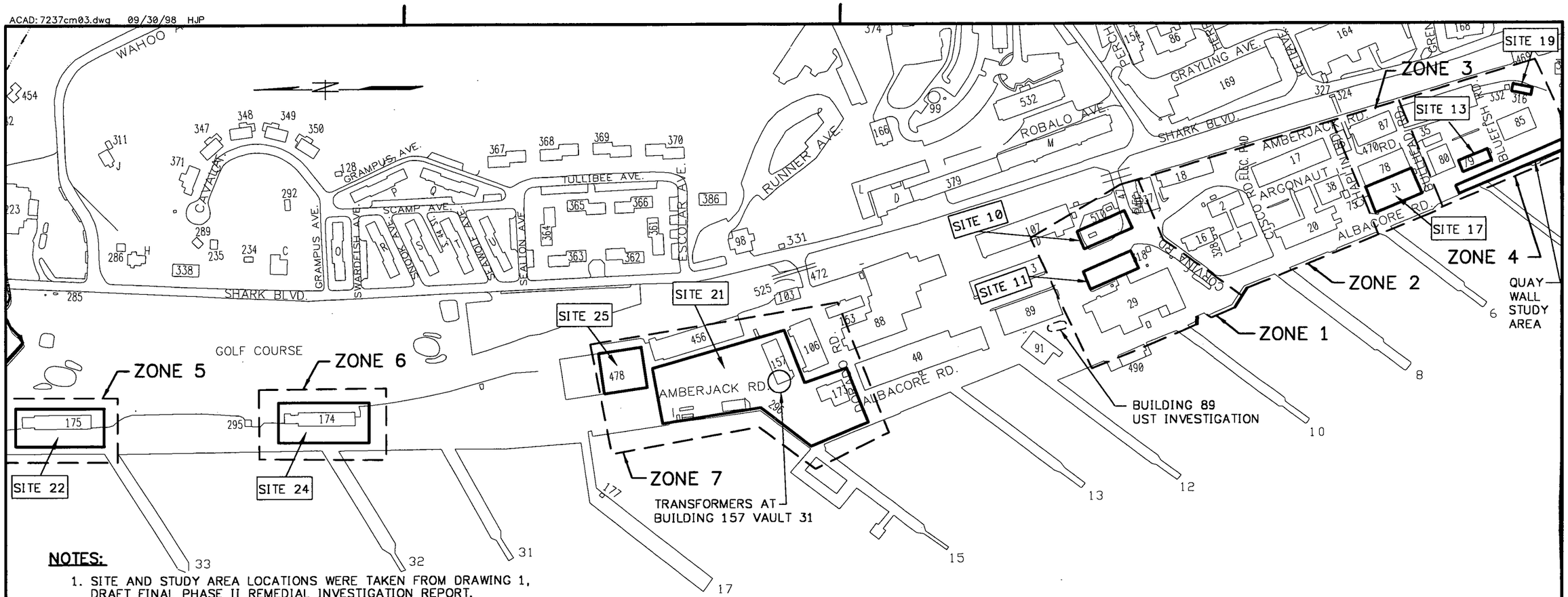


NOTES:

1. SITE AND STUDY AREA LOCATIONS WERE TAKEN FROM DRAWING 1, DRAFT FINAL PHASE II REMEDIAL INVESTIGATION REPORT, BROWN AND ROOT ENVIRONMENTAL, MARCH 1996.
2. SITE AND STUDY AREA BOUNDRIES ARE APPROXIMATE.
   - SITE 10 – FUEL STORAGE TANKS AND TANK 54-H
   - SITE 11 – POWER PLANT OIL TANKS
   - SITE 13 – BUILDING 79 WASTE OIL PIT
   - SITE 17 – HAZARDOUS MATERIALS/SOLVENT STORAGE AREA (BUILDING 31)
   - SITE 19 – SOLVENT STORAGE AREA (BUILDING 316)
   - SITE 21 – BERTH 16
   - SITE 22 – PIER 33
   - SITE 24 – CENTRAL PAINT ACCUMULATION AREA (BUILDING 174)
   - SITE 25 – CLASSIFIED MATERIALS INCINERATOR

0 300 600
SCALE IN FEET

LEGEND:

— — — LOWER SUBASE REMEDIAL INVESTIGATION ZONE BOUNDARY

——— LOWER SUBASE REMEDIAL INVESTIGATION SITE OR STUDY AREA BOUNDARY

NO.	DATE	REVISIONS	BY	CHKD	APPD	REFERENCES

DRAWN BY HJP DATE 9/30/98
CHECKED BY DATE
COST/SCHED-AREA
SCALE AS NOTED

Brown & Root Environmental

LOWER SUBASE
ZONE AND SITE LOCATION MAP
NSB-NLON, GROTON, CONNECTICUT

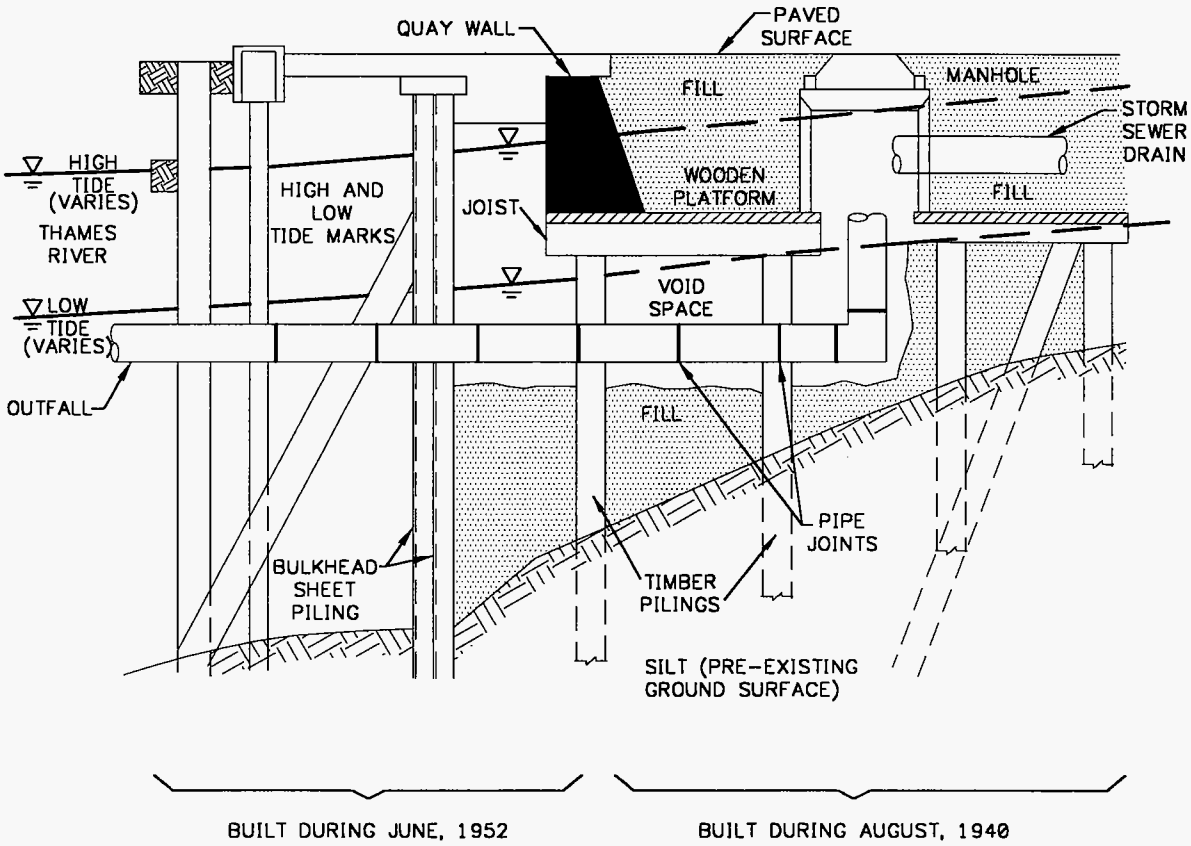
CONTRACT NO. 7237
OWNER NO. 0260
APPROVED BY Corey G. Rail DATE 10/7/98
APPROVED BY DATE
DRAWING NO. FIGURE 1-3
REV. 0

FORM CADD NO. SOUTH_BH.DGN - REV 0 - 02/11/97

CTO 0260

019809/P

ACAD: 7237GX10.DWG 09/30/98 HJP VIEW=PLOT BUNK.LAY



SOURCE: WEHREN, 1987

DRAWN BY HJP DATE 9/30/98	Brown & Root Environmental	CONTRACT NO. 7237	OWNER NO. 0260
CHECKED BY DATE	TYPICAL CROSS-SECTION THROUGH SOUTHERN LOWER SUBASE NSB-NLON, GROTON, CONNECTICUT	APPROVED BY Gary A. Pind	DATE 10/7/98
COST/SCHED-AREA		APPROVED BY	DATE
SCALE N.T.S.		DRAWING NO. FIGURE 1-4	REV. 0

FORM CADD NO. SOUTH_AV.DWG - REV 0 - 02/07/97

2.0 STUDY AREA INVESTIGATION

This section describes the technical approach for the sampling and analyses performed for the Lower Subase RI. It includes a discussion of sample nomenclature (Section 2.1); summaries of methodologies for the soil and vadose zone investigation (Section 2.2), the groundwater investigation (Section 2.3), and the sediment and surface water investigation (Section 2.4); and a discussion of surveying and mapping of sampling locations (Section 2.5). Site-specific sampling locations and analyses are detailed in Sections 4.0 through 11.0.

The field work for the Lower Subase RI was conducted in two phases during October and November 1997. Phase 1 included shallow and deep soil sampling in Zones 1 through 7 and monitoring well installation in Zones 3, 4, 6, and 7. Phase 2 included groundwater sampling from existing and newly installed monitoring wells, water-level and free-product measurements of existing and newly installed monitoring wells, and sediment and surface water sampling in the Thames River along the Lower Subase. All field work was conducted in accordance with the Lower Subase RI Work Plan (B&R Environmental, 1997d).

2.1 SAMPLE NOMENCLATURE

The sample nomenclature for the Lower Subase RI consists of a unique sample tracking identification number assigned to each sample. Sample numbers contain up to thirteen characters, with segments identifying the site number, sample medium, sample location, sample depth (soils only), and sampling round. Each segment of the sample number is defined as follows.

- **Site Number**: The first three characters identify the zone. Designation consists of "LS" for Lower Subase RI, followed by the corresponding zone number.

- **Sample Medium**: The fourth and fifth characters identify the sample medium (soil, groundwater, sediment, and surface water). Designations include SB - subsurface soil; GW - groundwater; SD - sediment; and SW - surface water.

- **Sample Location**: The three to six characters following the sample medium segment identify the sample location. Samples from Lower Subase RI locations are identified with three numeric characters, corresponding to the test boring or monitoring well location number for soils and groundwater, respectively. Samples from existing monitoring wells are identified by the previous investigation designation and include up to six alphanumeric characters.

- **Sample Depth Indicator (Soils Only)**: For soil samples, the sample depth indicator is identified by two numeric characters following the sample location. The sample depth indicator corresponds to the split-spoon or Geoprobe® sample number of a test boring. Split-spoon and Geoprobe® samples are numbered consecutively for each sample interval of a boring. Corresponding depth intervals are documented in the boring logs or notebooks. Sample depth information is included in the analytical database compiled for the Lower Subase RI.

- **Sampling Round:** The last two characters of the sample number identify the sampling round. All samples collected during the Lower Subase RI are designated as "01."

In addition, filtered groundwater samples are identified by the additional designation of "-F" suffixed to the sample number and noted as separate line items on the Chain of Custody Records.

Quality assurance (QA) and quality control (QC) samples are typically given a seven-character sample tracking identification number, consisting of three fields identifying the sample medium, sample type, and sample number. The sample medium consists of two characters with the same designations as described above. The QA/QC sample type designation follows the sample media and includes FD - field duplicate; RB - rinsate blank; AB - ambient blank; TB - trip blank; and, FB - source water blank. The sample number consists of three numeric characters, numbered sequentially for each sample type. Filtered water samples are suffixed with "-F," as stated above. The following exceptions to the sample nomenclature should be noted:

- No sample medium was associated with source water blank identification numbers.

- Groundwater field duplicates for environmental samples "LS1GW13MW101" and "LS6GW00201" are denoted as "Duplicate - 004" and "Dup 005", respectively.

- "Field Blank 001" collected during Phase 2 is an ambient blank for groundwater sampling.

2.2 SOIL AND VADOSE ZONE INVESTIGATION

This section describes the methodology for the soil and vadose zone investigation for the Lower Subase RI. The soil and vadose zone investigation involved subsurface soil sampling and analyses of 48 test borings.

2.2.1 Subsurface Soil Sampling

Ninety-six subsurface soil samples from forty-eight test borings were collected for analysis during Phase 1 of the Lower Subase RI. The objectives of the soil sampling and analyses were to collect additional data to determine the nature and extent of petroleum, semivolatile organic compounds (SVOC), and metals contamination in the soil in Zones 1 through 5 and 7, to characterize site conditions in Zone 6, and to identify any additional primary (leaking USTs, fuel distribution lines, etc.) or secondary (contaminated soils from previous releases) sources of contamination throughout the Lower Subase.

Thirty-four test borings were advanced using direct-push methods, and fourteen test borings were drilled and converted to monitoring wells using hollow-stem augering (HSA) techniques. Direct-push borings were installed by continuously advancing a 2-inch diameter Macro-Core® sampler in 4-foot intervals. HSA borings were advanced with 4¼-inch inside diameter (I.D.) hollow-stem augers. Soil samples were collected continuously in 2-foot intervals with 2-inch diameter split-spoon samplers. The headspace of each Macro-Core® or split-spoon sample was field screened with a photoionization detector (PID). Headspace readings, lithology, and any other observations recorded for a boring are provided in Appendix A. Test borings were advanced to the water table and either backfilled with bentonite pellets and, where appropriate, sealed at the surface with asphalt or converted to monitoring wells, as described in Section 2.3.1.

Two soil samples were collected from each boring for analyses. Samples were generally collected at two depths from each boring: shallow (less than 4 or 5 feet bgs, depending on the zone) and deep (greater than 4 or 5 feet bgs, depending on the zone). Soil samples were selected for analyses from each depth interval based on the highest PID field screening reading or, in the absence of PID readings above background levels, from the water table/vadose zone interface. Sample log sheets and chain-of-custody forms for soil samples are provided in Appendices B and C, respectively. Survey data for soil sampling locations are shown in Appendix D. Specific analyses and sampling intervals for soil samples are summarized in the site-specific discussions in Sections 4.0 through 10.0. The analytical program for the soil samples is discussed in the following section.

2.2.2 Analytical Procedures

Fixed-base laboratory services were provided by Katahdin Analytical Services, Inc., of Westbrook, Maine. The following fixed-base laboratory methods were used to analyze shallow and deep soil samples collected during the Lower Subase RI:

- The EPA Contract Laboratory Program (CLP) Statement of Work (SOW) for Organic Analysis Multi-Media, Multi-Concentration (Document Number OLM01.8) was used to analyze for Target Compound List (TCL) VOCs and SVOCs.

- The EPA CLP SOW for Inorganic Analysis Multi-Media, Multi-Concentration (Document Number ILM03.0) was used to analyzed for Target Analyte List (TAL) inorganic compounds.

- The EPA-600/4-79-020 Method 418.1 was used to analyze for TPH.

- The Synthetic Precipitation Leaching Procedure (SPLP), performed in accordance with SW-846 Method 1312, followed by EPA CLP SOW for Inorganic Analysis Multi-Media, Multi-Concentration (Document Number ILM03.0), was used to analyze for TAL metals or lead only.

2.3 GROUNDWATER INVESTIGATION

This section describes the field methods employed for the groundwater investigation of the Lower Subase RI. The groundwater investigation involved the installation of fourteen monitoring wells, groundwater sampling of the installed monitoring wells plus thirty-five existing monitoring wells, and the measurement of water level and free product thickness at sampled monitoring wells.

2.3.1 Monitoring Well Installation

Fourteen groundwater monitoring wells were installed during Phase 1 of the Lower Subase RI. Table 2-1 summarizes well construction and hydrogeologic information for the installed monitoring wells. Well construction diagrams are included in Appendix A. Locations of the installed wells are discussed in the site-specific sections (4.0 through 10.0). Table 2-2 summarizes well construction information for existing monitoring wells sampled during this investigation.

Monitoring wells were constructed of 2-inch-diameter polyvinyl chloride (PVC), flush-threaded well screen and riser. Well screen lengths were 5 feet, except MW1-6RI, which was 10 feet. Well screen slot sizes were 0.010 inch. The tops of the well screens were set between 0.6 and 2.7 feet above the water table at the time of installation to account for tidal fluctuations, except in MW2-3RI where the top of the well screen was installed 4.5 feet above the water table at approximately low tide so that the well screen would not straddle two separate stratigraphic units. A primary filter pack of Morie #0 silica sand was backfilled to at least 1 foot above the top of the well screen in the annular space between the well screen and the borehole wall. A secondary filter pack of Morie #00 was installed approximately 1 to 2 feet above the

primary filter pack. The remaining annular space was backfilled with a cement-bentonite grout, and an 8-inch-diameter flush-mounted steel casing was installed at the ground surface.

Monitoring wells installed during this investigation were developed to remove fine materials from the filter pack and well casing. Well development was conducted by overpumping with a 2-inch-diameter, centrifugal, submersible pump until the discharge water was visibly clear and measurements of pH, specific conductivity, and temperature were stabilized to within 10 percent. The pumps were periodically shut off and the water level allowed to recover to allow a natural surge in the direction opposite to pumping. Pumping was then continued, and the process was repeated.

2.3.2 Groundwater Sampling Procedures

Forty-nine monitoring wells were sampled during Phase 2 of the Lower Subase RI. Fourteen monitoring wells were installed during Phase 1 of this investigation and 35 existing monitoring wells were installed during previous investigations. Monitoring wells 13MW7, 13MW14, and NESO7 (Zone 1); WE4, WE5, and QW5 (Zone 4); and 19MW4 (Zone 5) could not be located and were assumed to be destroyed. These wells were not sampled as proposed in the Work Plan. In addition, monitoring well NESO4 (Zone 1) was dry during the field investigation. Monitoring well 13MW18 (Zone 1) was sampled during the field investigation but was not proposed for sampling in the Work Plan; it replaced monitoring well NES07 (Zone 1), which could not be located.

Groundwater samples were collected using low-flow purging and sampling techniques, in accordance with USEPA Standard Operating Procedure (SOP) GW001 and B&R Environmental SOP SA 1.1. Monitoring wells were purged using peristaltic pumps with dedicated Teflon® tubing lowered to the middle of the saturated screen. The monitoring wells were purged at a flow rate of 0.1 to 0.4 liters per minute. Water-quality parameters of pH, specific conductivity, salinity, dissolved oxygen (DO), temperature, Eh [oxidation/reduction potential (REDOX)], and turbidity were measured at three to five minute intervals during purging using a YSI® 6820 water quality meter in a flow-through cell, except for well 13MW18. Water-quality parameters were not measured in 13MW18 to avoid damage to the YSI® meter due to the presence of free product. Turbidity was also measured using a LaMotte® turbidimeter.

Non-tidally influenced wells were purged until the water-quality parameters stabilized to within the following limits for three consecutive measurements:

- pH ±0.1 units
- Specific conductivity 3 percent

- Temperature 3 percent
- DO 10 percent
- Eh/REDOX ±10 millivolts
- Turbidity 10 percent for values greater than 1 NTU.

(Well 13MW18 was purged for five well casing volumes, and the turbidity was measured with the LaMotte® turbidimeter after each volume purged.)

Purging of tidally influenced monitoring wells began approximately two hours prior to low tide. Tidal influence of wells was based on the October 27, 1997 round of water levels. Wells with more than 0.2 foot change in water level for one tidal cycle were considered tidally influenced. Purging continued for one hour, then sampling began regardless of whether or not water-quality parameters had stabilized to within the limits stated above. Purge data sheets for each monitoring well are included in Appendix B with the groundwater sample log sheets. Chain-of-custody forms for all groundwater samples collected are included in Appendix C, and survey data for all newly installed monitoring wells are shown in Appendix D.

After purging, groundwater samples were collected for analyses. Nonvolatile sample fractions were collected directly from the discharge end of the pump tubing. Volatile fractions were collected by drawing a column of groundwater into the tubing, crimping the tubing at the discharge end, withdrawing the sample tubing from the well, then filling sample containers by gravity flow. Filtered inorganic fractions were collected through a 0.45 micron filter connected to the discharge end of the tubing. Divalent iron was measured using a Hach® field test kit (Model IR-18C). Specific analyses for samples are provided in the site-specific discussions in Sections 4.0 through 10.0. Analytical procedures for groundwater samples are discussed in the next section.

2.3.3 Analytical Procedures

Fixed-base laboratory services were provided by Katahdin Analytical Services, Inc., of Westbrook, Maine and Air Toxics Limited of Folsom, California (under subcontract to Katahdin Analytical Services). The following fixed-base lab methods were used to analyze groundwater samples collected during the Lower Subase RI:

- The EPA CLP SOW for Low-Concentration Organic Analysis (Document Number OLC02.0) was used to analyze for TCL VOCs. The EPA CLP SOW for Organic Analysis Multi-Media, Multi-Concentration (Document Number OLM01.8) was used to analyze for TCL SVOCs.

- The EPA CLP SOW for Inorganic Analysis Multi-Media, Multi-Concentration (Document Number ILM03.0) was used to analyze for TAL inorganic compounds (total and dissolved).

- EPA-600/4-79-020 Method 418.1 was used to analyze for TPH.

- For natural attenuation parameters, Method 415.1 was used to analyze for total organic carbon (TOC); Method 350.1 was used to analyze for ammonia; Method 130.2 was used to analyze for hardness; Method 310.1 was used to analyze for alkalinity; Method 325.2 was used to analyze for chloride; Method 353.2 was used to analyze for nitrate; Method 375.4 was used to analyze for sulfate; Method 365.4 was used to analyze for phosphate (total); and EPA RSK SOP-175 was used to analyze for methane. All the aforementioned methods (except methane) are from Methods for the Analysis of Water and Wastes (EPA-600/4-79-020).

2.3.4 Water Level Measurement

Two rounds of water level measurements were taken during this investigation to determine the groundwater flow directions along the Lower Subase and to determine the tidal influence on monitoring wells to be sampled. Water levels were measured to the nearest 0.01 inch with an electronic water level indicator. The two rounds of measurement were conducted during one tidal cycle (high and low tide) on October 27, 1997, and November 13, 1997 (see tidal charts in Appendix E). The water level measurements are summarized in Table 2-3. Drawings 1 and 2 represent potentiometric surface maps generated from the water level measurement data collected during high tide conditions for Zones 1 through 4 and Zones 5 through 7, respectively. Drawings 3 and 4 represent potentiometric surface maps developed from water level measurement data collected during low tide conditions for Zones 1 through 4 and Zones 5 through 7, respectively.

2.3.5 Free Product Thickness Measurement

Free product thickness measurements were conducted at monitoring wells sampled during this investigation. Free product thicknesses were measured with an oil/water interface probe prior to purging and sampling at each monitoring well. Free-product was only detected in one well. A thin layer of a black, sticky, tar-like product was detected in 13MW18. An accurate measurement of the thickness could not be made. In addition, the groundwater sample collected from FOMW14 contained suds, indicating that detergents may be present in the groundwater.

2.4 SEDIMENT AND SURFACE WATER INVESTIGATIONS

This section describes the methodology for the sediment and surface water investigations for the Lower Subase RI. The sediment and surface water investigations involved sediment sampling and analyses and surface water quality measurements at twenty locations in the Thames River along the Lower Subase.

2.4.1 Sediment and Surface Water Sampling

Twenty sediment samples were collected during Phase 2 of the Lower Subase RI. Sample log sheets and chain-of-custody forms for the sediment samples are provided in Appendices B and C, respectively. Sediment was collected at each sampling location with a modified, stainless-steel Van Veen dredge sampler and transferred to sample containers with a stainless-steel trowel. Sediment samples were analyzed for TCL SVOCs, TAL inorganics, acid-volatile sulfides (AVS)/simultaneously extracted metals (SEM), TOC, ammonia, pH, and grain size. Analytical procedures for sediment samples are provided in Section 2.4.2.

Surface water quality parameters were measured at each sediment sampling location prior to sediment sampling. The measurements were collected over a period of approximately one hour prior to and one hour after low tide. At each location, surface water-quality was measured using a YSI® water quality meter at the water surface (shallow) and near the sediment surface (deep). Water-quality parameters measured included pH, temperature, specific conductivity, DO, turbidity, salinity, depth, and Eh/REDOX potential. Water-quality parameters were recorded on the sediment sample log sheets provided in Appendix B.

2.4.2 Analytical Procedures

Katahdin Analytical Services, Inc., of Westbrook, Maine performed the fixed-base analyses, with the exception of grain size, which was performed by Summit Contest, of Portland, Maine, under subcontract to Katahdin Analytical. The following fixed-base lab methods were used to analyze sediment samples collected during the Lower Subase RI:

- The EPA CLP SOW for Organic Analysis Multi-Media, Multi-Concentration (Document Number OLM01.8) was used to analyze for TCL SVOCs (and pesticides and PCBs for LS5SD00401).

- The EPA CLP SOW for Inorganic Analysis Multi-Media, Multi-Concentration (Document Number ILM03.0) was used to analyze for TAL inorganic compounds and lead.

- For engineering/ecological parameters, ASTM D422 was used to determine grain size distribution; SW-846 Method 9045 was used to measure pH; USEPA Method 350.1 was used to analyze for ammonia; a draft USEPA method for determination of acid volatile sulfide in sediment was used to analyze for acid volatile sulfide and simultaneously extracted metals; and Lloyd Kahn procedure was used to analyze for TOC.

2.5 SURVEYING AND MAPPING

Test boring locations and monitoring wells installed during this investigation were surveyed by Louis Federici and Associates for horizontal position and vertical elevation. Survey coordinates and elevations are provided in Appendix D. The survey control was tied into existing monuments at NSB-NLON. The horizontal grid system for the survey was the State Plane Coordinate System (SPCS) – North American Datum (NAD) of 1983, and the vertical datum was the North American Vertical Datum (NAVD) of 1988. Sediment and surface water sampling locations were located by visual estimation of distances from existing Lower Subase structures.

Survey information was plotted on drawings generated from the Subase map entitled "Base Traverse and Monuments" (NAVFAC Drawing No. 2,037,619, Code Ident. No. 80091, approved 1982) prepared for the Navy by Kieltyka, Woodis, & Pike Land Surveyors. Vertical elevations were converted from NAVD of 1988 to the 1982 Base Traverse system by a factor of +2.39 feet. Existing Phase I and Phase II RI survey data was in the 1982 Base Traverse system, and no correction was required.

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TABLE 2-1

SUMMARY OF RI MONITORING WELL INFORMATION
LOWER SUBASE
NSB-NLON, GROTON, CONNECTICUT
PAGE 1 OF 2

Well ID	Screened Lithology (Stratigraphic Unit)[1]	Ground Elevation (feet msl)[2]	Reference Elevation (feet msl)	Depth to Bedrock (feet bgs)[3]	Total Depth (feet bgs)	Screened Interval (feet bgs)	Well Diameter (inches)	Well Construction Type
ZONE 1								
No monitoring wells installed.								
ZONE 2								
No monitoring wells installed.								
ZONE 3								
MW1-3RI	Overburden (Fill)	8.08	7.65	--[4]	10.5	5.0-10.0	2	PVC[5]
MW2-3RI	Overburden (Fill)	8.27	7.78	--	10.0	3.0-8.0	2	PVC
ZONE 4								
MW1-4RI	Overburden (Fill)	8.27	7.95	--	10.0	4.0-9.5	2	PVC
MW2-4RI	Overburden (Fill)	9.35	8.85	--	10.0	3.0-8.0	2	PVC
ZONE 5								
No monitoring wells installed.								
ZONE 6								
MW1-6RI	Overburden (Terrace)	30.75	30.38	--	36.0	25.0-35.0	2	PVC
MW2-6RI	Overburden (Fill)	6.49	6.02	--	8.7	3.0-8.0	2	PVC
MW3-6RI	Overburden (Fill)	6.77	6.31	--	8.5	3.0-8.0	2	PVC
MW4-6RI	Overburden (Fill)	7.34	6.90	--	8.1	3.0-8.0	2	PVC
MW5-6RI	Overburden (Fill)	7.63	7.22	--	8.1	3.0-8.0	2	PVC
ZONE 7								
MW1-7RI	Overburden (Fill)	8.52	8.11	--	10.0	5.0-9.0	2	PVC
MW2-7RI	Overburden (Fill)	8.20	7.82	--	10.0	4.5-9.5	2	PVC
MW3-7RI	Overburden (Fill)	7.06	6.66	--	8.5	3.0-8.0	2	PVC
MW4-7RI	Overburden (Fill)	8.42	8.06	--	10.5	3.0-8.0	2	PVC
MW5-7RI	Overburden (Fill)	9.33	8.87	--	8.1	4.5-9.5	2	PVC

TABLE 2-1

SUMMARY OF RI MONITORING WELL INFORMATION
LOWER SUBASE
NSB-NLON, GROTON, CONNECTICUT
PAGE 2 OF 2

1 Fill = Silty sand or sand and/or gravel (artificial)
Terrace = Quaternary terrace deposits (sand and/or gravel)
2 msl - above mean sea level (Subase Datum 1982)
3 bgs - below ground surface.
4 Indicates that bedrock was not encountered.
5 Polyvinylchloride

TABLE 2-2

SUMMARY OF EXISTING MONITORING WELL INFORMATION
LOWER SUBASE
NSB-NLON, GROTON, CONNECTICUT
PAGE 1 OF 2

Well ID	Screened Lithology (Stratigraphic Unit)(1)	Ground Elevation (feet msl)(2)	Reference Elevation (feet msl)	Depth to Bedrock (feet bgs)(3)	Total Depth (feet bgs)	Screened Interval (feet bgs)	Well Diameter (inches)	Well Construction Type	Investigation(6)
ZONE 1									
13MW1	Overburden (Fill)	13.73	13.36	--(4)	20.0	7.5-17.5	2	PVC	Phase I RI
13MW2	Overburden (Fill)	13.23	12.80	--	20.0	7.7-17.7	2	PVC	Phase I RI
13MW3	Overburden (Fill)	13.15	12.89	--	20.0	7.4-17.4	2	PVC	Phase I RI
13MW8	Overburden (Fill)	7.80	7.34	--	27.0	3.7 - 13.7	2	PVC	Phase I RI
13MW9	Overburden (Fill)	7.57	6.91	--	20.0	4.8 - 14.8	2	PVC	Phase I RI
13MW18	Overburden (Fill)	12.65	12.12	--	15.0	5.0-15.0	2	PVC	Phase II RI
13MW19	Overburden (Fill)	8.34	8.05	--	16.0	5.0-15.0	2	PVC	Phase II RI
13MW20	Overburden (Fill)	10.71	10.45	--	16.0	3.0-13.0	2	PVC	Phase II RI
13MW21	Overburden (Fill)	9.03	8.70	--	30.0	5.0-15.0	2	PVC	Phase II RI
FOMW13	Overburden (Fill/Alluvium)	13.19	12.50	--	10.5	3.5-10.5	2	PVC	UST 54-H
FOMW14	Overburden (Fill/Alluvium)	12.95	12.68	--	10.2	3.2-10.2	2	PVC	UST 54-H
FOMW15	Overburden (Fill/Alluvium)	13.33	12.68	--	10.4	3.4-10.4	2	PVC	UST 54-H
FOMW16	Overburden (Fill/Alluvium)	12.89	12.62	--	9.9	2.9-9.9	2	PVC	UST 54-H
NESO4	Overburden (Fill)	8.51	8.22	--	Unknown(5)	2.9-7.9	2	PVC	NESO
ZONE 2									
13MW6	Overburden (Fill)	21.84	21.47	--	28.0	17.8-27.8	2	PVC	Phase I RI
13MW10	Overburden (Alluvium)	8.73	8.44	--	20.0	5.0-15.0	2	PVC	Phase I RI
13MW11	Overburden (Fill)	8.23	7.83	--	20.0	4.0 - 14.0	2	PVC	Phase I RI
13MW17	Overburden (Fill)	7.71	7.47	--	35.0	3.5 - 13.5	2	PVC	Phase I RI
ZONE 3									
13MW12	Overburden (Fill)	9.55	9.21	--	20.0	5.3-15.3	2	PVC	Phase I RI
ZONE 4									
13MW13	Overburden (Fill/Alluvium)	8.94	8.50	--	20.0	4.6-14.6	2	PVC	Phase I RI

TABLE 2-2

SUMMARY OF EXISTING MONITORING WELL INFORMATION
LOWER SUBASE
NSB-NLON, GROTON, CONNECTICUT
PAGE 2 OF 2

Well ID	Screened Lithology (Stratigraphic Unit)(1)	Ground Elevation (feet msl)(2)	Reference Elevation (feet msl)	Depth to Bedrock (feet bgs)(3)	Total Depth (feet bgs)	Screened Interval (feet bgs)	Well Diameter (inches)	Well Construction Type	Investigation(6)
13MW14	Overburden (Fill)	8.48	7.98	--	20.0	4.8-14.8	2	PVC	Phase I RI
13MW15	Overburden (Fill)	7.70	7.25	--	20.0	2.6-12.6	2	PVC	Phase I RI
13MW16	Overburden (Fill)	7.64	7.30	--	20.0	3.5-13.5	2	PVC	Phase I RI
NESO10	Overburden (Fill)	8.42	8.10	--	Unknown	4.3-9.3	2	PVC	NESO
NESO11	Overburden (Fill)	8.89	8.78	--	Unknown	3.6-8.6	2	PVC	NESO
QW4	Overburden (Void)	7.80	7.80	--	10.5	7.5-10.5	NA	Open	Quay Wall RSE
WE1	Overburden (Alluvium)	9.62	9.42	--	15.3	5.3 - 13.3	2	PVC	Wehran
ZONE 5									
19MW2	Overburden (Alluvium)	7.28	6.98	--	5.8	1.8 - 5.8	2	PVC	Pier 33 SI
19MW3	Overburden (Alluvium)	7.18	6.89	--	6.6	2.3-6.3	2	PVC	Pier 33 SI
ZONE 6									
No existing monitoring wells.									
ZONE 7									
20MW2	Overburden (Alluvium)	7.96	7.74	--	16.0	2.5-12.5	2	PVC	Pier 33 SI
20MW3	Overburden (Alluvium)	6.83	6.66	--	16.0	2.5-12.5	2	PVC	Pier 33 SI
20MW4	Overburden (Alluvium)	8.29	8.09	--	16.0	4.0-14.0	2	PVC	Pier 33 SI
20MW5	Overburden (Alluvium)	6.79	6.46	--	16.0	3.5-13.5	2	PVC	Pier 33 SI
20MW6	Overburden (Alluvium)	10.19	10.02	--	16.0	4.0-14.0	2	PVC	Pier 33 SI
20MW7	Overburden (Alluvium)	6.18	5.96	--	14.0	2.5-12.5	2	PVC	Pier 33 SI

1 Alluvium = Quaternary river/stream deposits
Fill = Silty sand or sand and/or gravel (artificial)
2 msl - above mean sea level (Subase Vertical Datum 1982)
3 bgs - below ground surface.
4 Indicates that bedrock was not encountered.
5 Information not available.
6 See 1.2.3 and Table 1-1 for details of investigations
NA Not available

TABLE 2-3

WATER LEVEL MEASUREMENTS
LOWER SUBASE
NSB-NLON, GROTON, CONNECTICUT
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Well ID	Ground Elevation[1]	Reference Elevation[1]	October 27, 1997				November 13, 1997			
			Low Tide		High Tide		Low Tide		High Tide	
			DTW[2]	Water Elevation[1]	DTW[2]	Water Elevation[1]	DTW[2]	Water Elevation[1]	DTW[2]	Water Elevation[1]
ZONE 1										
13MW1	13.73	13.36	10.16	3.20	10.13	3.23	10.09	3.27	10.11	3.25
13MW2	13.23	12.80	9.55	3.25	9.53	3.27	9.49	3.31	9.49	3.31
13MW3	13.15	12.89	9.66	3.23	9.63	3.26	9.62	3.27	9.63	3.26
13MW8	7.80	7.34	5.28	2.06	3.95	3.39	6.20	1.14	4.25	3.09
13MW9	7.57	6.91	4.87	2.04	3.37	3.54	5.50	1.41	3.62	3.29
13MW18	12.65	12.12	8.79	3.33	8.84	3.28	9.26	2.86	9.31	2.81
13MW19	8.34	8.05	4.20	3.85	4.21	3.84	4.33	3.72	4.37	3.68
13MW20	10.71	10.45	7.34	3.11	7.22	3.23	7.13	3.32	7.14	3.31
13MW21	9.03	8.70	5.01	3.69	5.01	3.69	5.09	3.61	5.06	3.64
FOMW13	13.19	12.50	9.27	3.23	9.24	3.26	9.16	3.34	9.10	3.40
FOMW14	12.95	12.68	9.42	3.26	9.39	3.29	9.25	3.43	9.23	3.45
FOMW15	13.33	12.68	9.45	3.23	9.42	3.26	9.38	3.30	9.33	3.35
FOMW16	12.89	12.62	9.39	3.23	9.38	3.24	8.80	3.82	8.82	3.80
NESO4[5]	8.51	8.22	5.54	2.68	5.52	2.70	Dry	NA	Dry	NA
ZONE 2										
13MW6	21.84	21.47	18.34	3.13	18.36	3.11	18.71	2.76	18.69	2.78
13MW10	8.73	8.44	5.47	2.97	5.26	3.18	5.73	2.71	5.71	2.73
13MW11	8.23	7.83	5.93	1.90	4.69	3.14	5.66	2.17	5.20	2.63
13MW17	7.71	7.47	5.43	2.04	3.98	3.49	5.66	1.81	4.24	3.23
NESO6	8.89	8.67	5.55	3.12	5.59	3.08	6.49	2.18	6.09	2.58

TABLE 2-3

WATER LEVEL MEASUREMENTS
LOWER SUBASE
NSB-NLON, GROTON, CONNECTICUT
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Well ID	Ground Elevation[1]	Reference Elevation[1]	October 27, 1997				November 13, 1997			
			Low Tide		High Tide		Low Tide		High Tide	
			DTW[2]	Water Elevation[1]	DTW[2]	Water Elevation[1]	DTW[2]	Water Elevation[1]	DTW[2]	Water Elevation[1]
ZONE 3										
13MW12	9.55	9.21	5.95	3.26	5.94	3.27	6.16	3.05	6.23	2.98
MW1-3RI	8.08	7.65	5.34	2.31	4.27	3.38	6.31	1.34	4.62	3.03
MW2-3RI	8.27	7.78	5.47	2.31	4.38	3.40	6.14	1.64	4.79	2.99
ZONE 4										
13MW13	8.94	8.50	5.15	3.35	5.24	3.26	5.37	3.13	5.24	3.26
13MW14	8.48	7.98	5.97	2.01	4.64	3.34	7.54	0.44	5.04	2.94
13MW15	7.70	7.25	NA[3]	NA	NA[3]	NA	7.08	0.17	4.12	3.13
13MW16	7.64	7.30	5.54	1.76	3.79	3.51	7.05	0.25	4.12	3.18
MW1-4RI	8.27	7.95	4.39	3.56	4.38	3.57	4.80	3.15	4.69	3.26
MW2-4RI	9.35	8.85	5.05	3.80	5.01	3.84	NM[4]	NM	NM[4]	NM
NESO10	8.42	8.10	5.20	2.90	5.05	3.05	6.20	1.90	5.62	2.48
NESO11	8.89	8.78	5.32	3.46	5.28	3.50	5.49	3.29	NM[4]	NM
QW4	7.80	7.80	4.90	2.90	4.73	3.07	6.49	1.31	3.51	4.29
WE1	9.62	9.42	6.10	3.32	6.13	3.29	6.32	3.10	6.33	3.09
ZONE 5										
19MW2	7.28	6.98	4.12	2.86	3.87	3.11	Dry	<1.23	4.28	2.70
19MW3	7.18	6.89	3.75	3.14	3.83	3.06	4.53	2.36	4.37	2.52
ZONE 6										
MW1-6RI	30.75	30.38	NM[4]	NM	27.06	3.32	27.21	3.17	27.16	3.22
MW2-6RI	6.49	6.02	2.63	3.39	2.62	3.40	2.95	3.07	2.81	3.21
MW3-6RI	6.77	6.31	2.94	3.37	2.93	3.38	3.26	3.05	3.10	3.21

TABLE 2-3

WATER LEVEL MEASUREMENTS
LOWER SUBASE
NSB-NLON, GROTON, CONNECTICUT
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Well ID	Ground Elevation[1]	Reference Elevation[1]	October 27, 1997				November 13, 1997			
			Low Tide		High Tide		Low Tide		High Tide	
			DTW[2]	Water Elevation[1]	DTW[2]	Water Elevation[1]	DTW[2]	Water Elevation[1]	DTW[2]	Water Elevation[1]
MW4-6RI	7.34	6.90	3.56	3.34	3.56	3.34	3.84	3.06	3.69	3.21
MW5-6RI	7.63	7.22	3.65	3.57	3.71	3.51	3.94	3.28	3.83	3.39
ZONE 7										
20MW2	7.96	7.74	4.69	3.05	4.58	3.16	5.65	2.09	5.09	2.65
20MW3	6.83	6.66	NA[3]	NA	NA[3]	NA	4.70	1.96	4.37	2.29
20MW4	8.29	8.09	5.00	3.09	4.86	3.23	5.53	2.56	5.22	2.87
20MW5	6.79	6.46	3.47	2.99	3.43	3.03	3.98	2.48	3.79	2.67
20MW6	10.19	10.02	6.78	3.24	6.78	3.24	6.96	3.06	6.95	3.07
20MW7	6.18	5.96	2.78	3.18	2.58	3.38	3.50	2.46	3.02	2.94
MW1-7RI	8.52	8.11	4.60	3.51	4.73	3.38	5.59	2.52	5.29	2.82
MW2-7RI	8.20	7.82	4.50	3.32	4.45	3.37	5.23	2.59	4.92	2.90
MW3-7RI	7.06	6.66	3.25	3.41	3.24	3.42	4.09	2.57	3.75	2.91
MW4-7RI	8.42	8.06	4.85	3.21	4.70	3.36	5.64	2.42	5.04	3.02
MW5-7RI	9.33	8.87	5.57	3.30	5.55	3.32	5.62	3.25	NM[4]	NM

1 Elevation in feet above mean sea level (Subase Vertical Datum 1982).
2 Depth to Water (feet below reference point).
3 Not accessible.
4 Not measured.
5 NESO4 well casing may be silted above well screen.

3.0 GENERAL DATA EVALUATION PROCEDURES

This section provides a summary of general analytical data evaluation and risk assessment procedures that are common to each of the sites studied during the Lower Subase RI for NSB-NLON. Section 3.1 provides a general discussion of various data quality issues (i.e., data quality objectives, data validation) related to the Lower Subase RI analytical data. Section 3.2 summarizes the procedures used to process the analytical data for this RI report, including creation and manipulation of the analytical database and preparation of contaminant-specific isoconcentration maps. Section 3.3 discusses general aspects of contaminant fate and transport analysis and the general technique to be used to evaluate if natural attenuation is a viable process for the remediation of petroleum hydrocarbon. Human health and ecological risk assessment procedures are discussed in Sections 3.4 and 3.5, respectively.

3.1 DATA QUALITY

Various quality control measures were implemented during the Lower Subase RI field sampling and laboratory analysis to ensure that the resultant data were suitable for their intended use. A brief summary of these measures is provided in this section.

This section does not address the data quality associated with historical analytical data (i.e., data collected for the Phase I and II RIs, as well as additional investigations). The quality of the data associated with these investigations is addressed in the historical investigative reports.

3.1.1 Data Quality Objectives

A detailed discussion of the Data Quality Objectives (DQOs) for the NSB-NLON Lower Subase RI is provided in the Lower Subase RI associated Quality Assurance Project Plan (QAPP) (B&R Environmental, 1997d). DQOs for all field and laboratory analyses, which include requirements for precision, accuracy, and completeness, are summarized in this section.

3.1.1.1 Precision

Precision characterizes the amount of variability and bias inherent in a data set. This parameter also describes the reproducibility of measurements of the same parameters for samples under similar conditions. Precision is expressed as a Relative Percent Difference (RPD), which is defined as the relation of the range relative to the mean. RPDs, which are typically expressed as percents, are used to evaluate both field and laboratory duplicate precision and are calculated as follows:

$$RPD = \frac{V1 - V2}{(V1 + V2)/2} \times 100$$

where RPD = relative percent difference
V1, V2 = two results obtained by analyzing duplicate samples

The precision objectives for CLP parameters are specified in the associated analytical protocols and were presented in Tables 3-1 and 3-2 of the QAPP. For non-CLP data, the precision objectives of ±50 percent for solid matrices and ±30 percent for aqueous matrices were employed for the project.

Field duplicates monitor the consistency with which environmental samples were obtained and analyzed. Laboratory duplicates measure the reproducibility of laboratory generated results. RPDs were calculated for each set of field and laboratory duplicates generated for the investigation. The associated analytical data were qualified as per data validation protocols when precision objectives were not achieved. The qualification of Lower Subase RI analytical data, as well as the implication of the data qualifications, is discussed in Section 3.1.3 of this report.

3.1.1.2 Accuracy

The degree of accuracy of a measurement, which is expressed as a percent recovery, is based on a comparison of the measured value with an accepted reference or true value. Accuracy measurements are determined by the analysis of "spiked" samples (i.e., blank, surrogate, or matrix spikes). These analyses measure the accuracy of the laboratory operations as affected by the sample matrix. Percent recovery is calculated using the following equation:

$$\%R = \frac{Ss - So}{S} \times 100$$

where %R = percent recovery
Ss = result of spiked sample
So = result of non-spiked sample
S = concentration of spiked amount.

In general, the accuracy objective for the Lower Subase RI project is defined as 75 to 125 percent (percent recovery). Method-specific objectives expressed on an analyte-specific basis were presented in Tables 3-3 to 3-7 of the Lower Subase RI QAPP. The associated analytical data were qualified as per the

validation protocol when accuracy objectives were not achieved. A discussion of the qualification of Lower Subase RI analytical data and the implication of the data qualifications is provided in Section 3.1.3.

3.1.1.3 Completeness

Completeness is a measure of the amount of valid data obtained from the field and laboratory analysis in relation to the total amount of data collected. Completeness is typically expressed as a percentage and is determined using the following equation:

$$\%C = \frac{V}{T} \times 100$$

where %C = percent completeness
V = number of results determined to be valid
T = total number of results

Under ideal conditions, the completeness objective would be 100 percent. However, samples can be rendered unusable during shipping or preparation (e.g., bottles broken or extracts accidentally destroyed) or analysis (e.g., loss of instrument sensitivity, strong matrix effects). The completeness objective for this project is 95 percent, as stated in the Lower Subase RI QAPP. The calculated percent completeness for all chemical analytical data collected during the Lower Subase RI project is 99.3 percent (i.e., 128 chemical analytical results out of a total of 17,307 data points were qualified as unusable), indicating that the data completeness objective for the project was achieved.

Table 3-1 contains a list of those sample results that were determined to be invalid and unusable via data validation. Section 3.1.3 contains a summary of the data validation results and describes, in general, the rationale behind the rejection of these analytical results.

3.1.2 Field Quality Control Samples

The following field QC samples were collected during the Lower Subase RI field sampling effort and analyzed in accordance with DQO requirements, as specified in the Lower Subase RI QAPP:

- Field duplicates were obtained at a frequency of one per every ten samples (10 percent per matrix). Field duplicates for soil samples are two separate samples collected from the same source. Aqueous sample duplicates are collected simultaneously. Duplicates assess the overall precision of the sampling and analysis program.

- Trip blanks of analyte-free water were generated by the laboratory, taken to the sampling site, and returned to the laboratory with the samples to be analyzed for VOCs. Analytical results for trip blanks are used to determine the level of contamination associated with the transportation of samples. One trip blank was collected per each cooler and analyzed for VOCs.

- An ambient condition blank, consisting of distilled water, was collected during the Lower Subase RI field investigation. The field team did not collect the ambient blank using the same sampling equipment as it used to collect the field samples, but the team did collect it while at the field sampling site by placing distilled water directly into the same type of container. The blank was then preserved and stored in the same manner as the field samples. This blank was used as a check of background contamination (e.g., vapors, dust, or exhaust fumes that are part of normal operations at the site) that may cause sample contamination.

- Source water blanks consist of the potable water used for decontamination of sampling equipment. These blanks are used to determine if potable water may be contributing to sample contamination. Source water blanks were collected at a rate of one blank per each potable water source.

- Rinsate blanks were obtained by pouring analyte-free water over sample collection equipment (e.g., bailers, etc.) after decontamination to assess the effectiveness of field decontamination procedures. Samples were obtained at a frequency of one per day per medium per analysis. However, only samples generated every other day were subjected to chemical analysis.

- Field blanks consisted of source water samples used in steam cleaning and/or decontamination and were used to determine the level of contamination associated with the source water. Field blanks were obtained at a frequency of one per event per decontamination water source.

Documentation for the actual collection of the aforementioned field QC samples for all Lower Subase RI analytical data is provided in Appendix C, Chain-of-Custody Records.

3.1.3 Data Validation

All samples collected as part of the Lower Subase RI and sent to the laboratory for chemical analysis were subjected to data validation. Data validation is an objective systematic process in which analytical data are reviewed to ascertain the validity of the reported results and to identify for the data user the possible limitation of these results. This section summarizes the various aspects of the data validation process.

3.1.3.1 General Data Validation Procedures

Validation of data generated for samples collected during the Lower Subase RI was completed in accordance with the procedures for Level D and Level C data validation as outlined in Navy guidance (Sampling and Chemical Analysis Quality Assurance Requirements for the Navy Installation Restoration Program, NEESA 20.2-047B). Level D data validation was performed for all samples analyzed via USEPA's CLP methods, as well as for some samples analyzed via SW-846 methods that are similar to the CLP methods (e.g., the 8000 series methods). Such data were validated in accordance with USEPA's CLP Functional Guidelines for Organic and Inorganic Data Review, as amended for use in USEPA Region I. Level C validation was completed for various engineering and chemical/physical parameters in view of method-specific quality assurance/quality control requirements and criteria outlined in the NEESA guidance document.

The validation process included consideration of the following: data completeness, holding time compliance, mass calibrations, field QC and laboratory-generated blanks, internal standards, surrogate spikes, blank spikes, matrix spikes, field duplicate precision, chemical interferences, quantitation, detection limits, and system performance.

Evaluation of laboratory and field QC blank analyses aided in the elimination of false positive results that were identified as laboratory artifacts. The overall determination of data utility or reliability was based upon laboratory compliance with specified methods and adherence to QC requirements. The noncompliance observed during the validation process resulted in qualification of analytical data. The qualifiers alert the data user to imprecise or estimated results and, in the worst case, unreliable and unusable data.

The net results of the validation process were summarized in sample delivery group-specific technical reports consisting of a memorandum, a section of qualified analytical results, Region I validation worksheets, and a supporting documentation section that provided the rationale for changes and/or qualification of the data. These memoranda provided a detailed explanation of the results of the data validation review. All data validation documentation is currently retained on file by B&R Environmental.

3.1.3.2 Data Validation Qualifiers

As mentioned previously, the qualification of analytical data during the validation process (i.e., application of U, J, UJ, UR, and R qualifiers) was conducted as required by the USEPA Functional Guidelines. The attachment of the data qualifiers to analytical results signifies the occurrence of quality control

noncompliance which have been noted during the course of data validation. The various data qualifiers are defined, as follows:

- U - Indicates that the chemical was not detected at the numerical detection limit (quantitation limit) noted. Nondetected results from the laboratory are reported in this manner. This qualifier is added to a positive result (reported by the laboratory) if the detected concentration is determined to be attributable to contamination introduced during field sampling or laboratory analysis.

- UJ - indicates that the chemical was not detected. However, the detection limit (quantitation limit) is considered to be estimated based on problems encountered during laboratory analysis. The associated numerical detection limit is regarded as inaccurate or imprecise.

- J - indicates that the chemical was detected. However, the associated numerical result is not a precise representation of the amount which is actually present in the sample. The laboratory quantity is considered to be an estimate.

- UR - Indicates that the chemical may or may not be present. The nondetected analytical results reported by the laboratory is considered to be unreliable and unusable. This qualifier is applied in cases of gross technical deficiencies (i.e., holding times missed by a factor of two times the specified time limit, severe calibration noncompliances, and extremely low quality control recoveries).

- R - Indicates that the chemical may or may not be present. The positive analytical result reported by the laboratory is considered to be unreliable and unusable. This qualifier is applied in cases of gross technical deficiencies.

The preceding data qualifiers may be categorized as indicative of major problems and minor problems. Major problems are defined as issues that result in the rejection of data, qualified with UR and R data validation qualifiers. These data are considered invalid and are not used for risk assessment and decision making purposes. A summary of the rejected results for the Lower Subase RI is contained in Table 3-1. Minor problems are defined as issues resulting in the estimation of data qualified with J and UJ data validation qualifiers. Estimated analytical results are considered to be suitable for risk assessment and decision making purposes.

3.1.3.3 Summary of Data Validation Results

A brief summary of the data validation results for the Lower Subase RI sampling effort is provided below. All validated analytical results for the RI are presented in Appendix H.

Organic Analyses

Bis(2-ethylhexyl)phthalate, diethyl phthalate, and di-n-butyl phthalate were identified frequently as laboratory and/or field QC blank contaminants. Other chemicals sporadically detected in the laboratory and field QC blanks were di-n-octyl phthalate, acetone, methylene chloride, bis(2-chloroethoxy)methane, chrysene, and phenol. Detection limits for these compounds in the affected environmental samples were elevated during the data validation process because positive results are considered to be attributable to blank contamination.

In general, analytical results for organic compounds were qualified as estimated, J or UJ, for observed noncompliances with surrogate spike analysis, calibrations, internal standards, matrix spike analyses, holding times, and field duplicate precision. Positive results reported at concentrations less than the Contract Required Quantitation Limit (CRQL) were also qualified as estimated. Because of missed holding time, organic results for the following environmental samples were estimated, J or UJ:

- LS5SD00201
- LS7GW20MW701

Holding times exceedances were not considered to be gross noncompliances in these samples; therefore, the rejection of sample data was not warranted. Holding time exceedance was considered to be a gross noncompliance for the volatile fraction of sample LS6GW00401. Results were qualified as UR and are unusable for risk assessment purposes.

Field duplicate/replicate imprecision was noted for various organic parameters in the following sample pairs:

- LS3SB0040101 / LS3SB0040101-D (some semivolatiles)
- LS7SB01000201 / LS7SB01000201-D [benzo(k)fluoranthene]
- LS7SB0010201 / LS7SB0010201-D (pyrene)

The associated results in the field duplicate pair samples only were regarded as estimated and were qualified as such.

Severe surrogate recovery problems (i.e., percent recovery less than 10 percent) for semivolatile organics were observed in the following samples:

- LS1SB0020201
- LS1SD0060101
- LS4SB0010301
- LS4SB0050301
- LS5SB0020101

These gross noncompliances resulted in the rejection of nondetected acid and/or base/neutral results in the affected samples.

Inorganic Analysis

Several inorganic chemicals were detected as contaminants in the laboratory and/or field QC blanks at varying concentrations. The detection limits of those results that were found to be attributable to blank contamination introduced during laboratory analysis or field sampling were raised during the validation process. Because of uncertainty near the Instrument Detection Limit (IDL), sample results less than two times the IDL were considered to be estimates and were qualified as such.

Inorganic sample results were typically qualified as estimated based on problems noted with instrument calibration, matrix spikes, laboratory and field duplicate precision, chemical interferences (ICP only), serial dilution analyses (ICP only), and analysis of Contract Required Detection Limit (CRDL) standards.

Noncompliant field duplicate RPDs were noted for some inorganic parameters in the following sample pairs and the associated sample results were qualified as J or UJ for field duplicate imprecision:

- LS3SB0020201 / LS3SB0020201-D (lead)
- LS2GW13MW1701 / DUP005 (selenium)
- LS7GW20MW601 / LS7GW20MW601-D (lead, selenium)
- LS7GW001001 / LS7GW001001-D (zinc)
- LS1SD00101 (calcium, copper)
- LS1SD00201 (calcium, copper)
- LS1SD00301 (calcium, copper)
- LS1SD00401 (calcium, copper)
- LS2SD00101 (calcium, copper)
- LS2SD00201 (calcium, copper)
- LS3SD00101 (calcium, copper)
- LS4SD00101 (calcium, copper)
- LS7SD00101 (calcium, copper)
- LS7SD00201 (calcium, copper)
- LS7SD00301 (calcium, copper)
- LS4GWNESO1001 (lead)
- LS2GW13MW1701 (selenium)
- LS3GW00101 (zinc)
- LS3GW00201 (zinc)
- LS4GW00101 (zinc)
- LS4GW00201 (zinc)
- LS4GWNESO1101 (zinc)
- LS4GWWE101 (zinc)
- LS5GW19MW201 (zinc)

- LS4SD00201 (calcium, copper)
- LS4SD00301 (calcium, copper)
- LS5SD00101 (calcium, copper)
- LS5SD00201 (calcium, copper)
- LS5SD00301 (calcium, copper)
- LS5SD00401 (calcium, copper)
- LS6SD00101 (calcium, copper)
- LS6SD00201 (calcium, copper)
- LS5GW19MW301 (zinc)
- LS7GW00701 (zinc)
- LS7GW00901 (zinc)
- LS7GW20MW201 (zinc)
- LS7GW20MW401 (zinc)
- LS7GW20MW501 (zinc)
- LS4GW13MW1401 (zinc)
- LS4GWQW401 (zinc)

Noncompliant field and/or laboratory duplicate RPDs were noted for the following SEM samples, which were qualified as estimated, (J) and (UJ):

- LS1SD00101 (copper, lead)
- LS1SD00201 (copper, lead)
- LS1SD00301 (copper, lead)
- LS1SD00401 (copper, lead)
- LS2SD00101 (copper, lead)
- LS2SD00201 (copper, lead)
- LS3SD00101 (copper, lead)
- LS4SD00101 (copper, lead)
- LS4SD00201 (copper, lead)
- LS4SD00301 (copper, lead)
- LS5SD00101 (copper, lead)
- LS5SD00201 (copper, lead)
- LS5SD00301 (copper, lead)
- LS5SD00401 (lead)
- LS6SD00101 (lead)
- LS6SD00201 (lead)
- LS7SD00101 (lead)
- LS7SD00201 (lead)
- LS7SD00301 (copper, lead)

SEM data are used in the ecological risk assessment only.

It should be noted that no inorganic results were qualified as rejected during data validation. In addition, all holding times were met for inorganic analyses.

Miscellaneous Parameters

Because of missed holding times, nitrate results for the following environmental samples were estimated, J or UJ:

- LS1GW13MW801
- LS1GWFOMW1301
- LS4GW00201
- LS4GW13MW1601

- LS4GWWE101
- LS7GW20MW501
- LS7GW00401
- LS7GW00701
- LS7GW00901

Holding time exceedances were not considered to be gross noncompliances; therefore, the rejection of sample data was not warranted.

Miscellaneous sample results were typically qualified as estimated based on problems noted with laboratory and field blank contamination, matrix spikes, and field and laboratory duplicate precision.

Because of observed field duplicate imprecision, analytical results in the following sample pairs were qualified as estimated:

- LS3SB0020201 / LS3SB0020201-D (total petroleum hydrocarbons)
- LS5SB0040101 / LS5SB0040101-D (total petroleum hydrocarbons)
- LS7SB0060101 / LS7SB0060101-D (total petroleum hydrocarbons)
- LS7SB0070101 / LS7SB0070101-D (total petroleum hydrocarbons)
- LS3SD00201 / LS3SD00201-D (acid-volatile sulfides)
- LS2GW13MW1701 / DUP005 (phosphorus)
- LS6GW00101 / LS6GW00101-D (phosphorus)
- LS6GW00201 / LS6GW00201-D (phosphorus)
- LS7GW20MW601 / LS7GW20MW601-D (phosphorus)
- LS7GW001001 / LS7GW001001-D (total organic carbon)
- LS3GW00201 (total organic carbon)
- LS4GW00101 (phosphorus)
- LS4GW00201 (total organic carbon)
- LS4GW13MW1301 (total organic carbon)
-
- LS4GW13MW1401 (total organic carbon)
- LS4GW13MW1601 (total organic carbon)
- LS4GWNEWSO1101 (total organic carbon)
- LS4GWQW401 (total organic carbon)
- LS4GWWE101 (total organic carbon)
- LS5GW19MW201 (total organic carbon)
- LS5GW19MW301 (total organic carbon)
- LS7GW00401 (total organic carbon)
- LS7GW00701 (total organic carbon)
- LS7GW00901 (total organic carbon)
- LS7GW20MW201 (total organic carbon)
- LS7GW20MW401 (total organic carbon)
- LS7GW20MW501 (total organic carbon)
- LS3GW00101 (total organic carbon)
- LS4GW00101 (total organic carbon)

All validated results for Lower Subase RI are presented in Appendix H. This database is inclusive of all results (i.e., nondetects and positive results) and is used to define the nature and extent of contamination, to assess contaminant fate and transport, and to complete the baseline human health and ecological risk assessments.

3.1.3.4 Field Data

Surface water and groundwater quality parameters were measured during the sampling effort either using field instruments or test kits. Validation of this field data was performed to eliminate outliers that resulted from human and equipment errors and to provide a defensible data set. The defensibility of the data is most relevant to the groundwater quality data that is used in this report to evaluate natural attenuation processes.

The data validation process involved comparing individual field parameter measurements to a predetermined, acceptable range for that particular parameter. If the measurement fell within the range, the data was accepted, and if the data fell outside the range, the data was rejected and labeled with a "R" qualifier. The acceptable ranges used during the validation for the field parameters are as follows:

Parameter	Groundwater	Surface Water
pH	1 to 14	1 to 14
Specific Conductivity	0 to 100 mV	0 to 100 mV
Temperature	2 to 65 °C	2 to 25 °C
Dissolved Oxygen	0 to 15 mg/L	0 to 15 mg/L
Salinity	0 to 38 ppt	0 to 38 ppt
REDOX Potential	-300 to +700 mV	-300 to +700 mV
Turbidity	0 to 1000 NTUs	0 to 1000 NTUs
Divalent Iron	0 to 10 mg/L	0 to 10 mg/L

Generally, the ranges were based on equipment specifications, field test kit quantitation limits, or known natural ranges. An exception to this selection process was made for groundwater temperature. The acceptable range used for groundwater temperature is higher than the normal range because groundwater in several zones of the Lower Subase is in contact with underground steam lines which results in elevated groundwater temperatures.

3.1.3.5 Missing Data

The following samples were not analyzed for dissolved methane because of laboratory error:

- LS2GWNESO601
- LS6GW00301
- LS6GW00401
- LS6GW00501

In addition, insufficient sample volume was received for LS3SB0050201 and therefore SPLP lead analysis was not performed on this sample.

3.2 DATA PROCESSING

The nature and extent of contamination evaluations and baseline risk assessments presented in this Lower Subase RI report are based on an analytical database compiled from environmental data available for the study area. This database consists of medium-specific analytical data from the multiple investigations at the Lower Subase that are summarized in this report. The analytical data for the Lower Subase were collected for the Navy by various contractors. In some cases, different sampling protocols were used to collect the samples. The samples were also analyzed using different laboratory methods. A database of much of the available analytical data was created and used during the preparation of the final Phase II RI Report (B&R Environmental, 1997b), which included an evaluation of a portion of the Lower Subase (Zones 1 through 4). Data from other investigations were entered into the database as part of the Lower Subase Existing Data Summary Report project, then supplemented with the data obtained for this Lower Subase RI. A complete list of investigations included in this report was summarized in Section 1.2.3 and Table 1-1.

The screening process for determining whether data were acceptable for inclusion in the database considered the following factors:

- Data age: appropriateness for present day nature and extent of contamination and risk assessment
- Data quality: data defensivability
- Data location: outside versus inside Lower Subase RI site boundary
- Frequency of analyses: number of samples per location

A complete summary of all analytical results (detections and nondetections) for each medium, including soil, sediment (Thames River and storm sewer), groundwater, surface water (Thames River and storm sewer), and biological, is provided in the database (Appendix H). Generally, information provided for each sample in the database includes sample number, sample depth, sample location, sample date, investigation during which the sample was collected, sample type, sample status (i.e., location intact or excavated), zone, sample duplicates, and validation status. The analytical results for each medium are sorted per zone.

Processing of the data contained in the database was necessary to provide frequency of detection and range of detection information for the COC screening tables and to create chemical-specific

isoconcentration drawings. Data evaluation/processing techniques similar to those used in the Phase II RI were also used for this report. The screening tables and isoconcentration figures for the seven zones of contamination and the Thames River are presented in subsequent Sections 4.0 through 11.0.

3.2.1 Isoconcentration Drawings

Isoconcentration drawings of primary COCs (i.e., TPH and lead in soil and groundwater) and key natural attenuation parameters (i.e., dissolved oxygen, REDOX potential, divalent iron, and conductivity in groundwater only) were created to help evaluate the nature and extent of contamination, to assist in determining if contaminant migration is occurring, and to aid in ascertaining if natural attenuation is occurring. The approach for creation of the drawings is discussed below.

3.2.1.1 Geostatistical Analysis

A geostatistical analysis of TPH, lead, and natural attenuation data was completed for this report to develop statistically based isoconcentration maps. The objective of the geostatistical analysis is to provide a means to better understand the data's spatial distribution. The following section provides a summary of the methods used to perform the above analysis on these data sets.

The data for this analysis were queried, sorted, and exported from the NSB-NLON FOXPRO database and imported into EXCEL, where they were edited for format purposes. The data files were then converted to an ASCII format and imported into the software GEOSOFT.

The first step in the analysis process involved building a semi-variogram for each raw (observed) data set. A variogram is a measure of correlation between values of a parameter at different spatial locations. The correlation of each measured point in the data set is a function of variability, sample locations, and separation distance. Generally, the farther apart the known data points are spaced the less data correlation is observed. An example of a modeled variogram overlain onto an observed variogram is presented as Figure 3-1. The observed semi-variogram is a plot of the raw data set variability ($\gamma(h)$) verses the spatial separation between sampling points (h). This relationship is known as the data set's variance which, in this case, is in units of $(mg/kg)^2$ for soils and $(\mu g/L)^2$ for groundwater samples.

A modeled variogram relationship is then constructed and overlain onto the observed variogram relationship. The modeled variogram relationships are based on variability increasing over a set station separation distance then becoming constant at large data increments. The modeled data results are based on four software input factors:

- An initial mathematically defined curved (i.e., exponential, gaussian, spherical, etc.)
- Range
- Sill
- Nugget

The separation distance (h) where $\gamma(h)$ is no longer increasing is referred to as the range; the plateau where $\gamma(h)$ becomes constant is referred to as the sill; and, the point where the data set intersects the $\gamma(h)$ axis is referred to as the nugget. These input variables are changed until a best fit modeled to observed variogram is obtained. An example variogram is provided for review that shows data variability verses data spacing for an observed and modeled data set (Figure 3-1).

A variogram model was constructed for each data set that closely matches each observed data set's variance verses separation distance. Several modeled curved responses were considered during this process. These responses included a power, spherical, gaussian, and exponential model. These different curved responses were all considered to examine which model verses observed variogram results in the lowest root mean square difference (RMS) or sigma value.

Differences in sigma values are dependent upon the data sets dynamic range, the number of data points and their separation distance. Table 3-2 presents parameters-specific standard deviations for the two confidence limits used for this analysis.

Each modeled verses observed variogram was constructed with a grid cell size of 10 feet and utilizing log gridding with a linear grid output. Log gridding was utilized due to the large dynamic range of the soil and groundwater chemistry data sets. The spherical curve model provided the lowest sigma values for each data set. Nugget values were equal to zero and range verses sill values were variable for each data set. The end result of the modeled variogram response is to form a basis for predicting grid values between known data points via kriging software.

The modeled variogram results were imported into the geostatistical data gridding and processing software KRIGRID. KRIGRID software interpolates between known data points using a kriging based algorithm. Kriging is a geostatistical method that determines the probable value at each grid node based on an analysis of the entire data set. The software operates by utilizing the modeled semi-variogram relationship as a basis for determining the probable value at each grid note.

The concentration data were processed in KRIGRID using the above described semi-variograms for each soil groundwater regime data set. The data were output as a gridded data and an error grid file. The gridded data file contains actual and predicted values at 10-foot by 10-foot intervals. The grid values are

assigned color zones based on the data's dynamic range. For example, data with a large dynamic range are often assigned color zone values in log increments where-as small dynamic range data sets are assigned color zones based upon a linear scale. The resulting colorized grid is a color contoured representation of the spatial description of contaminant concentrations in the units of measure (e.g., µg/L).

An error grid was simultaneously created during the kriging process. The error grid is a representation of the standard deviation of the predicted grid values at each grid cell location. Grid cells that are near observed data points have low standard deviation values. Standard deviation error values increase away from known data points. The mean standard deviation value of each error grid was used to determine how much area of the color contour grid was plotted.

A Boolean operation was performed on the original gridded data using the error grid. Boolean operations remove portions of one grid based upon a user-defined standard and the values of a second grid. It was determined that the criteria for removing or masking portions of the observed data grid would be based upon the mean error grid value or mean standard deviation of grid error for each data set. The mean standard deviation error grid values for each data set are presented in the above table. These data can also be used to construct data confidence maps, which are used to display confidence limits based upon a predefined standard deviation error value.

3.2.1.2 Soil

Isoconcentration drawings were created for both shallow and deep soils to show the variation in the distribution of contamination in soil with depth. Both historical and new soil analytical data were used to prepare the drawings. Analytical results for original and duplicate pairs were considered as independent samples, and the maximum of the pair was used for isoconcentration drawing preparation. This approach accounts for the heterogeneity of the soil medium and eliminates the potential for masking of high detections. The detection limits for nondetections were not considered for creation of the isoconcentration contours.

3.2.1.3 Groundwater

Isoconcentration drawings were created for groundwater to show the distribution of contamination in that medium. Only the current data from the Lower Subase RI were used to prepare the maps. Both detections and nondetections were considered for creation of an isoconcentration drawing. One-half of the detection limit was used for nondetections. Analytical results for original and duplicate pairs were considered as independent samples, and the maximum of the pair was used for isoconcentration drawing preparation. This approach is conservative and eliminates the potential for masking of high detections.

3.3 CHEMICAL FATE AND TRANSPORT ANALYSIS

Various aspects of contaminant fate and transport at the Lower Subase and the Thames River are discussed in this section. Properties that affect chemical migration are presented in Section 3.3.1. Section 3.3.2 presents a brief discussion of chemical persistence. Section 3.3.3 presents an overview of chemical fate and transport. Specific aspects of chemical transport at each site are discussed in Sections 4.0 through 11.0.

3.3.1 Chemical and Physical Properties

Various chemical and physical properties of all detected site compounds are presented and discussed in this section. These parameters may be used to estimate the environmental behavior of site chemicals. Physical and chemical properties of the organic chemicals found at the Lower Subase and Thames River are presented in Table 3-3.

Literature values of the water solubility, octanol/water partition coefficient, organic carbon partition coefficient, vapor pressure, Henry's Law constant, bioconcentration factor, and specific gravity are presented, when available. Calculated values, which were obtained using approximation methods, are presented when literature values are not available. A discussion of the environmental significance of each of these parameters follows.

3.3.1.1 Specific Gravity

Specific gravity is the ratio of the weight of a given volume of pure chemical at a specified temperature to the weight of the same volume of water at a given temperature. Its primary use is to determine whether a contaminant will have a tendency to float or sink in water if it is present as a pure compound or at very high concentrations. Contaminants with a specific gravity greater than 1 will tend to sink, whereas contaminants with a specific gravity less than 1 will tend to float. This parameter becomes important in discussions regarding the potential presence of free product or nonaqueous-phase liquids.

Of the commonly detected chemicals at the Lower Subase and Thames River, ketones and some monocyclic aromatics have specific gravities less than 1. The halogenated aliphatics, polynuclear aromatic hydrocarbons (PAHs), polychlorinated biphenyls (PCBs), phthalate esters, and pesticides have specific gravities greater than 1.

3.3.1.2 Vapor Pressure

Vapor pressure provides an indication of the rate at which a chemical volatilizes from both soil and water. It is of primary importance at environmental interfaces, such as surface soil/air and surface water/air. Volatilization is not as important when evaluating contaminated groundwater and subsurface soils. Vapor pressures for ketones, monocyclic aromatics, halogenated aliphatics, and nitrogen-containing compounds are generally many times higher than vapor pressures for pesticides and PCBs. Chemicals with higher vapor pressures are expected to enter the atmosphere much more readily than chemicals with lower vapor pressures. Volatilization is a significant loss process for volatile organics in surface water or surface soil. Volatilization is not significant for inorganics.

3.3.1.3 Solubility

The rate at which a chemical is leached from a waste deposit by infiltrating precipitation is proportional to its water solubility. More soluble chemicals are more readily leached than less soluble chemicals. The water solubilities presented in Table 3-3 indicate that the volatile organic chemicals (ketones, monocyclic aromatics, and halogenated aliphatics) and nitrogen-containing compounds are usually several orders of magnitude more water soluble than the pesticides and PCBs. The groundwater data show that the various types of volatile organics are the predominant contaminants.

The solubility of inorganics is strongly influenced by their valence state(s) and forms (hydroxides, oxides, carbonates, etc.). The solubility is also dependent on pH, Eh, and other ionic species in solution (the Debye-Huckel theory). The solubility products reported in the literature vary with the type of complex formed, but generally it can be noted that, for example, cadmium and copper complexes are more soluble than lead and nickel complexes.

3.3.1.4 Octanol/Water Partition Coefficient

The octanol/water partition coefficient (K_{ow}) is a measure of the equilibrium partitioning of chemicals between octanol and water. A linear relationship between the K_{ow} and the uptake of chemicals by fatty tissues of animal and human receptors (the bioconcentration factor) has been determined (Lyman et al., 1990). It is also useful in characterizing the sorption of compounds by organic soils where experimental values are not available. Pesticides and PCBs are several orders of magnitude more likely to partition to fatty tissues than the more soluble volatile organics. The K_{ow} is also used to estimate bioconcentration factors in aquatic organisms.

3.3.1.5 Organic Carbon Partition Coefficient

The organic carbon partition coefficient (K_{oc}) indicates the tendency of a chemical to bind to soil particles containing organic carbon. Chemicals with high K_{oc}s generally have low water solubilities and vice versa. This parameter may be used to infer the relative rates at which the more mobile chemicals (ketones, monocyclic aromatics, and halogenated aliphatics) are transported in the groundwater. Chemicals such as most pesticides, PAHs, and PCBs are relatively immobile in the soil and are preferentially bound to the soil. These compounds are not subject to groundwater transport to the extent that compounds with higher water solubilities are. However, these immobile chemicals are easily transported by erosional processes when they are present in surface soils.

3.3.1.6 Henry's Law Constant

Both the vapor pressure and the water solubility are of use in determining volatilization rates from surface water bodies and from groundwater. The ratio of these two parameters (the Henry's Law constant) is used to calculate the equilibrium chemical concentrations in the vapor (air) phase versus the liquid (water) phase for the dilute solutions commonly encountered in environmental settings. In general, chemicals having a Henry's Law constant of less than 1E-5 atm-m^3/mole, such as pesticides and PCBs, should volatilize very little and be present only in minute amounts in the atmosphere or soil gas. For chemicals with a Henry's Law constant greater than 5E-3 atm-m^3/mole, such as many of the halogenated aliphatics, volatilization and diffusion in soil gas could be significant.

3.3.1.7 Bioconcentration Factor

The bioconcentration factor (BCF) represents the ratio of aquatic-animal-tissue concentration to water concentration. The ratio is both contaminant- and species-specific. When site-specific values are not measured, literature values are used or the BCF is derived from the octanol/water coefficient. Many of the pesticides and PCBs will bioconcentrate at levels three to five orders of magnitude greater than those concentrations found in the water, whereas volatile organics and nitrogen-containing compounds are not as readily bioconcentrated.

3.3.1.8 Distribution Coefficient

The distribution coefficient (K_d) is a measure of the equilibrium distribution of a chemical or ion in soil/water systems. The distribution of organic chemicals is a function of both the K_{oc} and the amount of organic carbon in the soil. For ions (e.g., metals), K_d is the ratio of the concentration adsorbed on soil surfaces to the concentration in water. Distribution coefficients for metals vary over several orders of magnitude because the K_d is dependent on the size and charge of the ion and the soil properties governing exchange

sites on soil surfaces. Coulomb's Law predicts that the ion with the smallest hydrated radius and the largest charge will be preferentially accumulated over ions with larger radii and smaller charges. Soil and clay distribution coefficients for inorganics are shown in Table 3-4.

3.3.2 Contaminant Persistence

The persistence of various classes of chemicals is discussed in this section. Several transformation mechanisms affect chemical persistence, such as hydrolysis, biodegradation, photolysis, and oxidation/reduction reactions. The following general classes of compounds are discussed:

- Ketones
- Monocyclic aromatics
- Halogenated aliphatics
- PAHs
- Phthalate esters
- Pesticides
- PCBs
- Chlorinated dibenzo-p-dioxins (CDDs)
- Metals

3.3.2.1 Ketones

Ketones are highly volatile and soluble, and these two processes dominate the fate of these compounds in the environment. Ketones are not considered to be persistent in the environment, particularly in comparison to chemicals such as PCBs and pesticides. Hydrolysis is generally not a significant fate process for this class of chemicals, nor is bioconcentration significant, based on the low K_{ow}s (Howard, 1990).

Acetone is completely miscible in water and is unlikely to adsorb to soil or sediments or bioaccumulate. It has a high vapor pressure and, once released to the air, photolysis and reaction with hydroxyl radicals result in an average half-life of 22 days (Howard, 1990).

2-Butanone will partially evaporate into the atmosphere if released to the soil and may also leach into the groundwater. Once in the groundwater, 2-butanone may slowly degrade. In surface water, 2-butanone has a half-life of approximately 3 to 12 days. Hydrolysis, photolysis, bioconcentration, and adsorption are not significant fate processes for this chemical (Howard, 1990).

4-Methyl-2-pentanone may be removed from soil by direct photolysis, volatilization, or aerobic biodegradation. It is also susceptible to leaching and may be found in groundwater. If released to surface water, it has a volatilization half-life of 15 to 33 hours and is also subject to direct photolysis. This compound does not significantly bioconcentrate, oxidize, hydrolyze, or adsorb to soil (Howard, 1990).

3.3.2.2 Monocyclic Aromatics

Monocyclic aromatic compounds such as benzene, toluene, chlorobenzene, and xylenes are not considered to be persistent in the environment, particularly in comparison to chemicals such as PCBs and pesticides. Monocyclic aromatics are subject to degradation via the action of both soil and aquatic microorganisms. The biodegradation of these compounds in the soil matrix is dependent of the abundance of microflora, macronutrient availability, soil reaction (pH), temperature, etc.

Although these compounds are amenable to microbial degradation, it is not anticipated that degradation will occur at an appreciable rate, although macronutrient availability is not known. In the event that these compounds discharge to surface water bodies, volatilization and biodegradation may occur relatively rapidly. For example, a reported first-order biodegradation rate constant for benzene is 0.11 day^{-1} in aquatic systems (Lyman et al., 1990). This corresponds to an aquatic half-life of approximately 6 days. Other monocyclic aromatics are subject to similar degradation processes in aquatic environments (USEPA, 1982). However, chlorinated monocyclic aromatics such as chlorobenzene are not expected to be as susceptible to microbial degradation. For example, a reported first-order biodegradation rate constant for chlorobenzene is 0.0045 day^{-1} in aquatic systems (Lyman et al., 1990), which corresponds to an aquatic half-life of approximately 150 days.

Benzene in groundwater is significantly reduced by the action of aerobic bacteria. A biodegradation rate of 0.95 percent per day has been reported (Chiang et al., 1989). The amount of benzene, toluene, and xylenes in the groundwater was reported to be directly proportional to the availability of dissolved oxygen.

Additional environmental degradation processes, such as hydrolysis and photolysis, are considered to be insignificant fate mechanisms for monocyclic aromatics in aquatic systems (USEPA, 1982). However, some monocyclic aromatics such as benzene and toluene have been shown to undergo clay-, mineral-, and soil-catalyzed oxidation (Dragun, 1988).

3.3.2.3 Halogenated Aliphatics

Halogenated aliphatic hydrocarbons such as 1,1,2,2-tetrachloroethane and trichloroethene are subject to abiotic dehydrohalogenation. This process is an elimination reaction that results in the formation of an

ethene from a saturated halogenated compound (Olsen and Davis, 1990). Therefore, the presence of dichloroethane in groundwater in association with ethenes may be a result of this process. Research indicates that microbial degradation of highly chlorinated ethanes is a relatively slow process. 1,1,1-trichloroethane has been shown to break down to 1,1-dichloroethane and chloroethane (Smith and Dragun, 1984), with half-lives reported on the order of 6 to 8 months. Hydrolysis, photolysis, and oxidation are generally not considered to be significant fate processes for the chlorinated ethanes.

While trichloroethene is reportedly susceptible to degradation, the primary end product is reportedly vinyl chloride, which degrades slowly (Cline and Viste, 1984). It does not appear that appreciable degradation of halogenated aliphatics occurs in aerobic aquatic systems (USEPA, 1982) or in unsaturated soils (Lyman et al., 1990).

Photolysis is not considered to be a relevant degradation mechanism for this class of compounds (USEPA, 1982). Limited hydrolysis of saturated aliphatics (i.e., alkanes) may occur, but it does not appear to be a significant degradation mechanism for unsaturated species (i.e., alkenes) (USEPA, 1982).

Under certain conditions, volatilization is a significant fate process for these compounds. Volatilization is only significant at the air-soil or air-water interface. Adsorption should not be considered as an important fate for these types of compounds when compared to more hydrophobic compounds (PCBs for example).

3.3.2.4 Polycyclic Aromatic Hydrocarbons (PAHs)

PAHs have very low solubilities, vapor pressures, and Henry's Law constants and high K_{oc}s and K_{ow}s. The low-molecular-weight PAHs (e.g., acenaphthene, anthracene, fluorene, phenanthrene) may volatilize from surface waters, and the high-molecular-weight PAHs (e.g., benzo(a)pyrene, benzo(a)anthracene, chrysene, etc.) are less likely to volatilize. PAHs in soil are much more likely to bind to soil and be transported via mass transport mechanisms than to go into solution. PAHs are subject to degradation via aerobic bacteria but may be relatively persistent in the absence of microbial population or macronutrients such as phosphorus and nitrogen.

Bioconcentration of PAHs in aquatic organisms is greater for the higher-molecular-weight compounds than the lower-molecular-weight compounds. PAHs can be bioaccumulated from water, sediments, or lower organisms in the food chain.

Land spreading applications have indicated that PAHs are highly amenable to microbial degradation in soil. The rate of degradation is influenced by temperature, pH, oxygen concentrations, initial chemical

concentrations, and moisture. Photolysis, hydrolysis, and oxidation are not important fate processes for the degradation of PAHs in soil (ATSDR, 1993d).

The most important fates of PAHs in water are photo-oxidation, chemical oxidation, and biodegradation. PAHs do not contain functional groups that are susceptible to hydrolytic action, and hydrolysis is considered to be an insignificant degradation mechanism. The rate of photodegradation is influenced by water depth, turbidity, and temperature. Benzo(a)pyrene, chrysene, fluorene, and pyrene are reported to be resistant to photodegradation. PAHs may also be oxidized by chlorination and ozonation and may be metabolized by microbes under oxygenated conditions (ATSDR, 1993d).

3.3.2.5 Phthalate Esters

Phthalate esters are considered to be relatively persistent chemicals in the environment. Although numerous studies have demonstrated that phthalate esters undergo biodegradation, it appears that this is a slow process in both soils and surface waters. Certain microorganisms have been shown to excrete products that increase the solubility of phthalate esters and enhance their biodegradation (Gibbons and Alexander, 1989).

Biodegradation of bis(2-ethylhexyl)phthalate and other phthalates in water is an important fate mechanism, with a half-life of 2 to 3 weeks reported for bis(2-ethylhexyl)phthalate (Howard, 1989). Bioaccumulation is also a significant fate process. Hydrolysis of phthalate esters is very slow, with calculated half-lives of 3 years (dimethylphthalate) to 2,000 years [bis(2-ethylhexyl)phthalate] (USEPA, 1979). Similarly, photolysis and volatilization are considered to be insignificant degradation mechanisms (USEPA, 1979; Howard, 1989).

3.3.2.6 Pesticides

Whether pesticides are sprayed, dusted, or applied directly to the soil, the soil is the ultimate sink for these chemicals. Surface soil runoff may carry pesticides to adjacent surface water bodies. Bioconcentration of pesticides in the food chain is another important fate mechanism. Hydrolysis, oxidation, and photolysis are not generally important fate mechanisms for pesticides in soil or water. Hydrolysis half-lives for several pesticides are reported in periods of months to years (USEPA, 1979). Some of the more commonly detected pesticides are discussed below.

- **4,4'-DDT and its metabolites (4,4'-DDD and 4,4'-DDE)** are considered to be persistent chemicals. They undergo extensive adsorption to soil and are not highly soluble. Biodegradation may occur under both aerobic and anaerobic conditions in the presence of certain soil microorganisms. Under

aerobic conditions, 4,4'-DDT may be transformed to 4,4'-DDE, and under anaerobic conditions, 4,4'-DDD may result. These compounds are, however, somewhat volatile, with a reported half-life of 100 days for 4,4'-DDT. These compounds are highly lipophilic and therefore readily bioaccumulate (ATSDR, 1992d). 4,4'-DDT is no longer in production in the United States.

- **Dieldrin** is an extremely persistent pesticide but is no longer registered for general use. In soil, dieldrin will persist for long periods of time (more than 7 years) and may slowly evaporate. It does not readily leach to groundwater. Once in surface waters (via runoff), dieldrin adsorbs strongly to sediments and bioconcentrates and slowly photodegrades. Biodegradation and hydrolysis are not significant (Howard, 1991).

- The use of **heptachlor** was restricted to underground termite control in 1983. Heptachlor epoxide is formed by the biological transformation of heptachlor in the environment. These compounds sorb strongly to soil. Heptachlor is subject to biodegradation (forming heptachlor epoxide, which is highly resistent to biodegradation) and hydrolysis. Bioconcentration of both compounds is significant, and volatilization and photolysis are very slow (Howard, 1991).

- **Methoxychlor** will remain in the soil and does not leach significantly. It degrades more rapidly under anaerobic conditions (less than 28-day half-life in sediments) than in aerobic conditions (more than 100-day half-life in sediments). In water, methoxychlor may adsorb to sediments or it may bioaccumulate, although fish are reported to metabolize methoxychlor fairly rapidly (Howard, 1991).

3.3.2.7 Polychlorinated Biphenyls (PCBs)

PCBs are considered to be very persistent organic chemicals. Biodegradation is the only process known to transform PCBs under environmental conditions, and only the lighter compounds are measurably biodegraded (USEPA, 1979). Although some microorganisms (e.g., *Phanaerochaete chrysosporium*) may biodegrade PCBs, such fungi may not exist in local soil. There is experimental evidence to suggest that heavier PCBs (five or more chlorines per molecule) can undergo photolytic degradation, but there are no data to suggest that this process operates under environmental conditions (USEPA, 1979). Base-, acid-, and neutral-promoted hydrolysis are considered to be inconsequential degradation mechanisms for PCBs (USEPA, 1982).

3.3.2.8 Chlorinated Dibenzo-p-Dioxins (CDDs)

Little information is available on the fate of octachlorodibenzo-p-dioxin in the environment. However, 2,3,7,8-tetrachlorodibenzo-p-dioxin (TCDD) is expected to be fairly immobile in soil. Leaching through the

soil column is possible in soils of very low organic carbon content as a result of solvation or biotic mixing by earthworms. A white rot fungus (*Phanaerochaete chrysosporium*) has been shown to degrade TCDD, but this process is not reported in natural soil. Additionally, photoreaction and volatilization may remove some TCDD from soil surfaces (ATSDR, 1987b).

3.3.2.9 Metals

Metals are highly persistent environmental contaminants. They do not biodegrade, photolyze, hydrolyze, etc. The major fate mechanisms for metals are adsorption to the soil matrix (as compared to being part of the soil structure) and bioaccumulation.

The mobility of metals is influenced primarily by their physical and chemical properties in combination with the physical and chemical characteristics of the soil matrix. Factors that assist in predicting the mobility of inorganic species are the soil/pore water pH, soil/pore water Eh, and cation exchange capacity. The mobility of metals generally increases with decreasing soil pH and cation exchange capacity.

3.3.3 Contaminant Fate and Transport

This section presents a brief overview of contaminant fate and transport issues at the Lower Subase and Thames River. Site-specific concerns are contained in Sections 4.0 through 11.0. This discussion focuses on some of the major types of contaminants found at the site.

3.3.3.1 Volatile Organics

Volatile organic chemicals are typically considered to be fairly soluble and have a low capacity for retention by soil organic carbon and therefore are the organic compounds most frequently detected in groundwater. These types of chemicals may migrate through the soil column after being released by a spill event or by subsurface waste burial as infiltrating precipitation solubilizes them. Some portion of these chemicals is retained by the soil, but most will continue migrating downward until they reach the water table. At that time, migration is primarily laterally with the hydraulic gradient. Again, some portion of the chemical may be retained by the saturated soil.

Several of these compounds have specific gravities less than that of water (e.g., benzene, toluene). These compounds are typically found in fuels, and if a large enough fuel spill occurs, these compounds may move through the soil column as a bulk liquid, until they reach the water table. There, instead of going into solution, the majority of the release may remain as a discrete fuel layer on the water table surface, with some of the material going into solution at the water/fuel interface.

Similarly, compounds with specific gravities greater than that of water (e.g., trichloroethene) are often used in various industrial applications such as degreasing. If a large enough spill of these solvents occurs, they may also migrate as a bulk liquid but will not stop at the water table surface (i.e., they often mix/sink into the aquifer).

3.3.3.2 Polynuclear Aromatic Hydrocarbons

PAHs are generally considered to be fairly immobile chemicals in the environment. They are large molecules with high organic carbon partition coefficients and low solubilities when compared to the volatile organics. These compounds, when found in the soil, generally do not migrate vertically to a great extent. Instead, they are more likely to adhere to soil particles and be removed from the site via surface runoff and erosional processes.

3.3.3.3 Pesticides

Like the PAHs, pesticides as a class of compounds are not considered to be very mobile in the environment. These chemicals, upon application or disposal, tend to remain affixed to soil particles. Migration of pesticides occurs primarily by erosion via the action of wind or water.

3.3.3.4 Inorganics

Because metals are frequently incorporated into the soil matrix and remain bound to particulate matter, they also migrate from the source areas via bulk movement processes (erosion). The larger particles (greater than 0.45 microns, which are removed via the filtration step prior to water analysis) are not generally considered to be mobile in groundwater. The metals detected in unfiltered groundwater samples are likely to be representative of suspended soil material in the samples.

There are some instances, however, where metals are found at such concentrations or in such forms as to be able to migrate in solution. It is possible that industrial activities could saturate all available exchange sites in soil and hence a metal may be mobilized. Metals are also more mobile under acidic conditions, which may exist in areas where plating-type activities have occurred. Finally, a metal solution may be utilized in some industrial applications. In these cases, it is possible for metals to migrate vertically through the soil column and reach the groundwater.

3.3.4 Natural Attenuation

Monitored natural attenuation is a passive remediation method that can effectively reduce petroleum contamination in soil and groundwater to levels that do not pose a risk to human health and the

environment. Source control and performance monitoring are fundamental components of any monitored natural attenuation remedy. The technology works because common petroleum contaminants are readily biodegraded by microorganisms that occur naturally in the subsurface environment.

Natural attenuation results from the combined effects of several natural processes, including biodegradation, dilution, sorption, dispersion, volatilization, chemical and biological stabilization, transformation, and destruction of contaminants (USEPA, 1997d). For petroleum hydrocarbons, biodegradation is the most important process because it transforms contaminants to innocuous by-products such as water and carbon dioxide and reduces the total mass of the contaminants in the subsurface. The other processes act to lower the concentration of the contaminants in the environment but not to reduce their mass (Kelley et al., 1996).

Natural attenuation processes are typically occurring at all sites, but to varying degrees of effectiveness depending on the types and concentrations of contaminants present and the physical, chemical, and biological characteristics of the soil and groundwater (USEPA, 1997d). Natural attenuation processes may reduce the potential risk posed by site contaminants in three ways:

- The contaminant may be converted to a less toxic form through destructive processes such as biodegradation or abiotic transformations.

- Potential exposure levels may be reduced by lowering of concentration levels (through destructive processes, or by dilution or dispersion)

- Contaminant mobility may be reduced by sorption to the soil or rock matrix.

The main components of fuel oils, such as No. 2 and No. 6 fuel oils, which have been commonly used at the Lower Subase, are the PAHs. Napthalenes are the most mobile of the PAHs, due to their moderate water solubility and soil sorption potential relative to other PAHs. Napthalene biodegrades under both aerobic and anaerobic conditions (Kelley et al., 1996). Considerable recent work suggests strongly that other PAHs are biodegradable in nature and should be considered susceptible to bioremediation (Schneider and Billingsley, 1990).

Parameters indicative of biodegradation of petroleum hydrocarbons were collected during the Lower Subase RI to examine the viability of natural attenuation or bioremediation as a feasible remedial alternative for petroleum contamination within the groundwater. The parameters that were measured include dissolved oxygen, nitrate, divalent iron, sulfate, methane, oxidation reduction (REDOX) potential, pH, alkalinity, hardness, phosphate, ammonia, chloride, salinity, TOC, and common water quality

parameters (i.e., temperature, turbidity, and specific conductivity). The parameters were measured in each of the monitoring wells sampled in the seven zones. Monitoring wells upgradient, within, and downgradient of contaminant plumes were sampled. Further discussion on each parameter is provided below.

Typically, the most important electron acceptors in groundwater include dissolved oxygen, nitrate, iron (III), sulfate, and carbon dioxide (Wiedemeier et al., 1995). The biodegradation processes associated with these analytes are summarized in Table 3-5. Dissolved oxygen was measured to determine if aerobic oxidation is occurring. Divalent iron, dissolved nitrate, sulfate, and methane were measured to identify a correlation between electron acceptors and metabolic by-products indicative of an oxygen-depleted environment (suggesting past aerobic biodegradation and current anaerobic biodegradation).

Dissolved oxygen acts as a primary substrate or cosubstrate during the initial stages of metabolism and is the single most efficient electron acceptor responsible for the biodegradation of natural or anthropogenic organic carbon. During aerobic respiration, dissolved oxygen is utilized as an electron acceptor to mineralize natural organic carbon (or hydrocarbons) into CO_2 and water. Dissolved oxygen at concentrations less than 0.5 mg/L provides strong evidence of indigenous bacteria populations that are already established and actively degrading natural or anthropogenic carbon, utilizing anaerobic pathways.

Once dissolved oxygen has been depleted, anaerobic microbes will utilize nitrate (NO_3) as an electron acceptor. The microbes will anaerobically degrade hydrocarbons (denitrification) and generate nitrite and carbon dioxide.

Anaerobic microbes will utilize iron (III) as electron acceptors, after dissolved oxygen and nitrate have been depleted to anaerobically degrade hydrocarbons. Iron (III) reduction generates divalent iron and carbon dioxide.

Typically, after dissolved oxygen, nitrate, and iron (III) have been utilized, anaerobic microbes will utilize sulfate (SO_4) as an electron acceptor to anaerobically degrade hydrocarbons (sulfate reduction). The process of sulfate reduction results in the generation of sulfide and carbon dioxide. Sulfide can be present as the free sulfide ion (S^{-2}) or as dissolved hydrogen sulfide (H^2S and HS^-).

Methanogenesis is an anaerobic biodegradation process whereby bacteria utilize carbon dioxide as an electron acceptor, generating methane as a byproduct of fermentation. Therefore, since methane is not a chemical component in fuels, its presence above background provides a strong indication of methanogenic fermentation (and carbon dioxide utilization). Background concentrations of methane are

important to collect since some natural sources of methane could exit (e.g. groundwater derived from infiltration into or through a peat bog or other natural methane source).

The REDOX potential of groundwater is a measure of the relative tendency of the groundwater solution to accept or donate electrons as well as the amount of energy released during electron transfers within the solution. The REDOX potential depends upon and influences the rates and types of biodegradation processes. Therefore, the measurement of REDOX potential can provide evidence of the type of biodegradation processes (i.e., aerobic or anaerobic) that are active in a particular plume or even within different portions of the same plume.

Other parameters (i.e., pH, alkalinity, hardness, ammonia, and phosphate) were also collected to assist in determining if natural attenuation is in progress and to determine the levels of possible nutrients available for microorganisms. pH was measured because aerobic and anaerobic processes are pH-sensitive. Alkalinity and hardness are measures of the buffering capacity of the groundwater. In addition, alkalinity tends to increase during aerobic/anaerobic oxidation. Ammonia is an intermediate product of denitrification and can be used by some microorganisms as a nutrient (Schneider and Billingsley, 1990). Phosphate is a nutrient and electron acceptor for biodegradation. It acts in a similar capacity as divalent iron, nitrate, and sulfate (Schneider and Billingsley, 1990).

General groundwater field parameters such as chloride, specific conductivity, and temperature were collected to verify that the site samples were obtained from the same groundwater system. The temperature of groundwater effects the solubility of oxygen and other geochemical species, as well as the metabolic activity bacteria. Microbes are generally more active in warm water. Salinity measurements were taken to determine the potential impact of salt water intrusion on the viability of natural attenuation. High levels of salinity have been shown to impede the natural degradation process (Schneider and Billingsley, 1990).

TOC was measured in the groundwater because the rate of migration of organic compounds is dependent upon the amount of TOC in the aquifer matrix. The data will used for modeling future contaminant movement, if necessary.

Table 3-5 indicates the changes that are expected in groundwater chemistry as a result of biodegradation processes (Wiedemeier et al., 1995). Groundwater conditions that are indicative of biodegradation processes are included in Table 3-6 (Wiedemeier et al., 1995). The analytical data from MW-6RI, a well upgradient of Zone 6 and the Lower Subase in general that shows no signs of impact from contamination of the Lower Subase, will be considered as background levels for the natural attenuation parameters. The information provided in these two tables will be used in conjunction with the data from MW1-6RI, the

potentiometric surface maps for high and low tide conditions, and the isoconcentration maps of key parameters (i.e., dissolved oxygen, REDOX potential, divalent iron, specific conductivity, and TPH concentrations in soil and groundwater) to assess the zone-specific Lower Subase RI data. The goals of the assessment are to determine, on a zone-by zone basis, if natural attenuation of petroleum hydrocarbons is currently occurring in the groundwater and if natural attenuation and/or bioremediation are viable processes for remediation of petroleum hydrocarbons.

3.4 HUMAN HEALTH RISK ASSESSMENT PROCEDURES

A risk assessment provides the framework for developing risk information necessary to assist in developing potential remedial alternatives for a site. A baseline human health risk assessment consists of five major components, as follows:

- Data evaluation and identification of COCs
- Exposure assessment
- Toxicity assessment
- Risk characterization
- Characterization of uncertainty in the risk estimates

To assess potential public health risks, four major aspects of chemical contamination and exposure must be considered: contaminants with toxic characteristics must be found in environmental media; the contaminants must be released by either natural processes or by human action; potential exposure points must exist; and human receptors must be present at the point of exposure. Risk is a function of both toxicity and exposure. If any one of the requirements listed above are absent for a specific site, the exposure route is regarded as incomplete and no potential risks will be considered for human receptors.

The risk assessment for the Lower Subase RI estimates the potential for human health risk at each of the seven zones within the Lower Subase individually. Also included in this RI Report is an assessment of the human health risks associated with the Thames River, which may be impacted by contamination at the Lower Subase. Information on the distribution of contamination, the toxicity of the compounds detected in the various media, and a site-specific estimate of chemical intake via assumed exposure routes are combined in each of Sections 4.0 through 11.0 to estimate potential risks. This section provides a summary of the process used and all information that would have to be repeated from section to section in order to avoid redundancy in the document. The risk assessment conducted for this report follows the most recent guidance from the USEPA (USEPA, 1989d and 1991a), including Regional guidance (USEPA, 1989b, 1994f, 1995d, and 1996f).

The Data Evaluation Section is primarily concerned with the selection of COCs that are representative of the type and magnitude of potential human health effects. Both current and historical data are considered in developing a list of COCs for each medium. In turn, these COCs are used to evaluate potential risks. A generic discussion of the process is contained in Section 3.4.1, and site-specific discussions are presented in the subsequent sections.

The toxicity assessment presents the available human health criteria for all the selected COCs. This assessment is contained in Section 3.4.2, although the final lists of zone-specific COCs are presented throughout the document. This section is presented early to avoid repetition of the toxicity information because many COCs are common to several of the zones. Quantitative toxicity indices are presented where they are available. Enforceable standards such as Maximum Contaminant Levels (MCLs), regulatory guidelines such as Ambient Water Quality Criteria (AWQC) and Health Advisories, and dose-response parameters such as Reference Doses (RfDs) and Cancer Slope Factors (CSFs) are presented for each COC.

The Exposure Assessment section identifies potential human exposure pathways at the source areas under consideration. Exposure routes are identified based on information on source area chemical concentrations, chemical release mechanisms, patterns of human activity, and other pertinent information to develop conceptual site models for each type of source. One overall set of exposure routes was developed for this report, but not all routes are applicable to all sites. Section 3.4.3 presents the equations and relevant input parameters for estimating chemical intake. The site-specific risk assessments present only those routes relevant to each site and refer to Section 3.4.3 for the details on the estimation method.

The Risk Characterization section (Section 3.4.4) describes how the estimated intakes are combined with the toxicity information to estimate risks. The actual numerical results of this exercise are presented in the site-specific sections of this report. General uncertainties associated with the risk assessment process are discussed qualitatively in Section 3.4.5. Uncertainties associated with a particular site are provided in the site-specific sections.

3.4.1 Data Evaluation

Data evaluation is a site-specific task that uses a variety of information to determine which of the detected chemicals at a site are most likely to present a risk to potential receptors. The end result of this qualitative selection process is a list of COCs and representative exposure point concentrations for each medium. The rationale for the selection and/or exclusion of each detected chemical is presented in the site-specific sections, Sections 4.0 through 11.0. The methodology used to identify COCs for the Lower Subase RI

Report is provided in Section 3.4.1.1. The methodologies used to determine exposure point concentrations for the selected COCs are presented in Section 3.4.1.2.

3.4.1.1 Selection of Chemicals of Concern

COCs for the baseline human health risk assessments are limited to those chemicals that exceed a selection criterion. For this risk assessment, federal and state risk-based and health-based criteria were used to reduce the number of chemicals and exposure routes considered in a risk assessment. The premise of this screening step is that risk is typically dominated by a few chemicals and that, although dozens may actually be detected, many chemicals may contribute minimally to the total risk. The purpose of using Federal and state criteria is to satisfy the potential concerns of each regulatory agency since similar Federal and state criteria may not be developed using the same methodologies and exposure assumptions.

Maximum detected concentrations (in a single sample) at each site and in each medium were compared to the risk-based and health-based screening criteria. If the maximum concentration exceeded any of the screening criteria, that chemical was retained as a COC for all exposure routes involving that medium. For example, if barium was retained for soil, this chemical was evaluated as a COC for both ingestion and dermal exposure routes. If none of the chemicals detected in a medium exceeded a criterion, that medium was dropped from further consideration and the potential risks associated with exposure to that medium are regarded as relatively insignificant.

In general, all available, validated data from historical investigations and the Lower Subase RI sampling effort were used to identify COCs for a site. Site- and medium-specific COC summary screening tables are provided in Appendix I.5 through I.11. Field screening data, unvalidated data, and analytical results qualified as rejected, R, during the data validation process were not considered because of their potential unreliability. For soil, data obtained from excavated locations, soil collected from depths greater than 10 feet (the maximum, assumed depth for potential human exposure during excavation/construction), and composite soil samples were not used in the COC selection process.

Essentially, two types of COCs are identified in the baseline human health risk assessment: direct exposure COCs and additional COCs based on potential contaminant migration tendencies. Direct exposure COCs are those chemicals detected at maximum concentrations in excess of criteria developed for the protection of direct human contact with a medium (e.g., risk-based Region III COC screening levels for soil and tap water ingestion). Other health-based criteria (e.g., Connecticut Remediation Standard Regulations for pollutant mobility) are used to identify additional COCs based on likely contaminant migration pathways at the Lower Subase. All criteria used to identify COCs for solid environmental

matrices (soil and fish) and aqueous environmental matrices (groundwater and surface water) are presented in Tables 3-7 and 3-8, respectively.

Although both direct exposure and additional COCs are identified in the risk assessment, quantitative, numerical risk estimates are developed for direct exposure COCs only. Additional COCs based on potential contaminant migration tendencies are not expected to contribute significantly to the direct exposure pathways selected for quantitative evaluation in the risk assessment; therefore, these chemicals are not included in the numerical risk estimates. The elimination of these chemicals is not expected to adversely impact the results of the risk assessment. Additional COCs were addressed qualitatively and were considered when developing recommendations and conclusions for each site (i.e., migration concerns were used to identify whether additional sampling or remediation is warranted).

A discussion of the criteria used for COC selection is provided in the remainder of this section, on a medium-specific basis.

Soil

COCs were selected for shallow soil (soil from depths of 0 to 4 feet bgs or from 0 to 5 feet bgs, depending on the specific site) and "all soil." The "all soil" category refers to soil samples collected from depths of 0 to 10 feet bgs and is used to account for soil to which a construction worker and future resident may be potentially exposed. If a chemical is identified as a COC for surface soil, it is automatically retained as a COC for "all soil." If a compound is found in the subsurface soil at a concentration of concern (i.e., in excess of a screening criteria), it is retained as a COC for the "all soil" category only.

The following screening criteria were used to identify COCs for direct exposure:

USEPA Region III COC Screening Levels for Residential Soil Ingestion. Although current and likely future land use at the Lower Subase is strictly industrial, risk-based concentrations for soil ingestion for residential land use were used as a conservative approach. These values were developed using the current USEPA Region III Risk-Based Concentration (RBC) Table (USEPA, 1997c), which identifies concentrations of potential concern for nearly 600 chemicals in various media (air, drinking water, fish tissue, and soil) using certain reasonably maximum exposure default assumptions. The residential soil ingestion values were calculated by assuming that a receptor is exposed to soil for 350 days per year for a 30-year exposure period. For carcinogenic chemicals, the values used for COC screening are based on a 1E-6 target incremental lifetime cancer risk and incorporate age-adjusted factors (for small children and adults). The criteria for noncarcinogenic chemicals are based on a target HQ of 0.1, which is one-tenth of the suggested cumulative target noncarcinogenic risk for a potential receptor, and exposure defaults for

small children. The estimation of cumulative target noncarcinogenic risks is described in greater detail in Section 3.4.4.

Connecticut Remediation Standard Regulations (RSRs) for Direct Exposure (Residential and Industrial). Connecticut RSRs for direct exposure to soil under residential and industrial land use are presented in the COC screening tables. Although the standards for residential direct exposure are the limiting factor for COC selection (i.e., values for residential exposure are less than those for industrial exposure), both of these standards are provided for informational purposes. RSRs for direct exposure are calculated using methodologies similar to those used to develop the USEPA Region III COC Screening Levels for soil ingestion. However, reasonable maximum exposure default assumptions employed by the state are slightly different than those advocated by USEPA Region III (i.e., a residential receptor is assumed to be exposed to soil at a frequency of 365 days per year, instead of the USEPA's 350 days per year assumption). The standards for carcinogenic chemicals are based on a 1E-6 target incremental lifetime cancer risk. The standards for noncarcinogenic chemicals are based on a target HQ of 1. The State of Connecticut has not developed RSRs for all chemicals positively detected at the Lower Subase. For those chemicals lacking adopted RSRs, B&R Environmental has calculated RSRs (B&R Environmental, 1997e) using the methodologies outlined in the RSR guidance (CTDEP, 1996). These values were submitted to the state for review and they were revised based on comments received from the state (B&R Environmental, 1998). A summary of the RSRs developed by B&R Environmental and used in this risk assessment are presented in Appendix I.3.

In order to identify additional COCs based on potential contaminant migration tendencies, the following screening criteria were used to evaluate shallow soil and "all soil" (soil collected from depths of 0 to 10 feet bgs):

USEPA Generic Soil Screening Levels (SSLs) for Transfers from Soil to Air (Inhalation) and Migration to Groundwater. USEPA Generic SSLs (USEPA, 1996d) for direct inhalation are used to evaluate chemicals that may volatilize from soil, as well as contaminated particulates that may be present in air (fugitive dust) as a result of particulate entrainment from soil. Because of the shallow depth to groundwater at the Lower Subase, the SSLs associated with a dilution and attenuation factor of 1 were used to identify COCs. Both the inhalation and migration to groundwater SSLs are calculated using default, residential land use exposure factors, infinite source models, and conservative default assumptions for source delineation. Therefore, these values are conservative and are designed to be protective of potential exposure at most sites. The USEPA has calculated generic SSLs for approximately 110 organic and inorganic chemicals. SSLs for carcinogenic chemicals are based on a 1E-6 target incremental lifetime cancer risk. For noncarcinogenic chemicals, the SSLs are based on a target HQ of 1.

Connecticut RSRs for Pollutant Mobility (GB Classified Area). The state has developed pollutant mobility RSRs for GA/GAA (drinking water source) and GB (non-drinking water source) classified areas. Since the Lower Subase is classified by the state as a GB area, Connecticut RSRs for GB pollutant mobility were used to identify COCs. For most organic chemicals, RSRs for pollutant mobility are calculated using methodologies similar to those used to develop the USEPA generic SSLs for migration to groundwater. However, the actual models and reasonable maximum exposure default assumptions employed by the state are different than those advocated by USEPA Region III. The standards for carcinogenic chemicals are based on a 1E-6 target incremental lifetime cancer risk. The standards for noncarcinogenic chemicals are based on a target HQ of 1. It should be noted that RSRs for inorganics, pesticides, and PCBs apply to SPLP or TCLP analytical results only. Although RSRs for these chemicals were used to identify COCs in the baseline human health risk assessment, the comparison of site data to these standards is presented in tables in the Nature and Extent section for each site, instead of in the COC screening tables. As mentioned previously, the State of Connecticut has not developed RSRs for all chemicals positively detected at the Lower Subase. Therefore, B&R Environmental has calculated RSRs using state guidance (CTDEP, 1996) for use in the risk assessment (Appendix I.3).

Background

As per USEPA Region I guidance (USEPA, 1995d), background concentrations for chemicals in soil developed by Atlantic Environmental Services, and presented in Table 1-4 of this report were not used to eliminate COCs. All COCs for soil that are considered to be attributable to natural, background soil conditions were addressed in the risk assessment to provide a complete characterization of potential risk. A discussion of site data in comparison to the established background levels is provided in each site-specific uncertainty section. It should be noted that background concentrations were considered when developing recommendations and conclusions for each site (i.e., identifying whether additional sampling or remediation is warranted).

Groundwater

COCs for groundwater were selected using unfiltered and filtered sample data. If an inorganic chemical was detected in both the filtered and filtered groundwater samples at concentrations in excess of screening criteria, the chemical was identified as a COC for both sample matrices. However, to be conservative, the unfiltered data only were used in the quantitative risk assessment since the concentration of a chemical in the unfiltered sample matrix includes the chemical concentration associated with the dissolved sample matrix and any suspended particulates. If a chemical was detected in the filtered sample matrix, but not in the unfiltered sample matrix or was present in the filtered sample matrix at a concentration of concern, but not in the unfiltered sample matrix, this chemical was identified as a

COC for the filtered sample matrix only. In this instance, the filtered sample results were used in the quantitative risk assessment.

COCs for direct exposure to groundwater were identified using the following screening criteria:

USEPA Region III COC Screening Levels for Tap Water Ingestion. Although groundwater at the Lower Subase is not currently used as a drinking water supply and is not expected to be used as such in the future because of saline conditions, risk-based concentrations for tap water ingestion were used to conservatively identify COCs. The USEPA Region III criteria are calculated using an age-adjusted exposure equation, which assumes that a receptor uses groundwater for household purposes at a frequency of 350 days per year for 30-year exposure period. The screening values for tap water ingestion, which actually incorporate exposure via inhalation of volatiles, were developed using the current USEPA Region III RBC Table (USEPA, 1997c). For carcinogenic chemicals, the values used for COC screening are based on a 1E-6 target incremental lifetime cancer risk. The criteria for noncarcinogenic chemicals are based on a target HQ of 0.1.

Connecticut RSRs for the Protection of Groundwater (GA/GAA). Connecticut RSRs for the protection of groundwater are applicable to GA/GAA classified areas (drinking water source areas) only. Although the Lower Subase is a GB classified area (a non-drinking water source area), the groundwater RSRs for GA/GAA protection were used for information purposes and as a conservative approach for COC selection. RSRs for the protection of groundwater (GA/GAA) are calculated using methodologies similar to those used to develop the USEPA Region III COC Screening Levels for tap water ingestion. However, the exposure equation and reasonably maximum exposure default assumptions employed by the state are slightly different than those advocated by USEPA Region III (i.e., a receptor is assumed to be exposed to groundwater at a frequency of 365 days per year, instead of USEPA's 350 days per year age-adjusted exposure scenario). The standards for carcinogenic chemicals are based on a 1E-6 target incremental lifetime cancer risk. The standards for noncarcinogenic chemicals are based on a target HQ of 1. As mentioned previously, the State of Connecticut has not developed RSRs for all chemicals positively detected at the Lower Subase. Therefore, B&R Environmental has calculated RSRs using state guidance (CTDEP, 1996) for use in the risk assessment (Appendix I.3).

Federal and State Maximum Contaminant Levels (MCLs). Federal MCLs are standards promulgated under the Safe Drinking Water Act and are designed for the protection of human health (direct ingestion). State MCLs have been promulgated under guidance for Connecticut agencies (Title 19, Health and Safety, the Public Code of the State of Connecticut, Chapter II Environmental Health). Both Federal and state MCLs are developed in a similar manner (i.e., they are based on laboratory or epidemiological studies and apply to drinking water supplies). They are designed in a similar manner as the USEPA

Region III RBCs (i.e., for the prevention of human health effects associated with lifetime exposure of an average adult who consumes 2 liters of water per day). However, MCLs also reflect the technical feasibility of removing the contaminant from water. Although MCLs are typically enforceable standards for groundwater, these standards are not strictly applicable to groundwater at the Lower Subase since groundwater at the site is not currently used as a drinking water supply nor is it expected to be used as such in the future. It should also be noted that primary MCLs and secondary MCLs, based on aesthetic drinking water qualities (color, odor, taste, etc.), are used to identify COCs.

Connecticut Water Quality Standards. Because groundwater at the Lower Subase discharges directly to a nearby surface water body (the Thames River), screening criteria protective of surface water were used to identify additional COCs associated with potential contaminant migration pathways. Connecticut Water Quality Standards (WQSs) (CTDEP, 1997) for saltwater were employed, instead of Connecticut RSRs for the protection of surface water, since the Thames River is a saltwater body and because the RSRs consider freshwater criteria only. The use of the WQSs during COC selection is considered to result in a conservative identification of COCs since significant dilution of contaminants in the Thames River is anticipated because of the magnitude of groundwater discharge versus the magnitude of surface water discharge and tidal mixing.

It should also be noted that Federal Maximum Contaminant Goals (MCLGs) and Federal AWQCs are other health-based standards that were not used to identify groundwater COCs in the baseline human health risk assessment. These criteria were not used because they are extremely similar to the risk-based and health-based criteria identified in the previous paragraphs. These criteria are included in Tables 3-7 and 3-8 so that a comparison to other criteria used can be made and to indicate the conservative nature of the COC screening process used in the risk assessment.

Surface Water and Fish (Shellfish and Finfish)

COCs for surface water collected from the Thames River were identified using the USEPA Region III COC screening level for tap water ingestion, as discussed in the multi-site Phase II RI Report (B&R Environmental, 1997b). This approach results in a conservative list of COCs since surface water is not used as a drinking water supply. COCs for finfish and shellfish (oysters and mussels) were selected using the USEPA Region III COC screening level for fish ingestion, as discussed in the multi-site Phase II RI Report. Because no new chemical analytical data were recently collected for fish and surface water (i.e., only water quality parameters were measured during the Lower Subase RI sampling effort), the baseline human health risk assessment for the Thames River (Section 11.0 of this report) presented in the multi-site RI Report was not revised.

3.4.1.2 Exposure Point Concentrations

According to the Regional guidance, risk assessments are conducted using an exposure point concentration for each COC (except when assessing exposure to groundwater, where the maximum detected concentration and the average plume concentration are used as exposure point concentrations). The exposure point concentration is defined as the 95 percent upper confidence limit (UCL) and is calculated using the latest risk assessment guidance from USEPA (USEPA, 1992d). A value of one-half the detection limit is substituted for nondetected values in the calculation. Because of potential problems with sample heterogeneity, the maximum detected concentration reported for field duplicate pair samples was used in the calculation for soil and sediment matrices at the direction of USEPA. The average for the duplicate pair was employed for aqueous matrices.

For sample sets consisting of less than 10 samples, the maximum and average concentrations were used as the exposure point concentrations since the UCL does not provide a good estimation of the upper bound of the mean concentration for these small data sets (USEPA, 1992d). For larger sample sets, the methodology used is dependent on the distribution of the sample set. For this risk assessment, the distribution was determined using the Shapiro-Wilk W-Test (Gilbert, 1987). When the results of the test were inconclusive and the distribution was regarded as undefined, maximum and average detections were used as exposure point concentrations.

For normally distributed data, the calculation of the exposure point concentration (UCL) is a two-step process. First the standard deviation of the sample set must be determined, as follows:

$$S = \left[\frac{\Sigma(X_i - \bar{X})^2}{(n-1)}\right]^{1/2}$$

where: S = standard deviation
X_i = individual sample value
n = number of samples
$\bar{x}$ = mean sample value

The one-sided UCL on the mean is then calculated as follows:

$$UCL = \bar{X} + t\left(\frac{S}{n^{1/2}}\right)$$

where: UCL = 95 percent Upper confidence limit of the mean

3

$\bar{X}$	=	Arithmetic average
t	=	One-sided t distribution factor ($t_{0.95}$)
s	=	standard deviation
n	=	number of samples

For log-normally distributed data sets, the exposure point concentration is calculated using the following equation:

$$UCL = \exp\left(\bar{X} + 0.5s^2 + \frac{Hs}{(n-1)^{1/2}}\right)$$

where:	UCL	=	95 percent UCL of the mean
	exp	=	Constant (base of the natural log, e)
	$\bar{X}$	=	Mean of the transformed data
	s	=	Standard deviation of the transformed data
	H	=	H-statistic (from Gilbert, 1987; $H_{0.95}$)
	n	=	Number of samples

This equation uses individual sample results that have been transformed by taking their natural logarithm.

As mentioned previously, average and maximum plume concentrations were generally used as the exposure point concentrations for assessing risks associated with groundwater exposure. Because of the multiple rounds of groundwater sampling that were performed at some of the sites investigated in this RI, the first step in developing exposure point concentrations for this medium was to determine an average chemical concentration for each well (using the one-half detection limit for nondetected results). The maximum plume concentration was then defined as the highest average in a single well. The average of all the well-specific averages was considered to represent the average plume concentration. It should be noted that the maximum detected concentration in a single groundwater sample was used as the exposure point concentration if the calculated average and/or maximum plume concentration exceeded the maximum detection in a single sample.

Sample calculations for the determination of the distribution of a data set, UCL, and average and maximum plume concentrations are provided in Appendix I.3.

3.4.2 Toxicity Assessment

The toxicity assessment for the COCs examines information concerning the potential human health effects of exposure to COCs. The goal of the toxicity assessment is to provide, for each COC, a quantitative estimate of the relationship between the magnitude and type of exposure and the severity or probability of human health effects. The toxicity values presented in this section are integrated with the exposure assessment (Section 3.4.3) to characterize the potential for the occurrence of adverse health effects (Sections 3.4.4 and the site-specific sections).

The toxicological evaluation involves a critical review and interpretation of toxicity data from epidemiological, clinical, animal, and in vitro studies. This review of the data ideally determines both the nature of the health effects associated with a particular chemical and the probability that a given quantity of a chemical could result in the referenced effect. This analysis defines the relationship between the dose received and the incidence of an adverse effect for the chemicals of concern.

The entire toxicological database is used to guide the derivation of cancer slope factors (CSFs) for carcinogenic effects and Reference Doses (RfDs) for noncarcinogenic effects. These data may include epidemiological studies, long-term animal bioassays, short-term tests, and evaluations of molecular structure. Data from these sources are reviewed to determine if a chemical is likely to be toxic to humans. Because of the lack of available human studies, however, the majority of toxicity data used to derive CSFs and RfDs comes from animal studies.

For noncarcinogenic effects, the most appropriate animal model (i.e., the species most biologically similar to the human) is identified. Pharmacokinetic data often enter into this determination. In the absence of sufficient data to identify the most appropriate animal model, the most sensitive species is chosen. The RfD is generally derived from the most comprehensive toxicology study that characterizes the dose-response relationship for the critical effect of the chemical. Preference is given to studies using the exposure route of concern; in the absence of such data, however, an RfD for one route of exposure may be extrapolated from data from a study that used a different route of exposure. Such extrapolation must take into account pharmacokinetic and toxicological differences between the routes of exposure. Uncertainty factors are applied to the highest no-observed-adverse-effect-level (NOAEL) to adjust for inter- and intraspecies variation, deficiencies in the toxicological database, and use of subchronic rather than chronic animal studies. Additional uncertainty factors may be applied to estimate a NOAEL from a lowest-observed-adverse-effect-level (LOAEL) if the key study failed to determine a NOAEL. When chemical-specific data are not sufficient, an RfD may be derived from data for a chemical with structural and toxicologic similarity.

CSFs for weight-of-evidence Group A or B chemicals are generally derived from positive cancer studies that adequately identify the target organ in the test animal data and characterize the dose-response relationship. CSFs are derived for Group C compounds for which the data are sufficient but are not derived for Group D or E chemicals. No consideration is given to similarity in the animal and human target organ(s), because a chemical capable of inducing cancer in any animal tissue is considered potentially carcinogenic to humans. Preference is given to studies using the route of exposure of concern, in which normal physiologic function was not impaired, and in which exposure occurred during most of the animal's lifetime. Exposure and pharmacokinetic considerations are used to estimate equivalent human doses for computation of the CSF. When a number of studies of similar quality are available, the data may be combined in the derivation of the CSF.

Toxicological profiles for each of the COCs are presented in Appendix I.4. These profiles present a summary of the available literature on carcinogenic and noncarcinogenic effects associated with human exposure to the chemical. Brief summaries of the toxicity profiles for the major COCs are presented in Section 3.4.2.3.

3.4.2.1 Carcinogenic Effects

The toxicity information considered in the assessment of potential carcinogenic risks includes a weight-of-evidence classification and a slope factor. The weight-of-evidence classification qualitatively describes the likelihood that a chemical is a human carcinogen and is based on an evaluation of the available data from human and animal studies. A chemical may be placed in one of three groups in USEPA's classification system to denote its potential for carcinogenic effects:

- Group A - known human carcinogen
- Group B1 or B2 - probable human carcinogen
- Group C - possible human carcinogen

Chemicals that cannot be classified as a human carcinogen because of a lack of data are placed in Group D, and those for which there is evidence of noncarcinogenicity in humans are in Group E.

The CSF is the toxicity value used to quantitatively express the carcinogenic hazard of cancer-causing chemicals. It is defined as the upperbound estimate of the probability of cancer incidence per unit dose averaged over a lifetime. Slope factors are derived from studies of carcinogenicity in humans and/or laboratory animals and are typically calculated for compounds in Groups A, B1, and B2, although some Group C carcinogens also have slope factors and some B2 carcinogens have none (e.g., lead). Slope factors are specific to a chemical and route of exposure and are expressed in units of $(mg/kg/day)^{-1}$ for

both oral and inhalation routes. Inhalation cancer toxicity values are usually expressed as inhalation unit risks in units of reciprocal $\mu g/m^3$ [$1/(\mu g/m^3)$]. Because cancer risk characterization requires an estimate of reciprocal dose in units of 1/(mg/kg/day), the inhalation unit risk must be converted to the mathematical equivalent of an inhalation cancer slope factor, or risk per unit dose (mg/kg/day). This is done by assuming that humans weigh 70 kg and inhale 20 m^3 of air per day [i.e., the inhalation unit risk ($1/\mu g/m^3$) is divided by 20 m^3, multiplied by 70 kg, and multiplied by 1,000 µg/mg to yield the mathematical equivalent of an inhalation slope factor (1/mg/kg/day)]. CSFs for COCs at the Lower Subase are presented in Table 3-9. The primary sources of information for these values are the USEPA (USEPA, 1997b and 1998) and USEPA Region III (USEPA, 1997c).

USEPA's database (IRIS - the Integrated Risk Information System) was consulted as the primary source for CSF values, as well as for RfDs. USEPA intends that IRIS supersede all other sources of toxicity information for risk assessment. If values are not available in IRIS, the annual Health Effects Assessment Summary Tables (HEAST) were consulted, as well as the current USEPA Region III Risk-Based Concentration table (USEPA, 1997c). If no CSF is available from any of these sources, carcinogenic risks are not quantified and potential exposures are addressed in the general uncertainty section, Section 3.4.5.

CSFs exist for several (but not all) Class C compounds, which are identified as "possible" human carcinogens. These compounds typically exhibit inadequate evidence of carcinogenicity in humans and limited evidence in animals. In this human health risk assessment, Class C compounds are evaluated quantitatively as class A/B1/B2 compounds, but the risks associated with exposure to Class C compounds are also discussed separately if these chemicals are major risk drivers, underscoring the uncertainty associated with these estimations.

Dermal CSFs are derived from the corresponding oral values. In the derivation of a dermal CSF, the oral CSF is divided by the gastrointestinal absorption efficiency to determine a CSF based on an absorbed dose rather than an administered dose. The oral CSF is divided by the absorption efficiency because CSFs are expressed as reciprocal doses. Dermal CSFs and the absorption efficiencies used in their determination are also included in Table 3-9. When no absorption rate is available in the literature, no adjustment is made.

Risk estimates for PAHs have, in the past, assumed that all carcinogenic PAHs have a potency equal to that for benzo(a)pyrene. While benzo(a)pyrene was well studied, other Class B2 PAHs had insufficient data with which to calculate a CSF. USEPA has published provisional guidance to assess PAHs (USEPA, 1993b). Estimated orders of potential potency (rather than a toxicity equivalence factor or TEF) were developed based on skin painting tests and are rounded to one significant figure (based on an order of magnitude). The values are based on a comparable endpoint (complete carcinogenesis after repeated

exposure to mouse skin). The quality of the data does not support any greater precision. The orders of potential potency used in this health risk assessment are presented in Table 3-10 and are those proposed for use by USEPA Region I (USEPA, 1994f).

USEPA has determined that the CSF for benzo(a)pyrene is 7.3 $(mg/kg/day)^{-1}$ and that no acceptable inhalation unit risk factor exists for this compound. Therefore, the guidance is applicable only to oral exposure. There is "no basis for judgment that benzo(a)pyrene or other PAHs will be equipotent by oral and inhalation routes" (USEPA, 1993b). The effects of particulates and cocarcinogens on benzo(a)pyrene effects in the lungs have not been addressed, thereby preventing establishment of an inhalation potency for benzo(a)pyrene and relative potencies for other PAHs.

3.4.2.2 Noncarcinogenic Effects

For noncarcinogens, it is assumed that there exists a dose below which no adverse health effects will be seen. Below this "threshold" dose, exposure to a chemical can be tolerated without adverse effects. For noncarcinogens, a range of exposure exists that can be tolerated. Toxic effects are manifested only when physiologic protective mechanisms are overcome by exposures to a chemical above its threshold level. Maternal and developmental endpoints are considered systemic toxicity.

The potential for noncarcinogenic health effects resulting from exposure to chemicals is assessed by comparing an exposure estimate (intake or dose) to a Reference Dose (RfD). The RfD is expressed in units of mg/kg/day and represents a daily intake of contaminant per kilogram of body weight that is not sufficient to cause the threshold effect of concern. An RfD is specific to the chemical, the route of exposure, and the duration over which the exposure occurs. Separate RfDs are presented for ingestion and inhalation pathways. In particular, Reference Concentrations (RfCs) in units of mg/m^3 are typically presented for the inhalation pathway. Because characterization of noncarcinogenic effects requires an estimate of dose in units of mg/kg/day, the inhalation RfC must be converted to an inhalation RfD. The conversion is performed by assuming that humans weigh 70 kg and inhale 20 m^3 of air per day [i.e., the inhalation RfC (mg/m^3) is multiplied by 20 m^3/day and divided by 70 kg to yield an inhalation RfD (mg/kg/day)].

To derive an RfD, USEPA reviews all relevant human and animal studies for each compound and selects the study (studies) pertinent to the derivation of the specific RfD. Each study is evaluated to determine the no-observed-adverse-effect-level (NOAEL) or, if the data are inadequate for such a determination, the lowest-observed-adverse-effect-level (LOAEL). The NOAEL corresponds to the dose (in mg/kg/day) that can be administered over a lifetime without inducing observable adverse effects. The LOAEL corresponds to the lowest daily dose that induces an observable adverse effect. The toxic effect characterized by the

LOAEL is referred to as the "critical effect." To derive an RfD, the NOAEL (or LOAEL) is divided by uncertainty factors to ensure that the RfD will be protective of human health. Uncertainty factors are applied to account for extrapolation of data from laboratory animals to humans (interspecies extrapolation), variation in human sensitivity to the toxic effects of a compound (intraspecies differences), derivation of a chronic RfD based on a subchronic rather than a chronic study, or derivation of an RfD from the LOAEL rather than the NOAEL. In addition to these uncertainty factors, modifying factors between 1 and 10 may be applied to reflect additional qualitative considerations in evaluating the data. For most compounds, the modifying factor is one.

A dermal RfD is developed by multiplying oral RfD by the gastrointestinal tract absorption factor. The resulting dermal RfD, based on an absorbed dose, is used to evaluate the dermal (unabsorbed) dose calculated by the dermal exposure algorithms.

Reference Doses for the COCs at the Lower Subase are presented in Table 3-11. The primary source of these values is the IRIS database, followed by other USEPA sources described for the carcinogens. This table also includes the primary target organs affected by a particular chemical. This information may be used in the Risk Characterization section to segregate risks by target organ effects, unless the total Hazard Index is below unity.

3.4.2.3 Toxicity Summaries for Major Chemicals of Concern

This section contains brief summaries of the toxicological profiles for the major COCs. The detailed profiles are contained in Appendix I.4.

PAHs. Benzo(a)pyrene is the most widely studied chemical in this class. It is used as the basis for defining the toxicity of other potentially carcinogenic PAHs. Benzo(a)pyrene is widely distributed in the tissues of treated rats and mice but is primarily found in tissues high in fat. While the carcinogenicity of complex mixtures containing PAHs (such as coal tar, coke oven emissions, and cigarette smoke) is suggested, the carcinogenicity cannot be attributed solely to PAHs. The carcinogenicity of benzo(a)pyrene is based largely on the results of animal studies in which the animals were exposed to large doses of purified compound via atypical routes of exposure.

The noncarcinogenic PAHs appear to affect the liver, kidneys, and blood of exposed laboratory animals. Considered exposure routes include ingestion and inhalation, and exposure has resulted in anemia and mild liver lesions and occasionally renal disease. The effects vary for the individual compounds.

Arsenic. Organic and inorganic arsenic compounds are almost completely absorbed upon ingestion. Arsenic is distributed to the liver, kidneys, and lungs, then redistributed to the hair, nails, teeth, bone, and skin. Acute oral exposure to arsenic causes liver swelling, skin lesions, and neurological effects. The only noncarcinogenic effects clearly attributable to chronic oral exposure are dermal hyperpigmentation and keratosis. Inhalation of arsenic causes lung cancer, and USEPA has classified arsenic as a Class A carcinogen via this route of exposure. Oral exposure to high concentrations in water is associated with an increased risk of skin cancer, which is not generally lethal.

Beryllium. Beryllium is poorly absorbed from the gastrointestinal tract and therefore has low toxicity upon oral exposure. Occupational exposure has resulted in dermatitis and berylliosis (acute pulmonary granulomatosis). Inhalation exposure and intratracheal instillation have caused lung tumors in rats and monkeys, and therefore USEPA classifies beryllium as a B2 carcinogen. The oral studies have yielded inconclusive results.

Lead. Lead is efficiently absorbed by children. The fate of lead in the body depends in part on the amount and rate of previous exposures, the age of the receptor, and the rate of exposure. The principal effects of acute oral exposure are colic, anemia, and, in severe cases, acute encephalopathy (particularly in children). Long-term exposure may result in neurological and hematological effects. Some of the effects on the blood and subtle neurobehavioral changes in children occur at levels so low as to be considered nonthreshold effects. Rat and mouse studies have shown increases in renal tumors, but the human studies have yielded inconclusive results that failed to account for the presence of other potentially carcinogenic materials. USEPA has classified lead as a B2 carcinogen based on the results of animal studies.

Manganese. Manganese is considered to be an essential human nutrient, but exposure to high concentrations can cause lethargy and other neurological effects. Inhalation of manganese results in respiratory symptoms and psychomotor disturbances in occupationally exposed individuals.

3.4.3 Exposure Assessment

The exposure assessment defines and evaluates the exposures experienced by a receptor population. In order to have an exposure, several factors must be present: first, there must be a source of contamination; second, there must be a mechanism through which a receptor can come into contact with the contaminants in that medium; and third, there must actually (or potentially) be a receptor present at the point of contact.

The exposure assessment presented in this section of the report consists of several sections that characterize the physical site setting and the receptors of concern, identify the potential contaminant migration and exposure pathways, define the contaminant concentrations at the point of exposure, and present the equations used to quantify exposure in terms of contaminant intake (dose). Appendix I.3 of this report contains sample calculations for the exposure assessment. Tables of intakes are not presented in the body of the report, but the calculated values may be seen within the site-specific spreadsheets in Appendices I.5 through I.12.

3.4.3.1 Exposure Setting

This section contains information on the land use and receptor characteristics in the area surrounding the Lower Subase and Thames River.

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

The Lower Subase is bordered on the west by the Thames River and on the east by the Providence and Worcester Railroad. A quay wall runs along the Thames River for the entire length of the NSB-NLON. The Lower Subase contains piers and berths for submarine docking, as well as facilities for submarine maintenance, repair, and overhaul. The Lower Subase is used strictly for industrial purposes.

For the purposes of this report, the Lower Subase extends to and includes Pier 2 to the south and Pier 33 to the north. Building 175, located just north of Pier 33, is included within the Lower Subase. The Lower Subase is a secure, access-restricted portion of NSB-NLON.

Exposed Populations. NSB-NLON is considered to lie within the boundaries of Groton and Ledyard, which contained a total population of 45,144 in the 1990 census (Atlantic, 1992). Adjacent communities to the base include Northwest (located east of Route 12; population 5,520 in 1980), Pleasant Valley (located south of the base; population 4,374 in 1980), and the base itself (population 4,099 in 1980). The community of Gales Ferry in Ledyard borders the base on the north (population 7,802 in 1988). A detailed assessment of the types of activities that currently occur and those that are planned was presented in Appendix E of the Phase I RI Report (Atlantic, 1992).

3.4.3.2 Conceptual Site Model

This section discusses the general conceptual site model for the Lower Subase and Thames River. A conceptual site model facilitates consistent and comprehensive evaluation of the risks to human and ecological health by creating a framework for identifying the paths by which human health may be impacted by contaminants predicted to exist at the source areas. A conceptual site model depicts the relationships between the elements necessary to construct a complete exposure pathway, as follows:

- Sources and potential COCs
- Contaminant release mechanisms
- Contaminant transport pathways
- Exposure mechanisms and exposure routes
- Receptors

Two simple conceptual site models were developed for all source areas to provide the basis for identifying the potential risks to human health and the environment. One model was developed for sites at which the source is at the ground surface (Figure 3-3), and the second model considers sites at which the wastes were initially emplaced (either intentionally or unintentionally) in the subsurface (Figure 3-4). These models consider the current operating conditions of the facilities and the actual or potential receptors who could come into contact with the COCs.

The conceptual site models first consider the sources assumed to be available, either currently or in the future. At these sites, the sources are the wastes disposed at these facilities or the contaminated soil resulting from on-site activities. Contaminants may be released from these sources by mechanisms such as wind or water erosion or leaching to the subsurface. Once released from the source, contaminants are transported in media such as air, surface water, or groundwater. Receptors may be exposed either directly or indirectly to contaminants in these media via a variety of mechanisms. The exposure mechanisms considered include routine domestic activities, working outdoors, etc. These exposure mechanisms generally act along one or more exposure routes such as ingestion, inhalation, or direct dermal contact.

The conceptual site models also indicate those exposure routes that are carried through the quantitative risk assessment for each receptor. An objective of the development of the conceptual site model is to focus attention on those pathways that contribute the most to the potential impacts on human health and the environment and to provide the rationale for screening out other exposure pathways that are minor components of the overall risk.

Sources of Contamination. Each site within the Lower Subase has its own source of contamination. The following sites are considered to have potential sources:

- **Zone 1** (Site 10 - Fuel Storage Tanks and Tank 54-H; Site 11 - Power Plant Oil Tanks; and Building 89 UST) - Various USTs (some of which are still in use and some of which have been removed) containing diesel fuel, No. 2 and No. 6 fuel oils, waste oils, and lubricating and hydraulic oils.

- **Zone 2** - Buildings with various uses (mainly used for administrative purposes), carpenter's shop, and sanitary sewer pump station/emergency generator.

- **Zone 3** [Site 17 - Hazardous Materials/Solvent Storage Area (Building 31)] - Former battery service shop and current hazardous/flammable materials warehouse.

- **Zone 4** [Site 13 - Building 79 Waste Oil Pit; Site 19 - Solvent Storage Area (Building 316)]; and Quay Wall) - Former diesel train engine servicing area, solvent storage building (currently used as such), and storm sewer outfall near Pier 4.

- **Zone 5** (Site 22 - Pier 33 and Building 175) Building formerly used to store above-ground battery acid storage tanks (containing sulfuric acid) and diesel fuel USTs.

- **Zone 6** [Site 24 - Central Paint Accumulation Area (Building 174)] - Primary paint storage facility, which also houses boat sandblasting and paint activities.

- **Zone 7** (Site 21 - Berth 16; Site 25 - Classified Materials Incinerator; and Transformers at Building 157 Vault 31) - Buildings with various current and historical uses (from instructional to maintenance use), diesel fuel UST, septic tank and leaching field, incinerator, and former PCB transformer storage area.

Also included in the study area investigation is the fuel oil distribution lines and steam, condensate, and electrical ducts associated with each zone.

The Thames River, which is considered the final site under investigation in this RI Report, receives both surface and subsurface discharges from all of the zones within the Lower Subase. The Thames River is considered to be a unique site since it is not an actual source of contamination.

Ultimately, the aforementioned sources have the potential to release chemicals to the surface and/or subsurface soil. This soil then serves as a secondary source of contamination.

Contaminant Release and Migration Mechanisms. Chemicals may be released from the sites by a variety of mechanisms including stormwater runoff and subsequent erosion of surface soil, infiltration of soluble chemicals and subsequent migration through the subsurface soil to the water table where the chemicals may migrate downgradient, and via wind erosion of surface soil from unpaved areas.

Storms generate runoff, which is directed toward stormwater drainageways. Initially, this water may move across a site as sheet flow, which can entrain loose soil material. This soil is moved from the site as a sediment and will be deposited where the flow velocity diminishes below that needed to carry a particular grain size. Typically at sites in undeveloped areas, this soil/sediment is deposited in small drainageways and migrates farther downstream with each new storm, which also adds new material.

Soluble chemicals released to the ground surface may also migrate downward through the soil column with infiltrating precipitation. The migration of these chemicals may be somewhat impeded by the chemical's tendency to bind to soil organic material. Eventually, these soluble chemicals may reach the water table. Once in the groundwater, chemicals may continue to migrate via dispersion and advection in the downgradient direction. Eventually, these chemicals may discharge with the groundwater to the Thames River.

Chemicals adsorbed to surface soil may also be released from a site via wind erosion of loose soil material. These particulates are carried downwind and potentially off site if the grain size is small enough and the wind velocity is great enough. Additionally, chemicals may also be released from soil via volatilization.

3.4.3.3 Potential Routes of Exposure

A receptor can come into contact with contaminants in a variety of ways, which are generally the result of interactions between a receptor's behavior or lifestyle and an exposure medium. This assessment defines an exposure route as a stylized description of the behavior that brings a receptor into contact with a contaminated medium.

Air. This pathway is based on the scenario that a receptor is immersed in air that contains suspended particulates and volatile organic vapors originating from the source areas as part of daily living. Subsequent exposure of the receptor occurs upon inhalation of the ambient air.

Initially, a qualitative comparison of maximum detected soil concentrations and USEPA Generic SSLs for inhalation, based on intermedia transfer (from soil to air), was performed to determine if additional quantitative analysis of this potential exposure pathway was warranted. The inhalation SSLs are based

on residential land use and lifetime exposure scenarios and are therefore relatively conservative values for potential receptors under current land use conditions. Exposures to fugitive dust and volatile organic compounds released from soil (shallow soil and "all soil") were found to be insignificant based on the qualitative screening, which is summarized in the site-specific COC screening tables (Appendix I.5 through I.12). Maximum chemical detections in soil were less than the SSLs for all zones within the Lower Subase; the inhalation exposure pathway was therefore not considered for further evaluation. A discussion of the inhalation pathway, as it pertains to each of the seven zones, is provided in the site-specific exposure assessments in Sections 4.0 through 10.0.

Incidental Ingestion of Soil. Incidental ingestion could occur when soils containing COCs are transferred from hand to food or a cigarette.

Direct Contact with Soil. Receptors may come into direct contact with soil affected by the release of chemicals from the source areas. During the receptor's period of contact, the individual may be exposed via inadvertent ingestion of a small amount of soil or via dermal absorption of certain contaminants from the soil.

Direct Contact with Groundwater. It is possible that an excavation (for construction, utility maintenance, etc.) could be deep enough to come into contact with the shallow groundwater. In such an instance, workers could be exposed to the groundwater via dermal contact. Potable use of groundwater was not considered to be likely to occur at the Lower Subase under current and/or future land use since the saline water quality near the Thames River would prevent groundwater from being used for this purpose.

Direct Contact with Surface Water. Receptors may also come into direct contact with surface water containing chemicals in a dissolved phase. In most cases, this exposure would be of short duration (unless swimming or water skiing are involved), and individuals may be exposed via dermal contact and/or incidental ingestion. Water skiing was considered for the Thames River.

Ingestion of Shellfish. Finally, persons could be exposed to potentially site-related contaminants when ingesting shellfish and finfish harvested from the Thames River. It was assumed that local residents consume shellfish and finfish collected in the vicinity of the site. Harvesting of shellfish is actually controlled by commercial interests that move the shellfish to depuration beds in other water bodies prior to sale and combine them with shellfish taken from other water bodies. Therefore, evaluation of shellfish under this exposure scenario is considered to be highly conservative.

3.4.3.4 Potential Receptors

Several potential receptors have been identified under both current and future land use conditions. These receptors were identified by analyzing the interaction of current land use practices and the identified sources of contamination.

Several receptor groups have been defined for this risk assessment. The original receptors identified in the Phase II RI and Lower Subase RI Work Plans (Atlantic, 1993 and B&R Environmental, 1997d) have been modified to conform to current guidance, to provide some consistency between sites, to focus the assessment on potentially meaningful exposures, and, in general, to streamline the risk assessment process. These receptors are as follows:

- Full-time employees - Adult military or civilian personnel assigned to work 40 hours per week at a particular facility.

- Construction workers - Adult civilian personnel who may be involved in a short-term, one-time construction project at a site.

- Adult recreational users - Civilian or military personnel involved in recreational activities such as water skiing (Thames River). Also includes local residents or military persons who may consume locally harvested shellfish and finfish from the Thames River.

- Future residents - Persons (adults and children) residing at a site assuming that the facility is closed and developed for residential purposes.

One or more of these receptor groups are evaluated quantitatively for each of the sites under investigation in this report. Table 3-12 contains a matrix summary of the particular combinations of receptor groups developed for the Lower Subase RI Report.

Adult recreational users only are evaluated for ingestion of finfish/shellfish. Exposure and associated risks for adult and child receptors are assumed to be similar (USEPA, 1989a and 1989c). Although child recreational users may also be exposed to finfish/shellfish, by convention, the evaluation of the child receptor is not warranted because the risks for this receptor are considered to be adequately addressed by assessing exposure for adult recreational users. Studies indicate that adult receptors typically eat more fish than children. However, overall exposure and potential risks for both receptors are expected to be comparable since differences in body weights for adults and children compensate for the differences in consumption rates.

Future adult and child resident receptors have been included in the baseline human health risk assessment at the direction of USEPA. The primary purpose for including this evaluation is to aid in future decision making and risk management activities. These receptors are not potential receptors under current land use and are included only to provide an indication of potential risks if the facility were to close and then be developed for residential use. Although enlisted and officer personnel reside at the base under current conditions, the residential scenario is not applicable for these receptors since they do not reside in the areas of investigation and they are assigned to the base for a relatively short period of time (e.g., three or so years). A future residential scenario is also considered unlikely given the critical nature of the facility with respect to support of the submarine fleet and national defense.

Two variations of each receptor are considered, as per USEPA Region I guidance. The first is identified as a central tendency exposure (CTE) receptor, which is developed using both regional guidance (USEPA, 1994f) and professional judgment regarding site-specific conditions. The second class of receptor is called the reasonable maximum exposure (RME) and was developed as per USEPA guidance (USEPA, 1989d and 1994f).

3.4.3.5 Exposure Pathways

An exposure pathway consists of four elements: a source and mechanism of release, a route of contaminant transport through an environmental medium, a contact point for a human receptor, and an exposure route at the point of contact. All four components must be present for the exposure pathway to be considered complete. This section summarizes the potentially complete exposure pathways that are quantitatively evaluated in the risk assessment and provides the rationale for those pathways that are not evaluated. Table 3-13 presents a summary of the potentially complete and incomplete exposure pathways and receptors.

3.4.3.6 Quantification of Exposure

Estimates of exposure are based on the contaminant concentrations at the exposure points and on scenario-specific assumptions and intake parameters. The models and equations used to quantify intakes are described in this section and have been obtained from a variety of USEPA guidance documents, which are cited in the specific intake estimation sections that follow.

Exposures are dependent on the predicted concentrations of chemicals in environmental media and local land use practices, and both are subject to change over time. This results in a large number of possible combinations of receptors, media, exposure pathways, and concentrations. As mentioned previously,

Table 3-13 presents a summary of the exposure pathways to be evaluated in the quantitative risk assessment. Some of these scenarios (such as occupational, trespassing, and recreational scenarios) may be applicable under both current and future land use conditions.

Exposure model parameters are presented in Tables 3-14, 3-15, and 3-16 for potential future residents, full-time employees and construction workers, and recreational users, respectively. The parameters are those presented in the Phase II RI (B&R Environmental, 1997b), which were based on parameters identified in the Phase II RI Work Plan (Atlantic, 1993). The values also reflect current USEPA guidance. All parameters are referenced in footnotes on each table. These parameters are used in the equations presented in this section, along with the exposure point concentrations presented in the site-specific sections, to calculate intakes, which will be used to determine risks. Individual chemical intakes for each receptor/exposure route combination are presented in the spreadsheets in Appendices I.5 through I.11.

Incidental Ingestion of Soil. The estimation of intake of contaminants in soil is determined using the predicted concentration of a contaminant in the location of interest. This pathway is evaluated for the construction worker, full-time employee, and child and adult residents. Age-adjusted ingestion factors are used to estimate intakes for future residents because of the higher ingestion rate experienced by small children. In general, intakes associated with soil ingestion are calculated using the following equation:

$$\text{Intake}_{si} = \frac{(C_{si})(IR)(FI)(EF)(ED)(CF)}{(BW)(AT)}$$

where:

Intake_{si}	=	intake of contaminant "i" from soil (mg/kg/day)
C_{si}	=	concentration of contaminant "i" in soil (mg/kg)
IR	=	ingestion rate (mg/day)
FI	=	fraction ingested from contaminated source (decimal fraction)
EF	=	exposure frequency (days/yr)
ED	=	exposure duration (yr)
CF	=	conversion factor (10^{-6} kg/mg)
BW	=	body weight (kg)
AT	=	averaging time (days);
		for noncarcinogens, AT=ED*365 days/yr;
		for carcinogens, AT=70 yr*365 days/yr

For adults not involved in construction activities, ingestion rates are considered to range from 50 mg/day (adults under CTE conditions) to 200 mg/day (potential future child residents for the RME). Ingestion rates of 480 mg/day (RME) (USEPA, , 1991a) and 240 mg/day (CTE) are considered for construction

personnel. Exposure frequencies range from 80 days per year for the CTE construction worker to 250 days per year for the RME full-time employee. Values of 1.0 for the RME and 0.5 for the CTE are used for the fraction of soil from the contaminated source ingested by a potential receptor.

Dermal Contact with Soil. The estimation of intake of a contaminant in soil via absorption through the skin is determined using the predicted concentration in the soil at the location of concern. Evaluation of the dermal absorption pathway is performed for the construction worker, full-time employee and child and adult residents. As with soil ingestion, age-adjusted contact rates are employed for potential future residents. Dermal absorption from potentially contaminated areas is calculated using the following equation:

$$Intake_{si} = \frac{(C_{si})(SA)(AF)(ABS)(Fd)(CF)(EF)(ED)}{(BW)(AT)}$$

where:

$Intake_{si}$	=	amount of chemical "i" absorbed during contact with soil (mg/kg/day)
C_{si}	=	concentration of chemical "i" in soil (mg/kg)
SA	=	skin surface area available for contact (cm^2/day)
AF	=	skin adherence factor (mg/cm^2)
ABS	=	absorption factor (decimal fraction)
Fd	=	Fraction available for contact from contaminated source (decimal fraction)
CF	=	conversion factor (10^{-6} kg/mg)
EF	=	exposure frequency (days/yr)
ED	=	exposure duration (yr)
BW	=	body weight (kg)
AT	=	averaging time (days); for noncarcinogens, AT=ED*365 days/yr; for carcinogens, AT=70 yr*365 days/yr

Dermal contact with soil by potential receptors is assumed to occur at the same exposure frequency as soil ingestion. Exposed surface areas of 19 percent of the total body surface area (to account for forearms, head, and hands) for the adults and 30 percent of the total body surface area (to account for forearms, head, hands, and feet) for the children were selected based on default clothing scenarios expressed in the USEPA dermal exposure guidance (USEPA, January 1992b). Soil adherence factors were selected from the published range of 0.2 to 1.0 mg/cm^2 (USEPA, January 1992b). Values of 1.0 (RME) and 0.5 (CTE) were used for the fraction of soil available for contact from the contaminated source. Dermal absorption factors are provided in Table 3-17 (USEPA Region I, 1998).

Dermal exposures to COCs in soil were evaluated following methodology supplied by EPA Region I. COCs with chemical-specific absorption factors in Table 3-17 were quantitatively evaluated in the human health risk assessment. For those COCs without chemical-specific dermal absorption factors, dermal exposures were evaluated using a generic absorption factor of 0.1 for organics and 0.01 for inorganics and the results were discussed in the uncertainty section. In general, PAHs and metals, which were detected frequently in the soil samples and selected as COCs, tend to strongly adhere to organic matter in soil. For these chemicals to be percutaneously absorbed, they must first desorb from soil and diffuse through the skin. Various factors affect the rate of dermal absorption, including the amount of soil on the skin surface, soil characteristics (moisture, pH, organic carbon content, etc.), skin characteristics (thickness, temperature, hydration, etc.), volatilization losses, and chemical-specific properties.

Dermal Contact with Groundwater/Surface Water. Because the groundwater at the Lower Subase and surface water in the Thames River are not used for potable supplies, only limited exposure scenarios are considered under current site conditions. It is possible under future land use conditions that deep excavations at the Lower Subase for activities such as utility maintenance and construction could result in a dermal exposure to the shallow groundwater (that is contained in the overburden). Dermal contact with surface waters may also occur while receptors are involved in certain activities, such as water skiing in the Thames River.

The following equation will be used to assess exposures resulting from dermal contact with water (USEPA, 1992b):

$$DAD_{wi} = \frac{(DA_{event})(EV)(ED)(EF)(A)}{(BW)(AT)}$$

where:

DAD_{wi}	=	dermally absorbed dose of chemical "i" from water (mg/kg/day)
DA_{event}	=	absorbed dose per event (mg/cm^2-event)
EV	=	event frequency (events/day)
ED	=	exposure duration (yr)
EF	=	exposure frequency (days/yr)
A	=	skin surface area available for contact (cm^2)
BW	=	body weight (kg)
AT	=	averaging time (days);
		for noncarcinogens, AT=ED*365 days/yr;
		for carcinogens, AT=70yr*365 days/yr

The absorbed dose per event (DA_{event}) is estimated using a nonsteady-state approach for organic compounds and a more traditional steady-state approach for inorganics. For organics, the following equations apply:

$$\text{If } t_{event} < t^*, \text{ then: } DA_{event} = (2\ K_p)\ (C_{wi})\ (CF) \left(\frac{\sqrt{6\ \tau\ t_{event}}}{\pi} \right)$$

$$\text{If } t_{event} > t^*, \text{ then: } DA_{event} = (K_p)(C_{wi})(CF)\left(\frac{t_{event}}{1 + B} + 2\ \tau \left(\frac{1 + 3\ B}{1 + B} \right) \right)$$

where: t_{event}	=	duration of event (hr/event)
t^*	=	time it takes to reach steady-state conditions (hr)
K_p	=	permeability coefficient from water through skin (cm/hr)
C_{wi}	=	concentration of chemical "i" in water (mg/L)
τ	=	lag time (hr)
π	=	constant (unitless; equal to 3.141592654)
CF	=	conversion factor (10^{-3} L/cm^3)
B	=	partitioning constant derived by Bunge Model (dimensionless)

Values for the chemical-specific parameters (t_{event}, t^*, K_p, τ, and B) were obtained from the current dermal guidance. If no published values were available for a particular organic compound, they were calculated using equations provided in the cited guidance. Details regarding the procedures used to derive the constants, as well as sample calculations, are provided in Appendix I.3.

The following nonsteady-state equation is used to estimate DA_{event} for inorganics:

$$DA_{event} = (K_p)\ (C_{wi})\ (t_{event})$$

In general, the recommended default value of 0.001 was used for inorganic constituents.

Groundwater exposure times for adult construction workers are 8 hours per day for 120 days per year for the RME and 80 days per year for the CTE. The exposure duration for this receptor was set at 1 year. Construction workers exposed to groundwater are assumed to be exposed only on their forearms and hands, for a total area of 3,800 cm^2. Receptors involved in recreational activities (water skiing) are assumed to experience whole body exposure, for a total surface area of 20,000 cm^2 for adults. Water skiing exposure frequencies for the adult receptor were set at 16 days per year (RME) and 8 days per year (CTE).

Incidental Ingestion of Surface Water. Direct contact with surface waters while water skiing could result in the inadvertent ingestion of small amounts of water. Exposure is evaluated using the following equation (USEPA, 1989d):

$$Intake_{wi} = \frac{(C_{wi})(CR)(ET)(EF)(ED)}{(BW)(AT)}$$

where: $Intake_{wi}$ = intake of chemical "i" from water (mg/kg/day)
C_{wi} = concentration of chemical "i" in surface water (mg/L)
CR = contact rate (L/hr)
ET = exposure time (hr/day)
EF = exposure frequency (days/yr)
ED = exposure duration (yr)
BW = body weight (kg)
AT = averaging time (days);
for noncarcinogens, AT=ED*365 days/yr;
for carcinogens, AT=70 yr*365 days/yr

Exposure times, frequencies, and durations are the same as described above for dermal contact with surface water. The contact rate for adult recreational users exposed to surface water was set at 0.05 liters per hour (USEPA, 1989b).

Ingestion of Shellfish/Finfish. Indirect chemical exposure may also occur via the ingestion of shellfish or finfish harvested from the Thames River. It is possible, though unlikely, that local residents could be exposed to shellfish from this area. However, all harvesting is supposedly controlled by commercial concerns that remove the shellfish to off-site depuration beds, where they are combined with shellfish from other areas prior to sale. The following model will be used to assess potential exposures resulting from ingestion of shellfish and finfish from the Thames River (USEPA, 1989d):

$$Intake_{fi} = (C_{fi})(IR)(EF)(ED) \ / \ (BW)(AT)$$

where: $Intake_{fi}$ = intake of chemical "i" from shellfish/finfish (mg/kg/day)
C_{fi} = concentration of chemical "i" in shellfish/finfish (mg/kg)
IR = ingestion rate (kg/day)
EF = exposure frequency (days/yr)

ED	=	exposure duration (yr)
BW	=	body weight (kg)
AT	=	averaging time (days);
		for noncarcinogens, AT=ED*365 days/yr;
		for carcinogens, AT=70 yr*365 days/yr

The following ingestion rates were used:

- For shellfish, 0.055 killogram per day for the RME and 0.003 killogram per day for the CTE
- For finfish, 0.054 killogram per day for the RME and 0.0095 killogram per day for the CTE

Actual shellfish concentrations were available for oysters and clams, which are the only two species of potential commercial interest in the river. Finfish tissue concentrations were estimated using surface water data and chemical-specific bioconcentration factors. Receptors are assumed to be exposed for 350 days per year for the RME and 234 days per year for the CTE.

3.4.3.7 Exposure to Lead

The equations and methodology presented in the previous section cannot be used to evaluate exposure to lead because of the absence of published does-response parameters for this chemical. Exposure to lead was added using the USEPA Integrated Exposure Uptake Biokinetic (IEUBK) Model for lead, version 0.99D (USEPA, 1994c). This model is designed to estimate blood levels of lead in children (under 7 years of age) based on either default or site-specific input values for air, drinking water, diet, dust, and soil exposure. Exposures to lead by nonresidential adults are evaluated by use of a slope-factor approach developed by the USEPA Technical Review Workgroup for Lead (USEPA, 1996f and 1996g). The approach focuses on estimating fetal blood lead concentrations in women exposed to lead contaminated soils.

Studies indicate that infants and young children are extremely susceptible to adverse effects from exposure to lead. Considerable behavioral and developmental impairments have been noted in children with elevated blood lead levels. The threshold for toxic effects to children from this chemical is believed to be in the range of 10 µg/dL to 15 µg/dL. Blood lead levels greater than 10 µg/dL are considered to be a "concern."

In general, the IEUBK Model and Technical Review Work Group Model for lead were used to address exposure to lead when groundwater and surface water concentrations exceed the 15 µg/L Federal Action Level promulgated under the Safe Drinking Water Act and when detected soil concentrations exceeded

the OSWER soil screening level of 400 mg/kg for residential land use (USEPA, 1994e). Exposure concentrations, as well as default parameters for some input parameters, were used in the evaluation. Exposures to lead are discussed in the site-specific sections (Sections 4.0 through 11.0). The input parameters used and the results of lead models, estimated blood lead levels, and probability density histograms are presented in the site-specific appendices (I.5 through I.12).

An analysis was conducted to determine the optimal sample size for lead and presented in Appendix F of the Final Lower Subase RI Work Plan (September, 1997). A copy of this analysis are included in Appendix I.13. Standard formulas presented in EPA's DQO guidance [EPA QA / G-4 (Guidance for the Data Quality Objective Process); September 1994] as well as EPA's *Methods for Evaluating the Attainment of Cleanup Standards: Volume 1: Soils and Solid Media* [EPA 230/02-89-042 (1989)] were used to determine the number of samples that were sufficient to meet the limits based on specified decision errors and the DQO constraints for comparing a mean against a regulatory threshold. The results of the analysis indicated that there were sufficient soil samples for lead for Zones 1, 2, and 5 and that additional sampling at Zones 3, 4, and 7 may be required. No data was available for Zone 6; therefore, no conclusions could be made in regards to the number of samples required for Zone 6.

A summary of the preliminary lead analytical results from the Lower Subase RI was submitted to the EPA for review and comment on October 27, 1997. The EPA provided written comments on the data package on November 12, 1997. Subsequent discussions with EPA Region I during a conference call on November 19, 1997 indicated that the sample set for each zone was adequate and no further sampling was required.

Removal of "hot spots" from the zone-specific data sets were also discussed with EPA during the conference call. Data sets which are skewed because of one high outlier may require an extremely large number of samples if the formal DQO process is followed to determine the sample size. Removal of "hot spots" from the data set can be used to show that the remaining samples provide an adequate mean and sample size. This approach is also appropriate to evaluate future risks to human receptors after a remedial action such as "hot spot" removal is completed. This approach was not used in the human health risk assessment. For the Baseline Risk Assessment all lead data was used to determine risks. This approach resulted in the development of conservative risks for each zone. An evaluation of risks for future scenarios (i.e., with "hot spots" removed) will be included in the Feasibility Study for the Lower Subase.

3.4.4 Risk Characterization

This section provides a characterization of the potential human health risks associated with the potential exposure to COCs at the Lower Subase and Thames River. Section 3.4.4.1 outlines the methods used to estimate the type and magnitude of health risks, and site-specific sections in Chapters 4.0 through 11.0 present the results for the current and potential future land use conditions for the individual sites. Section 3.4.5 contains a discussion of the uncertainties associated with all aspects of the process.

3.4.4.1 Risk Characterization Methodology

Potential human health risks resulting from exposure to COCs are estimated using algorithms established by USEPA. The methods described by USEPA are protective of human health and are likely to overestimate (rather than underestimate) risk. The methodology uses specific algorithms to calculate risk as a function of chemical concentration, human exposure parameters, and toxicity.

Risks from hazardous chemicals are calculated for either carcinogenic or noncarcinogenic effects. Some carcinogenic chemicals may also exhibit noncarcinogenic effects. Potential impacts are then characterized for both types of health effects.

Chemical Carcinogens. Risks attributable to exposure to chemical carcinogens are estimated as the probability of an individual developing cancer over a lifetime as a result of exposure to a potential carcinogen. At low doses, the incremental lifetime cancer risk (ILCR) is determined as follows (USEPA, 1989d):

$$ILCR_i = (Intake_i)(CSF_i)$$

where: $ILCR_i$ = Incremental Lifetime Cancer Risk for chemical "i", expressed as a unitless probability

$Intake_i$ = Intake of chemical "i" (mg/kg/day)

CSF_i = Cancer Slope Factor of chemical "i" $(mg/kg/day)^{-1}$

Risks below 1E-6 (or a risk less than 1 in 1 million) are generally considered to be acceptable by USEPA, and risks greater than 1E-4 (1 in 10,000) are generally considered to be unacceptable by the Agency.

When carcinogenic risks exceed 1E-2 using the above methodology, USEPA (USEPA, 1989d) specifies that the one-hit model be used, as follows:

$$ILCR_i = 1 - \exp[(-Intake_i)(CSF_i)]$$

Risks are estimated for all carcinogenic compounds regardless of the class designation (A, B, or C).

Noncarcinogens. The hazards associated with the effects of noncarcinogenic chemicals are evaluated by comparing an exposure level or intake to a Reference Dose (RfD). The ratio of the intake to the RfD is called the Hazard Quotient (HQ) and is defined as follows (USEPA, 1989d):

$$HQ_i = \frac{Intake_i}{RfD_i}$$

where: HQ_i = Hazard Quotient for chemical "i" (unitless)
$Intake_i$ = Intake of chemical "i" (mg/kg/day)
RfD_i = Reference Dose of chemical "i" (mg/kg/day)

If the ratio of the intake to the RfD exceeds unity, there exists a potential for noncarcinogenic (toxic) effects to occur. A Hazard Index (HI) is generated by summing the individual HQs for all the COCs. If the value of the HI exceeds unity, there is a potential for noncarcinogenic health effects associated with that particular chemical mixture, and therefore it is necessary to segregate the HQs by target organ effects. The HQ should not be construed as a probability in the manner of the ILCR but rather a numerical indicator of the extent to which a predicted intake exceeds or is less than an RfD.

3.4.5 Uncertainties Analysis

There is uncertainty associated with all aspects of the baseline human health risk assessment presented in the preceding sections. This section will present a summary of these uncertainties, with a discussion of how they may affect the final risk numbers discussed in Sections 4.0 through 11.0.

There is uncertainty associated with all steps of the risk assessment process. Uncertainty in the selection of COCs is associated with the current status of the predictive databases and the procedures used to include or exclude constituents as chemicals of concern. Uncertainty associated with the exposure assessment includes the values used as input variables for a given intake route, the methods used and the assumptions made to determine exposure point concentrations, and the predictions regarding future land use and population characteristics. Uncertainty in the toxicity assessment includes the quality of the existing data to support dose-response relationships and the weight-of-evidence used for determining the carcinogenicity of chemicals of concern. Uncertainty in risk characterization includes that associated with

exposure to multiple chemicals and the cumulative uncertainty from combining conservative assumptions made in earlier activities.

While there are various sources of uncertainty, as described above, the direction of uncertainty can be influenced by the assumptions made throughout the risk assessment, including selection of COCs and selection of values for dose-response relationships. Throughout the entire risk assessment, assumptions were made so that the final calculated risks would be overestimated because of the safety factors built into the assumptions. Thus, the resultant uncertainty in the numerical risk assessments is in how much lower the actual risks are.

Generally, risk assessments carry two types of uncertainty, measurement and informational uncertainty. Measurement uncertainty refers to the usual variance that accompanies scientific measurements. For example, this type of uncertainty is associated with analytical data collected for each site. The risk assessment reflects the accumulated variances of the individual values used.

Informational uncertainty stems from inadequate availability of information needed to complete the toxicity and exposure assessments. Often, this gap is significant, such as the absence of information on the effects of human exposure to low doses of a chemical, the biological mechanism of action of a chemical, or the behavior of a chemical in soil.

Once the risk assessment is complete, the results must be reviewed and evaluated to identify the type and magnitude of uncertainty involved. Reliance on results from a risk assessment without consideration of uncertainties, limitations, and assumptions inherent in the process can be misleading. For example, to account for uncertainties in the development of exposure assumptions, conservative estimates must be made to ensure that the particular assumptions made are protective of sensitive subpopulations or the maximum exposed individuals. If a number of conservative assumptions are combined in an exposure model, the resulting calculations can propagate the uncertainties associated with those assumptions, thereby producing a much larger uncertainty for the final results. This uncertainty is biased toward overpredicting both carcinogenic and noncarcinogenic risks. Thus, both the results of the risk assessment and the uncertainties associated with those results must be considered when making risk management decisions.

This interpretation is especially relevant when the risks exceed the point-of-departure for defining "acceptable" risk. For example, when risks calculated using a high degree of uncertainty are below an "acceptable" risk level (i.e., 1E-6), the interpretation of no significant risk is straightforward. However, when risks calculated using a high degree of uncertainty are above an "acceptable" risk level (i.e., 1E-4), a conclusion can be difficult unless uncertainty is considered.

Recent USEPA guidance on risk assessment (USEPA, 1992c and 1994f) requires risk assessors to use exposure and toxicity assumptions from the "high end" and the "central tendency" of their distributions. These values correspond to the RME and CTE scenarios.

3.4.5.1 Uncertainty in Selection of Chemicals of Concern

There is a minor amount of uncertainty associated with the final risk values based on the selection of COCs to be used in the quantitative risk assessment. However, the use of predetermined USEPA Region III screening values based on conservative land use scenarios (i.e., residential land use for soil and ingestion/inhalation for groundwater/surface water) in combination with the reduction of the values for carcinogens to correspond to a 1E-6 cancer risk should ensure that the most significant contributors to risk from a site are evaluated. The elimination of chemicals that are present at concentrations that correspond to a less than a 1E-6 cancer risk and less than a 0.1 HI should not affect the final conclusions regarding contaminants that could cause a potential health concern. In addition, other health-based and state risk-based criteria were used to conservatively select COCs.

3.4.5.2 Uncertainty in the Exposure Assessment

Uncertainty in the exposure assessment arises for the methods used to calculate exposure point concentrations, determination of land use conditions, the selection of receptors, and the selection of exposure parameters. Each of these is discussed below.

Determination of Land Use. The current land use patterns were well established by Atlantic Environmental Services during the Phase I and Phase II RI. Detailed interviews with base personnel were used to establish the potentially exposed populations and the activities that could bring them into contact with contaminated media. In addition, planned construction projects were identified.

One issue associated with land use that contains a high degree of uncertainty is the potential conversion of the base (particularly the sites under consideration in the RI) to residential uses at some time in the future. This scenario is considered to be highly unlikely given the dispersed population patterns currently surrounding the base and the heavily industrialized nature of the facility at the current time. These factors, in addition to the critical nature of the facility with respect to support for the submarine fleet, make a future industrial land use scenario much more likely, at least for the foreseeable future.

Calculation of Exposure Point Concentrations. For media at some zones, fewer than ten samples were available. This makes the estimation of the upper 95 percent confidence limit on the mean highly

uncertain and, therefore, the average and maximum detected chemical concentrations were used to assess risks. As a result, the estimations of risk for the RME, where maxima were used as exposure concentrations, are most likely to be overstated because it is unlikely that potential receptors would be exposed to the maximum concentration over the entire exposure period.

For some sites, the risk evaluation focused on one or more smaller areas of concern. These boundaries are somewhat artificial and originated as investigations of something perhaps like a tank or are simply gross geographical boundaries. Exposures may or may not occur in these particular areas, and therefore risks could be under- or overestimated.

Exposure Routes and Receptor Identification. Based on the work performed by Atlantic Environmental Services, exposure routes and receptor groups were fairly well defined. In this report, an attempt was made to simplify the various groups identified and to determine a single set of exposure parameters to apply to each group. This may either under- or over-estimate the risks, with the final result dependent on how well the receptors were defined.

Selection of Exposure Parameters. Each exposure factor selected for use in this risk assessment has some associated uncertainty. Generally, exposure factors are based on surveys of physiological and lifestyle profiles across the United States. The attributes and activities studied in these surveys generally have a broad distribution. To avoid underestimation of exposure, USEPA guidelines on the RME receptor were used that generally consist of the 95th percentile for most parameters. Therefore, the selected values for the RME receptor represent the upper bound of the observed or expected habits of the majority of the population.

Generally, the uncertainty can be assessed quantitatively for a number of assumptions made in determining factors for calculating exposures and intakes. Many of these parameters were determined from statistical analyses on human population characteristics. Often the database used to summarize a particular exposure parameter (i.e., body weight) is quite large. Consequently, the values chosen for such variables in the RME scenario have low uncertainty. For many parameters for which limited information exists (i.e., dermal absorption of organic chemicals from soil), there is greater uncertainty. However, there are often sufficient data to estimate these parameters with low uncertainty.

Many of the quantities used to calculate exposures and risks in this report are selected from a distribution of possible values. For the RME scenario, the value representing the 95th percentile is generally selected for each parameter to ensure that the assessment bounds the actual risks from a postulated exposure. This risk number is used in risk management decisions but does not indicate what a more average or typical exposure might be or what risk range might be expected for individuals in the exposed population.

To address these issues, USEPA has suggested the use of the CTE receptor, whose intake variables are set at approximately the 50th percentile of the distribution. The risks for this receptor seek to incorporate the range of uncertainty associated with various intake assumptions. Many of the parameters were estimated using professional judgment, although USEPA Region I provides some default parameters (USEPA, 1994f).

An additional source of uncertainty associated with the exposure assessment of the baseline human health risk assessment is the presence of the hospital at the base, which is located near Tautog Avenue. Sick or ailing individuals represent a subpopulation of potential concern since they may experience an increased risk because of increased sensitivity to chemical exposure. The sites under investigation in this RI Report are not near the hospital. Therefore, the degree of uncertainty associated with this aspect of the exposure analysis is not expected to be great.

3.4.5.3 Uncertainty in the Toxicological Evaluation

Uncertainty associated with the toxicity assessment is associated with hazard assessment and dose-response evaluations for the chemicals of concern. The hazard assessment deals with characterizing the nature and strength of the evidence of causation, or the likelihood that a chemical that induces adverse effects in animals will also induce adverse effects in humans. Hazard assessment of carcinogenicity is evaluated as a weight-of-evidence determination, using USEPA methods. Positive animal cancer test data suggest that humans contain tissue(s) that may also manifest a carcinogenic response; however, the animal data cannot necessarily be used to predict the target tissue in humans. In the hazard assessment of noncancer effects, however, positive animal data suggest the nature of the effects (i.e., the target tissues and type of effects) anticipated in humans.

Uncertainty in hazard assessment arises from the nature and quality of the animal and human data. Uncertainty is reduced when similar effects are observed across species, strain, sex, and exposure route; when the magnitude of the response is clearly dose-related; when pharmacokinetic data indicate a similar fate in humans and animals; when postulated mechanisms of toxicity are similar for humans and animals; and when the chemical of concern is structurally similar to other chemicals for which the toxicity is more completely characterized.

Uncertainty in the dose-response evaluation includes the determination of a slope factor for the carcinogenic assessment and derivation of an RfD or Reference Concentration (RfC) for the noncarcinogenic assessment. Uncertainty is introduced from interspecies (animal to human) extrapolation, which, in the absence of quantitative pharmacokinetic or mechanistic data, is usually based on consideration of interspecies differences in basal metabolic rate. Uncertainty also results from

intraspecies variation. Most toxicity experiments are performed with animals that are very similar in age and genotype so that intragroup biological variation is minimal, but the human population of concern may reflect a great deal of heterogeneity, including unusual sensitivity or tolerance to the COC. Even toxicity data from human occupational exposure reflect a bias because only those individuals sufficiently healthy to attend work regularly (the "healthy worker effect") and those not unusually sensitive to the chemical are likely to be occupationally exposed. Finally, uncertainty arises from the quality of the key study from which the quantitative estimate is derived and from the database. For cancer effects, the uncertainty associated with dose-response factors is mitigated by assuming the 95 percent upper bound for the slope factor. Another source of uncertainty in carcinogenic assessment is the method by which data from high doses in animal studies are extrapolated to the dose range expected for environmentally exposed humans. The linearized multistage model, which is used in nearly all quantitative estimations of human risk from animal data, is based on a nonthreshold assumption of carcinogenesis. There is evidence to suggest, however, that epigenetic carcinogens, as well as many genotoxic carcinogens, have a threshold below which they are noncarcinogenic (William and Weisburger, 1991); therefore, the use of the linearized multistage model is conservative for chemicals that exhibit a threshold for carcinogenicity.

For noncancer effects, additional uncertainty factors may be applied in the derivation of the RfD or RfC to mitigate poor quality of the key study or gaps in the database. Additional uncertainty for noncancer effects arises from the use of an effect level in the estimation of an RfD or RfC, because this estimation is predicated on the assumption of a threshold below which adverse effects are not expected. Therefore, an uncertainty factor is usually applied to estimate a no-effect level. Additional uncertainty arises in estimation of an RfD or RfC for chronic exposure from less-than-chronic data. Unless empirical data indicate that effects do not worsen with increasing duration of exposure, an additional uncertainty factor is applied to the no-effect level in the less-than-chronic study. Uncertainty in the derivation of RfDs is mitigated by the use of uncertainty and modifying factors that normally range between 3 and 10. The resulting combination of uncertainty and modifying factors may reach 1,000 or more.

Class C carcinogens are classified as possible human carcinogens because the evidence for their carcinogenicity in animals is limited. The inclusion of these compounds in the estimation of total carcinogenic risk adds to the uncertainty of the final risk numbers by potentially overestimating the human health effects.

The derivation of dermal RfDs and CSFs from oral values may cause uncertainty. This is particularly the case when no gastrointestinal absorption rates are available in the literature or when only qualitative statements regarding absorption are available.

Uncertainty also arises in the dose-response assessment for values derived for several principal chemicals of concern by using studies with limitations. For example, Class B2 PAHs for which no toxicity data are available are evaluated using benzo(a)pyrene toxicity data with estimated orders of potential potency for the average and RME receptors. This may either underestimate or overestimate the carcinogenic risks associated with PAHs.

The carcinogenicity of arsenic via ingestion is not confirmed by the available data. However, USEPA has proposed an oral unit risk factor that was used for all oral and dermal exposures to arsenic at this site. Since arsenic is a major risk driver, the risks may be overstated.

Some uncertainty is associated with the evaluation of chromium, which was assumed to be present in its hexavalent state. Since hexavalent chromium is considered to be more toxic than the trivalent state, which is essentially more common, risks for this chemical are probably overestimated to some degree.

3.4.5.4 Uncertainty in the Risk Characterization

Uncertainty in risk characterization results primarily from assumptions made regarding additivity of effects from exposure to multiple compounds from various exposure routes. High uncertainty exists when cancer risks for several substances are summed across different exposure pathways. This assumes that each substance has a similar effect and/or mode of action. Often compounds affect different organs, have different mechanisms of action, and differ in their fate in the body, so additivity may not be an appropriate assumption. However, the assumption of additivity is made to provide a conservative estimate of risk.

Finally, the risk characterization does not consider antagonistic or synergistic effects. Little or no information is available to determine the potential for antagonism or synergism for the COCs. Therefore, this uncertainty cannot be discussed for its impact on the risk assessment, since it may either underestimate or overestimate potential human health risk.

3.5 ECOLOGICAL RISK ASSESSMENT METHODOLOGY

In addition to characterizing the nature and extent of site contamination and assessing potential risks to human health, the RI process requires an assessment of the potential adverse effects of site contamination on the environment. Specifically, ecological receptors that use the Thames River near the Lower Subase may be at risk from environmental contamination associated with NSB-NLON. Accordingly, an ecological risk assessment (ERA) was performed to characterize the potential risks from Lower Subase-related contaminants to ecological receptors.

3.5.1 Overview

This section provides an outline of the general approach that was taken to assess the impacts of site contamination on ecological receptors and the habitats that support these organisms. This assessment generally follows a two-step process:

Step 1: Preliminary Problem Formulation and Ecological Effects Evaluation (Section 3.5.3)

- Preliminary Problem Formulation - This first phase of an ERA discusses the goals, breadth, and focus of the assessment. It includes general descriptions of sites to be investigated with emphasis on the habitats and ecological receptors present. This phase also involves characterization of contaminant sources and migration pathways, evaluation of routes of contaminant exposure, and selection of analytes to be assessed. Assessment and measurement endpoints are also selected in this phase. Finally, a conceptual model is developed that describes how contaminants associated with the Thames River near the Lower Subase may come into contact with ecological receptors.

- Preliminary Ecological Effects Evaluation - In this phase, medium-specific ecological screening guidelines for each analyte (i.e., concentrations of each contaminant above which adverse effects to ecological receptors may occur) are identified. This step is undertaken concurrently with the exposure assessment described below.

Step 2: Preliminary Exposure Assessment and Risk Characterization (Section 3.5.4)

- Preliminary Exposure Estimate - This portion of the ERA includes the identification of the data used to represent concentrations of contaminants to which ecological receptors may be exposed in various media. It also includes the selection of exposure point contaminant concentrations from those data.

- Preliminary Risk Calculation - In this step, exposure point concentrations are compared to guidelines in order to characterize potential risk to ecological receptors. The ratio of the exposure point concentration to the guideline is called the hazard quotient (HQ). HQs were calculated for all analytes assessed in the ERA. When HQs exceeded 1.0, risks were considered possible and the anlaytes were retained as COCs.

When these two steps are completed, the results can be interpreted and the uncertainties associated with the ERA can be addressed. The above process, described in further detail below, represents the general ERA approach recommended in the most recent EPA guidance for performing ERAs (USEPA, 1997a), which served as the basis for the ERA methodology. Furthermore, the ERA was conducted in accordance

with other available ERA guidance documents (USEPA, 1996a; Wentsel et al., 1996) and other ERA publications (Ingersoll et al., 1997; Suter, 1993; Calabrese and Baldwin, 1993). Also, the methods used in this ERA paralleled those used in the NSB-NLON Phase II RI ERA (B&R Environmental, 1997b), where applicable.

Due to the potential complexity of ERAs, they are often conducted using a tiered approach and punctuated with Scientific/Management Decision Points (SMDPs). SMDPs are meetings involving the risk assessors, risk managers, and client to control costs, prevent unnecessary analyses, and ensure that the ERA is proceeding in an efficient, timely manner. Information analyzed in one tier is evaluated to determine whether the objectives of the study have been met and then it may be used to identify the data required for the next tier, if necessary. This ERA can be considered a "screening-level" assessment since it is based on comparing contaminant concentrations against conservative screening values. Typically, a "screening level" assessment is followed by a more detailed baseline ERA (BERA), which may encompass more detailed lab and field studies for extensive modeling. However, the basis of this "screening level" assessment was to fill in data gaps for the BERA conducted during the Phase II RI.

3.5.2 Background and Previous Ecological Investigations

Ecological data were collected from the Thames River along the Lower Subase during several previous studies. These studies include the original and supplemental investigations for the NSB-NLON Phase II RI and investigations for the SEAWOLF Homeporting Environmental Empact Statement (EIS) and Pier 17 Environmental Assessment (EA). The data collected from the later two studies were not validated and they were not evaluated quantitatively in the NSB-NLON Phase II RI. However, those data and the NSB-NLON Phase II RI data were both used to scope the additional sampling necessary for the Lower Subase RI and both were evaluated in this ERA. A brief summary of these studies is provided below.

Numerous ecological studies of the Thames River near NSB-NLON have been performed in support of the SEAWOLF Homeporting dredging project and the data were included in the SEAWOLF Class Submarine Homeporting EIS (Maguire, 1995). In 1990, sediment samples were collected in the reach of the Thames River from NSB-NLON to the mouth of the river. Several samples were collected near Piers 32 and 33 and in the river channel near the ends of several other piers. Sediment samples were analyzed for contaminants, and benthic macroinvertebrate community analysis was also performed. Several metals and organics, mainly PAHs, were detected in samples in and near the Lower Subase, but concentrations were low. Only a few detections of some metals exceeded Effects Range-Low (ER-L) sediment screening values (Long et al., 1995). The ER-L is defined as the concentration below which adverse effects are rarely observed. The results of the benthic macroinvertebrate analysis showed that abundance generally decreased from the mouth of the river to NSB-NLON, but community composition was similar. The study

suggested that these differences may be due to shallower depth, lower salinity, and increasing riverine influences in the up-river samples.

Sediment samples were also collected for the SEAWOLF Homeporting project in the Thames River in and near NSB-NLON in 1991. Several grab and core samples were collected; three of the grab samples were collected near Piers 32 and 33. In addition, toxicity testing of sediments was performed on an amphipod (*Ampelisca abdita)*, a clam (*Macoma nasuta)*, and a sandworm (*Nereis virens)*. Bioaccumulation tests for metals and PAHs with *Macoma* and *Nereis* were also performed. Slightly elevated concentrations of some metals and PAHs were detected in Pier 32 and 33 sediment samples. Several exceedances of ER-Ls were observed, along with occasional exceedances of Effects Range-Mediums (ER-Ms). Concentrations below the ER-M and above the ER-L are in the range in which adverse effects are occasionally observed. Mortality for Pier 32 and 33 sediments was not significantly greater than that for control and reference sediments for *Ampelisca* or *Nereis*. Mortality for *Macoma* was significantly greater than control and reference sediments only if an outlier was removed from the data set. No significant bioaccumulation of metals or PAHs was detected in *Macoma* or *Nereis*.

Sediment samples were also collected in 1994 in the river channel from NSB-NLON to the I-95 bridge in support of the SEAWOLF EIS. Only a few elevated concentrations of some metals were detected, and PAH concentrations were relatively low. No exceedances of ER-L values for PAH compounds were observed. Due to refined displacement and trim estimates in 1994, it was determined that the SEAWOLF submarine could traverse the river in 39 feet of water. Hence, the Navy proposed berthing the SEAWOLF at Piers 8 and 10 instead of Piers 32 and 33. As a result, three sediment samples were collected in 1995 near Piers 8 and 10. Slightly elevated concentrations of several metals were detected. Several exceedances of ER-L values were observed, although no exceedances of ER-M values were observed. Only a few exceedances of ER-L values were observed for PAHs.

In addition to the samples collected in support of the SEAWOLF EIS, sampling was conducted near Piers 15 and 17 in 1994 for the Pier 17 EA (Maguire, 1994). Several surface sediment samples were collected around Piers 15 and 17, benthic macroinvertebrate surveys were conducted, and sediment toxicity tests using *Ampelisca* were performed, as well as bioaccumulation studies with *Macoma* and *Nereis*. Several metals and PAHs in sediment samples exceeded ER-L values, and ER-M values were exceeded for some metals and PAHs in two samples collected near Pier 17. Benthic macroinvertebrate diversity and abundance were low in samples collected near Pier 17 but were relatively high in samples collected near Pier 15. No significant mortality was observed for *Ampelisca* relative to control and reference sediments. Some bioaccumulation of PAH compounds was observed for *Macoma* and *Nereis*, and some bioaccumulation of PCBs was observed in *Nereis* but not in *Macoma*. No significant bioaccumulation of metals was observed.

Also, an ecological risk assessment for the Thames River was performed in support of the NSB-NLON Phase II RI (B&R Environmental, 1997b). Surface water and sediment sampling and benthic macroinvertebrate analysis were conducted. Native shellfish, including blue mussels, oysters, and hardshell clams, were collected, and a caged mussel deployment study was performed. Only a few COCs were identified in surface water. In sediments, some elevated concentrations of some metals and PAHs were detected. Several exceedances of ER-L values were observed; exceedances of ER-M values were sporadic. Some PAHs were detected in one blue mussel sample near the Lower Subase. A few PAHs were also detected in one caged mussel sample in the Lower Subase. Low levels of metals were detected in caged and native shellfish. The results of the benthic macroinvertebrate study indicated that, in general, the benthic community near NSB-NLON was similar to that in the upstream and downstream samples.

Due to the potential for ecological risks displayed by some analyses in the risk assessment, a supplementary ecological risk assessment was performed as part of the NSB-NLON Phase II RI, which focused on the Thames River closer to the base. The supplemental investigation consisted of surface water and sediment sampling, toxicity tests with *Ampelisca* and *Leptocheirus*, modeling of potential risks to the herring gull and double-crested cormorant, and acid volatile sulfide/simultaneously extracted metals (AVS/SEM) analysis of sediments. Some exceedances of guideline values were observed in surface water and sediments samples, but sediments from only one sampling location in the Lower Subase exhibited toxicity (to *Ampelisca*). AVS concentrations exceeded semi-extractable metals (e.g., copper, cadmium, nickel, lead, and zinc) concentrations at all locations, indicating decreased bioavailability of several metals. Moreover, although elevated Hazard Index (HI) values were calculated for the avian species investigated, potential risks to these receptors are most likely much lower due to the use of several conservative assumptions in the models. In particular, the receptors were assumed to forage 100 percent of the time in the river near the Lower Subase, and the Lower Subase comprises only a fraction of the home range of these receptors. The conservative nature of the ecological risk assessment for avian receptors is described in detail in the uncertainty of the Thames River ecological risk assessment. The NSB-NLON Phase II RI ecological risk assessment concluded that, with the possible exception of the Lower Subase area, potential risks to ecological receptors from Thames River contaminants are relatively low and that potential risks to benthic receptors, primarily shellfish near the Lower Subase, are the only risks that may require further characterization.

In summary, the results of the SEAWOLF EIS studies and the NSB-NLON Phase II RI studies indicate that potential risks to ecological receptors from contaminants in the reach of the Thames River along NSB-NLON are relatively low. Elevated concentrations of contaminants were detected near the Lower Subase in samples collected for those studies and in Pier 17 EA samples. However, little or no mortality was

observed in toxicity tests that used sediment samples from the Thames River near the Lower Subase. Diversity and abundance of benthic macroinvertebrates in the Lower Subase area of the river were similar to those found elsewhere in the Thames River, with the exception of a few samples collected near Pier 17. Some bioaccumulation of PAHs and PCBs was observed in Pier 17 benthic receptor studies. Some PAHs were also detected in one blue mussel sample and one caged mussel sample taken during the NSB-NLON Phase II RI at the Lower Subase. Furthermore, the Navy has completed dredging activities associated with Pier 17 replacement and SEAWOLF homeporting projects. Thus, several of the sediment sampling locations from the studies summarized above have been altered, and hence, the data from those samples are unusable and the conclusions drawn from those data may no longer be valid. Each of the studies discussed above was conducted for different purposes. In other words, although data exist from the unaltered sampling locations in the Lower Subase area, no comprehensive study to define the nature and extent of contamination in the Thames River next to the Lower Subase has been conducted. For this reason, additional sediment sampling was conducted in the river adjacent to the Lower Subase to more fully define the nature and extent of contamination, to determine if the Lower Subase is contributing contaminants to the river adjacent to the base, and to more fully characterize the related potential ecological risks to benthic receptors, as described in detail below.

For the most part, the analysis of sediment samples in this ERA focused on PAH compounds (SVOCs) and metals, since these compounds were found to exceed guidelines in the studies discussed above. PAHs were also shown to bioaccumulate in the tissues of benthic organisms.

3.5.3 Preliminary Problem Formulation and Ecological Effects Evaluation

Section 3.5.3.1 discusses the components of preliminary problem formulation and Section 3.5.3.2 discusses the components of ecological effects evaluation.

3.5.3.1 Preliminary Problem Formulation

Site Background

The preliminary problem formulation of an ERA contains a description of the background of the study area, in this case the Lower Subase and nearby Thames River. The site background is described in detail in Section 1.0.

Habitat Types and Ecological Receptors

The preliminary problem formulation of an ERA also contains a description of the specific habitat types and ecological receptors that are found on each study area. These descriptions are presented in the Thames River ecology section of this report (Section 1.3.8).

Major Contaminant Sources and Migration Pathways

The seven zones investigated in this ERA have different contaminant sources, release mechanisms, and migration pathways. These items were investigated on a zone-specific basis and discussed in individual ERA sections. However, all the migration pathways applicable to the Thames River from Lower Subase-related contaminant inputs are aquatic. Precipitation runoff may carry constituents to nearby surface water and sediment at each zone. Infiltrating precipitation may cause the contamination of subsurface soil and groundwater. Upon infiltrating the soil column and reaching the water table, a contaminant may be carried with the flow of groundwater to downgradient locations. Groundwater from the site eventually discharges to the Thames River and contaminants may be subsequently deposited in sediment or they may accumulate in the tissues of aquatic organisms.

Exposure Routes

Aquatic and semi-aquatic organisms in and near the Thames River near the Lower Subase may be exposed to contaminants via direct contact with surface water and sediments, incidental ingestion of surface water and sediments, and consumption of contaminated food items. Aquatic and semi-aquatic organisms may also be exposed to constituents from contaminated groundwater that discharges to nearby surface water. It should be noted that the primary receptors of interest in this ERA are sediment-dwelling organisms. Therefore, potential risks to aquatic (e.g., fish) and semi-aquatic organisms (e.g., waterfowl) were not investigated.

Selection of Analytes to be Investigated

Analytes initially included in the ERA for quantitative analysis were all contaminants detected in sediment samples from the two sediment sampling rounds of the NSB-NLON Phase II RI and samples collected in 1997 as part of this RI for the Lower Subase. However, calcium, magnesium, potassium, and sodium were excluded as analytes to be investigated since they are essential nutrients that are toxic only at extremely high concentrations. In addition, several other types of data were assessed qualitatively in this ERA. Detailed descriptions of those data and the data sets mentioned above that were used quantitatively

in this ERA are included in Section 3.5.4.1. Also, the process that was used to select COCs from those data sets is described in Section 3.5.4.2.

Assessment and Measurement Endpoints

One of the major tasks in preliminary problem formulation is the selection of assessment and measurement endpoints (USEPA, 1997a and Wentsel et al. 1996). An assessment endpoint is defined as "an explicit expression of actual environmental values that are to be protected" (USEPA, 1997a). Measurement endpoints are "measurable ecological characteristics that are related to the valued characteristic chosen as the assessment endpoint" (USEPA, 1997a). Previous ecological investigations in the Thames River near NSB-NLON have indicated that potential risks are confined to sediment-dwelling organisms. As a result, the primary assessment endpoint for this ERA is protection of benthic invertebrate communities.

As indicated above, measurement endpoints are related to assessment endpoints, but these endpoints are more easily quantified or observed. In essence, measurement endpoints serve as surrogates for assessment endpoints. While declines in populations and shifts in community structure can be quantified, studies of this nature are generally time consuming and difficult to interpret. However, measurement endpoints indicative of observed adverse effects on individuals are relatively easy to measure in toxicity studies and can be related to the assessment endpoint. For example, contaminant concentrations that lead to decreased reproductive success or increased mortality of individuals in toxicity tests could, if found in the environment, result in shifts in population structure, potentially altering the benthic community composition of the Thames River near the base.

For sediments, the measurement endpoints were contaminant concentrations in sediment associated with adverse effects on growth, survival, and reproduction of benthic organisms (sediment guidelines).

Conceptual Site Model

The conceptual model is designed to diagrammatically identify potentially exposed receptor populations and applicable exposure pathways, based on the physical nature of the site and the potential contaminant source areas. Actual or potential exposures of ecological receptors associated with the sites assessed in this ERA were determined by identifying the most likely pathways of contaminant release and transport. A complete exposure pathway has three components: a source of contaminants that can be released to the environment, a route of contaminant transport through an environmental medium, and an exposure route or contact point for an ecological receptor. Since the results of previous studies indicated that potential risks are primarily confined to sediment-dwelling organisms, the conceptual model for the Lower Subase

ERA focuses on those organisms. Since the elements of the conceptual model are not thought to differ between zones, zone-specific conceptual models were not applicable. A preliminary conceptual model for the Thames River near the Lower Subase is presented in Figure 3-4.

3.5.3.2 Preliminary Ecological Effects Evaluation

For this ERA, exposure point concentrations of detected analytes in sediment were screened against ecologically based sediment guidelines to determine if they should be retained as COCs. For inorganics, Effects Range-Low (ER-L) guidelines (Long et al., 1995) were used. For organics, site-specific guidelines were calculated using Equilibrium Partitioning (EqP). When ER-L values were not available for certain inorganics or insufficient information was available to use EqP for certain organics, surrogate values were gathered from other sources. Sediment guidelines need to be evaluated relative to the technical basis of their derivation (Ingersoll et al. 1997). Hence, the methods used for the selection of sediment guidelines used in this ERA are provided below.

Inorganics

Values developed (Long and Morgan, 1991) and updated (Long et al., 1995) were chosen to serve as guidelines for inorganics in Thames River sediments. These values are widely accepted and probably the most common sediment guidelines used in ERAs. Long and Morgan developed "apparent effects" data sets for various metals by compiling biological effects data (e.g., reductions in marine benthic populations) for a specific metal, placing the associated concentrations in ascending order and then identifying the 10th and 50th percentiles. Long and Morgan defined the 10th and 50th percentiles as the Effects Range-Low (ER-L) and the Effects Range-Median (ER-M), respectively, for each chemical considered. The more conservative ER-L values were used to identify sediment inorganic COCs for the Thames River.

ER-L values have not been derived for several inorganics that were detected in Thames River sediment samples. For these analytes, surrogate values were selected from other sources, including sediment quality criteria established by various government agencies. These were the same surrogate guidelines used in the NSB-NLON Phase II RI ERA. In a few instances, sediment-specific guidelines could not be identified; these inorganics were, therefore, retained as COCs if present at concentrations in excess of background concentrations. The guidelines mentioned above were used for metals detected in all seven zones and are presented in Table 3-18.

As mentioned earlier, numerous studies have demonstrated that the concentration of AVS present in sediments represents a major factor in influencing the pore water concentration and bioavailability of certain metals (cadmium, copper, nickel, lead, and zinc) in sediments. Sediments with concentrations of

AVS in excess of the concentration of those metals will have very low metal activity in the interstitial water (Ankley et al., 1996); AVS metals present in these sediments are unlikely to bioaccumulate or elicit toxic effects. These relationships have been used to develop equilibrium partitioning (EqP) methods for predicting the bioavailability of divalent metals in sediments (Ankley et al., 1996) and for developing site-specific sediment guidelines.

The EqP process cannot be used to develop separate metal-specific (e.g., copper) sediment criteria. This is because cationic metals (i.e., copper, lead, cadmium, nickel, zinc) have differing affinities for AVS. The presence of two or more of these metals in sediments alters the amount of AVS available for binding the remaining cations (Ankley et al., 1996). The equilibrium models developed (Ankley et al., 1996) account for the fact that metals act in an additive fashion when binding to AVS. That is, each of the five metals (copper, lead, cadmium, zinc, and nickel) will bind to the AVS and be converted to copper sulfide, lead sulfide, cadmium sulfide, zinc sulfide, and nickel sulfide in this sequence (i.e., in the order of increasing solubility). Simultaneously extracted metals (SEM) are defined as the metals extracted in the cold acid used in the procedure to quantify AVS. SEM provides an indication of the biologically available concentrations of metals present in sediment pore water. The term $[SEM_i]$ represents the excess SEM for each of the ith metals. The least soluble metal sulfide considered in AVS/SEM analysis is copper sulfide. If the copper SEM is less than the AVS (SEM < AVS), then all of the copper SEM is present as copper sulfide and the soluble fraction of copper equals zero. The remaining available AVS can be calculated as follows:

$$\text{Remaining [AVS]} = \text{[AVS]} - \text{[copper SEM]}$$

This computation is repeated for the next least soluble metal (lead) and so on. In essence, AVS is "assigned" to the metals in the sequence of their solubility products from the lowest to the highest: $SEM_{copper} < SEM_{lead} < SEM_{cadmium} < SEM_{zinc} < SEM_{nickel}$. That is, AVS would combine first to copper, followed by lead, etc., until all AVS is exhausted. Once AVS is depleted, the remaining metals may exist as excess SEM and may be biologically available.

It has been determined (Ankley et al., 1996) that site-specific sediment criteria can be developed based on the relationship between AVS and these cationic metals. A sediment will meet its site-specific sediment criterion if the sum of the molar concentrations of SEM_{copper}, $SEM_{cadmium}$, SEM_{nickel}, SEM_{lead} and SEM_{zinc} are less than the molar concentrations of AVS. However, even though a sediment meets its site-specific sediment quality criterion, the criterion is specific only for these five cationic metals and does not necessarily mean that a sediment is not toxic.

In addition to deriving site-specific metals criteria, USEPA's National Sediment Inventory (USEPA, 1994a) program has developed the following preliminary classification scheme for the sum of the molar concentrations of SEM_{copper}, $SEM_{cadmium}$, SEM_{nickel}, SEM_{lead} , SEM_{zinc} and AVS (although the values for AVS and SEM in this ERA are presented in mg/kg);

- SEM - AVS > 5 indicates a high probability of adverse impacts to aquatic life
- SEM - AVS = 0 to 5 indicates a medium probability of adverse impacts and
- SEM < 0 indicates a low probability of adverse impacts

AVS and SEM concentrations of copper, cadmium, lead, nickel, and zinc were measured in 1997 Lower Subase RI sediment samples and several NSB-NLON Phase II RI samples collected from the Thames River to investigate the bioavailability of those metals. Therefore, AVS/SEM data are available for each individual zone investigated in this RI.

Several factors influence the spatial and temporal distribution of AVS in sediments. It has frequently been observed that surficial sediments generally contain less AVS than deeper sediments. This presumably is due to oxidation of AVS at the sediment surface, which may be enhanced by bioturbation (Peterson et al., 1996). Hence, the surficial layer of Thames River sediment samples (i.e., the upper few inches) was used for AVS/SEM analysis. Also, the amount of AVS in sediments can vary seasonally. In systems where the amount of oxygen overlying the sediments remains appreciable in the colder months of the year, AVS tends to decrease. This phenomenon is thought to be linked to a constant rate of oxidation of the AVS in conjunction with a seasonal decrease in sulfate-reducing bacteria. However, in contrast, systems in which the water overlying the sediments becomes anaerobic during winter can maintain relatively high sediment AVS concentrations. As a result, seasonal factors and chemistry data from water overlying sediments were taken into account when interpreting AVS concentrations and AVS/SEM ratios in Thames River sediments.

In addition, recent observations from the Duluth, Minnesota EPA laboratory suggest that the relative concentrations of certain cationic metals (cadmium, copper, nickel, lead, and zinc) may influence the seasonal amount of AVS in sediments. To illustrate, a recent zinc-spiked sediment study by Liber et al. (1996) demonstrated a strong positive correlation between the amount of zinc added to test sediments and the subsequent concentrations of AVS in their sediment samples. Surficial depletion and seasonal variation of AVS were unexpectedly low in that study. These observations indicated that zinc sulfide is more stable than the iron sulfide that was presumably the source of most of the AVS in the control sediments. That is, zinc sulfide does not undergo oxidation to the degree that iron sulfide does. Studies conducted by Di Toro et al. (1996) confirm that cadmium and zinc form more stable sulfide complexes than iron. Therefore, seasonal variability in AVS concentrations will be less pronounced when the

sediment concentrations of these metals are elevated. For these reasons, the relative concentrations of cationic metals in relation to expected seasonal variations in AVS was considered in this ERA.

Organics

EqP models have been developed to predict biologically available concentrations of non-polar organic compounds in sediment. The capacity of a sediment to adsorb organic chemicals is a function of the mass fraction of organic carbon in sediment (f_{oc}). f_{oc} is the unitless equivalent of total organic carbon (TOC), which is typically expressed in units of mg/kg for sediment. A chemical's octanol/water partition coefficient (K_{ow}) provides an indication of the degree to which the chemical will be sorbed to sediment organic carbon and is therefore not biologically available. These relationships can be used to predict the amount of chemical that may be biologically available in a sediment containing a given amount of organic carbon. Based on these interrelationships, a site-specific organic carbon normalized sediment guideline can be determined for a specific chemical having a specific organic carbon partition coefficient (K_{oc}), independent of other sediment properties (USEPA, 1993a).

Although K_{ow} values are routinely measured in the laboratory, K_{oc} values are seldom reported. However, K_{oc} can be predicted from K_{ow}. Using the K_{ow} values, the following regression formula was used to predict K_{oc} (USEPA, 1993a):

$$\log_{10}K_{oc} = 0.00028 + 0.983 \log_{10}K_{ow}$$

The predicted K_{oc} value, in combination with chronic surface water guidelines, was then used to predict site-specific chronic guideline sediment values using the following formula (USEPA, 1993a):

Site-specific sediment guideline = CAWQC * f_{oc} * K_{oc}

Where: CAWQC = chronic ambient water quality criterion (mg/L)
f_{oc} = fraction of organic carbon (unitless)
K_{oc} = organic carbon partitioning coefficient (L/kg)

K_{ow} values obtained from USEPA's Athens, Georgia laboratory (Karickoff, 1996) were preferentially used. If values were not available from the laboratory, the EPA developed values used in the NSB-NLON Phase II RI ERA were used (USEPA, 1992a). K_{ow} values used for the calculation of site-specific sediment guidelines are presented on Table 3-19. Site-specific sediment guidelines for organics were calculated for each individual zone using the average TOC value from the sediment samples collected in each zone. Average TOC values per zone are presented on Table 3-20.

The surface water guidelines preferentially used in this ERA to calculate site-specific sediment guidelines were chronic ambient water quality criteria (CAWQCs) developed by USEPA for marine systems. As defined in 40 CFR 131, saltwater guidelines are applicable for water bodies with salinity values greater than 10 ppt such as the Thames River. Exposures of NSB-NLON aquatic receptors to contaminants are assumed to be primarily chronic (long term), usually at sublethal concentrations; CAWQCs are developed to protect sensitive aquatic species from exposures to chronic, sublethal contaminant concentrations. CAWQCs, therefore, serve as conservative and appropriate values for use in EqP calculations.

CAWQCs were not uniformly available for all detected sediment analytes. When a CAWQC had not been developed for a specific analyte, it was necessary to identify surrogate chronic guidelines. In several instances where CAWQCs were not available, final chronic values (FCVs) were used. FCVs are developed by USEPA (Office of Water) when the amount and type of aquatic toxicity data for a contaminant are not adequate to calculate an AWQC based on ecological toxicity (USEPA, 1996a). For example, some AWQCs are based on Food and Drug Administration (FDA) action levels for human fish consumption and, hence, are not suitable for ecological screening. In that case, EPA suggests the use of the FCV (USEPA, 1996a).

In general, the literature contains more acute toxicity data for aquatic receptors than chronic toxicity data. In a few instances, acute toxicity data were obtained from the literature to serve as surrogate data for chronic guideline derivation. Acute toxicity is generally expressed as the LC_{50} or the aqueous concentration of a contaminant lethal to 50 percent of the test population. For this ERA, chronic guidelines were derived by dividing available LC_{50} (or acute AWQC) values by 100.

Frequently, neither CAWQC nor toxicity data were available for some analytes. This was particularly true for organic compounds. In these instances, a computer program developed by USEPA (USEPA, 1994b) was used to derive guideline values for these contaminants. This program includes a series of models based on quantitative structure-activity relationships (QSAR) that permit the prediction of toxicity endpoints for a chemical based on the known toxicity of related chemicals to similar organisms. Chemical-specific parameters used to predict toxicological endpoints included log K_{ow}, melting point, molecular weight, and the chemical's solubility in water. In addition, values were obtained from the widely used ECOTOX database (USEPA, 1995b). The EqP methods and the methods for deriving or obtaining surrogate (non-CAWQC) surface water guidelines described above were those used in the NSB-NLON Phase II RI ERA (B&R Environmental, 1997b).

3.5.4 Preliminary Exposure Estimate and Risk

Section 3.5.4.1 describes the components of preliminary exposure evaluation and Section 3.5.4.2 describes the components of risk calculation.

3.5.4.1 Preliminary Exposure Estimate

Data Sets and Exposure Point Concentrations

Two sediment data sets were evaluated for each zone for use in this ERA. The first data set included sediment samples collected in 1993 and 1995 as part of the NSB-NLON Phase II RI and recently collected data for this Lower Subase RI. All these data were validated and collected relatively recently. All the Lower Subase RI sediment samples were collected in the Thames River near the Lower Subase since the main focus of this ERA was the assessment of potential risks in that area. Accordingly, only NSB-NLON Phase II RI sediment samples collected near the Lower Subase around and between the piers were included in the data set with the Lower Subase RI data.

Sediment chemistry data in the Lower Subase area were available from several SEAWOLF EIS sediment sampling rounds (Maguire, 1995) and from the Pier 17 EA (Maguire, 1994). Nonetheless, those data were not analyzed in this ERA since they were not validated and a large portion of the data are older than the NSB-NLON Phase II RI and Lower Subase RI data (up to 8 years old). Also, no data from those studies are available in Zone 3 near the Lower Subase and several zones had only one or two samples collected near the Lower Subase. SEAWOLF EIS and Pier 17 data were used, however, in the greater Thames River analysis described in Section 3.5.4.2.

Data from sampling locations in the Thames River that have been dredged as part of Navy activities were excluded from the NSB-NLON Phase II RI/Lower Subase data set since those data are not representative of current conditions.

The maximum detected concentrations of analytes in each zone were used as exposure point contaminant concentrations to be screened against sediment guidelines in the risk characterization step. When sufficient sample sizes were available, the average contaminant concentrations from each zone were also used to provide a risk range. For conservatism, when duplicates were available for a sample, the maximum from either one of the duplicates was used when determining the maximum contaminant concentration for each data set. The average of two duplicates was used when calculating the average contaminant concentration for each data set.

Background Sediment Data

The Thames River is tidally influenced with water quality characteristics typical of marine systems (i.e., salinity greater than 10 ppt). Depending on the point in the tidal cycle, the river upstream from NSB-NLON may be influenced by the incoming tide or by freshwater moving downstream. Therefore, because of the tidal influence, no true "upstream," reference station exists for the sampling stations on the Thames River. In order to try to distinguish concentrations of inorganics attributable to naturally occurring conditions (versus those that may be attributable with activities on the NSB-NLON), average concentrations of inorganic constituents reported in sediments collected from two locations in Long Island Sound (NOAA, 1994) were selected to represent background sediment conditions for the Thames River (Table 1-3). These background data were also used in the NSB-NLON Phase II RI ERA (B&R Environmental, 1997b).

Surface Water and Sediment Parameters

Surface water parameters, including temperature, salinity, dissolved oxygen, pH, conductivity, redox potential, and turbidity, were measured during fall 1997 sampling. The measurement of these parameters in water overlying sediments is used to help interpret chemical and physical conditions in sediments. The parameters were also measured in the shallow surface water to determine the variability of these parameters in the water column. Since the Thames River is a tidal estuarine system, these parameters will vary by season, amount of precipitation, tidal cycle, and other influences. Thus, these data were used only to characterize conditions at the time of sampling. Emphasis was placed on dissolved oxygen and pH data since those two parameters are the most readily interpretable. Salinity was used to verify that the use of marine guidelines was appropriate in this ERA.

In addition to TOC (discussed earlier), other sediment parameters were measured. These include percent moisture, percent solids, ammonia, pH, and grain size. Percent moisture and percent solids provide information on the physical nature of the sediments. Increased concentrations of ammonia or unusually high or low pH in sediments, mainly in porewater, can potentially be toxic to benthic organisms.

Sediments are typically categorized by particle size. Two useful categories of sediment are coarse (sand and coarse material greater than 75 um) and fine (silts and clays less than 75 um). The coarse fraction is usually composed of stable, inert, inorganic silicate materials that are non-cohesive and generally not associated with chemical contamination. Organic chemicals and metals bind more readily to the finer particles in sediment (Burton, 1992). This occurs because the finer particles have more binding sites (i.e, more surface area per volume) and finer particles are more likely to be ionized (Burton, 1992).

Sediment depositional areas often contain higher percentages of finer particles than sediments in other areas. As a result, grain size can be used to determine whether a sample was collected in a depositional area that may contain the highest concentrations of contaminants, and thus, would provide a conservative measure of total sediment contaminant concentrations in a waterbody.

Grain size analysis was performed for all sediment samples collected as part of this Lower Subase RI. The results and interpretation of the grain size analysis for each sample are presented on a zone-by-zone basis.

Data from Historical Investigations

Since this ERA is a screening-level ERA, sophisticated, focused ecological analyses were not conducted. Yet, as discussed earlier, several previous studies included toxicity testing, community analysis, shellfish tissue studies, and other ecological analyses of Thames River media. These studies include the SEAWOLF EIS, Pier 17 EA, and NSB-NLON Phase II RI ERA. Data and conclusions from these studies are discussed qualitatively for each applicable zone.

Moreover, monitoring data are available for three National Pollutant Discharge Elimination System (NPDES) storm water outfalls along the Lower Subase (into the Thames River). Data are available for the following periods: October 1, 1992 through September 30, 1993 (Navy, 1993); October 1, 1994 through September 30, 1995 (Diversified Technologies Corporation, 1995); October 1, 1995 through September 30, 1996 (Navy, 1996); and October 1, 1996 through September 30, 1997 (Navy 1997). Since stormwater could be a source of contaminants from the Lower Subase to the Thames River near the base, these data were evaluated qualitatively in this ERA. The three outfalls are located in Zone 1, Zone 4, and between Zones 5 and 6, respectively. Hence, data for those outfalls are discussed in zone-specific sections. Data include several parameters, including oil and grease, chemical oxygen demand, dissolved solids, suspended solids, phosphorus, nitrogen, fecal coliform, and some metals. Also, acute toxicity testing data from stormwater monitoring are available for some years for the water flea (*Daphia pulex*) and the fathead minnow (*Pimephales promelas*). Emphasis was placed on concentrations of copper, lead, and zinc since those three metals are of greatest regulatory concern in the three outfalls listed above.

3.5.4.2 Risk Calculation

As identified by USEPA (USEPA, 1997a), the preliminary risk calculation step in the ERA process compares exposure-point contaminant concentrations with guidelines protective of ecological receptors. Before the concentrations of analytes were compared to guidelines, the maximum concentrations of inorganics in Lower Subase sediments were compared to the average background concentrations.

Inorganics whose maximum concentrations did not exceed average background concentrations were eliminated from further consideration in the ERA. This step was also used in the NSB-NLON Phase II RI. Inorganics with maxima in excess of average background and all detected organics were compared to sediment guidelines. The ratio of the exposure point contaminant concentration to the guideline is called the hazard quotient (HQ), defined as follows:

$$HQ_i = EPC_i/ESG_i$$

where: HQ_i = Ecological Effects Quotient for analyte "i" (unitless)
EPC_i = Exposure Point Concentration for analyte "i" (µg/kg or mg/kg)
ESG_i = Ecological Screening Guideline for analyte "i" (µg/kg or mg/kg)

When the ratio of the exposure point concentration to its respective guideline exceeded 1.0, adverse impacts were considered possible, and the contaminant was retained as a COC. The HQ value should not be construed as being probabilistic; rather, it is a numerical indicator of the extent to which an exposure point concentration exceeds or is less than a guideline. When HQ values exceed 1.0, it is an indication that ecological receptors are potentially at risk; additional evaluation or data may be necessary to confirm with greater certainty whether ecological receptors are actually at risk, especially since most guidelines are conservatively derived (see below).

The use of HQs is probably the most common method used for risk characterization in ERAs. Advantages of this method, according to Barnthouse et al. (1986), include the following:

- The HQ method is relatively easy to use, is generally accepted, and can be applied to any data.
- The method is useful when a large number of contaminants must be screened.

This method of risk characterization has some inherent limitations. One primary limitation is that it is a "no/maybe" method for relating toxicity to exposure. That is, it uses single values for exposure concentrations and guidelines and does not account for the variability in both these parameters nor for incremental or cumulative toxicity.

The comparisons described above are presented in zone-specific screening tables to select zone-specific COCs. Screening tables include the frequency of detection for each analyte, as well as the maximum exposure point concentration, and as mentioned earlier, contaminant-specific guidelines. Separate screening tables are also provided for average concentrations. As a result, two sets of COCs were generated for each zone: maximum concentration COCs and average concentration COCs.

In summary, the COC selection process is as follows:

- The maximum concentrations of all metals detected in NSB-NLON Phase II RI and Lower Subase RI sediment samples (in each zone) were compared to average background concentrations, with the exception of the essential nutrients mentioned earlier. If the maximum concentration did not exceed the background concentration, it was dropped from further consideration; if it exceeded the background concentration, it was retained.

- All metals whose maxima exceeded the background concentration and all detected organics were compared to sediment guidelines. If the maximum concentration of those analytes did not exceed its guideline, it was dropped from further consideration; if it exceeded the guideline, it was retained as a COC.

- Steps 1 and 2 were also followed using average concentrations. Hence, a list of maximum concentration COCs and a list of average concentration COCs was generated.

- If no suitable guidelines were available for either an inorganic or organic, it was retained as a COC.

The use of conservative guidelines and maximum detected concentrations as a starting point for assessing risks in the screening-level assessment is necessary to ensure that potential risks are not underestimated. However, the use of only a comparison of conservative guidelines to maximum detected concentrations as a tool for determining the need for, nature, and magnitude of additional ecological work and/or a complex baseline ERA has severe limitations.

The undertaking of costly additional ecological analyses must be weighed against their benefits, especially in such cases where remedial alternatives are limited or do not exist. Moreover, the environment may suffer as sites of lesser ecological significance are given the same priority as sites of clearly greater ecological concern For these reasons, the consideration of other relevant factors should be employed as part of the screening-level assessment, as discussed below.

Other Risk Characterization Considerations

Several factors to be considered that are outside the boundaries of the simple concentration/guideline comparisons have already been presented. These include comparisons to background, frequency of detection, and the use of average contaminant concentrations.

The magnitude of the HQs should also evaluated. As described earlier, the relationship between the magnitude of a HQ and toxicity is not necessarily linear. However, the magnitude of an HQ can be used as rough approximation of the extent of potential risks, especially if there is sufficient confidence in the guideline used. Most widely accepted sediment guidelines are designed to be conservative. Therefore, less conservative guidelines are presented when sediment contaminant concentrations exceed the most conservative guidelines available. For metals, ER-M values were used (Long et al., 1995) when ER-L values were exceeded.

The use of less conservative guidelines provides balance to the conservative screening-level assessment. For example, ER-L guidelines (Long et al., 1995) were used as most conservative guidelines when available. However, an ER-L is defined as the concentration below which adverse ecological "effects would rarely be observed" (Long et al., 1995). The ER-M is the point below which adverse effects "would occasionally occur" (Long et al., 1995). Therefore, ascribing risk to a sediment contaminant detected in a concentration that exceeds the ER-L but is below the ER-M can be misleading. Hence, as stated above, when metals concentrations exceeded conservative guidelines, less conservative guidelines are also presented in separate tables, when available, to provide balance to the assessment. These tables present all the analytes whose maxima exceeded the conservative guidelines.

Less conservative guidelines from other sources are also presented for perspective, including those for organics. These include Florida Department of Environmental Protection (FDEP) Probable Effects Levels (PELs) and Ontario Ministry of the Environment (MOE) Severe Effects Levels (SELs) (Jones et al., 1996). Both of these sets of guidelines are loosely analogous to ER-Ms, although the Ontario values were developed for freshwater. EPA's sediment quality benchmarks (SQBs) were also considered when one of the original guidelines was exceeded (Jones et al., 1996).

Furthermore, toxicity data and information from various sources in the literature were discussed as they relate to the results of each zone-specific ERA. These sources include the United States Fish and Wildlife Service (USFWS) Contaminant Harard Reviews, commonly referred to as the "Eisler" publications, the NOAA National Status and Trends Program, and ecotoxicological journals. It should be noted, however, that for clarity and avoidance of redundancy, most of this discussion of data from these sources pertinent to individual COCs is presented in the Thames River overall/cumulative section, discussed below.

A "weight-of-evidence" approach (USEPA, 1997a) was used to determine the extent of potential risks when HQ values exceeded 1.0, although analytes were automatically retained as COCs if their maximum concentration HQ exceeded 1.0 after screening against conservative sediment guidelines. A multi-agency/consultant workgroup established in Massachusetts to examine the question of how to conduct a weight-of-evidence approach defined the process as follows (Ingersoll et al., 1997):

> The weight-of-evidence approach is the process by which measurement endpoint(s) are related to an assessment endpoint to evaluate if there is a significant risk of harm to the environment. The approach is planned and initiated at the problem formulation stage and results are integrated at the risk characterization stage.

A weight of evidence summary table is provided for each zone. In addition, conclusions regarding the potential risks in each zone and recommendations for additional ecological study or remedial considerations are presented in each zone-specific section.

Overall/Cumulative Assessment

For ease of assessment, practicality of sampling, and identification of contaminant sources, the Lower Subase was separated into zones for this RI. This was appropriate for the ERA, since the primary receptors of concern are sedimentary benthic organisms that, in general, do not migrate up or down the river. However, the reach of the Thames River near the base represents a fairly large area that, from an ecological standpoint, can be viewed as a larger system that is independent of zone distinctions. Therefore, the results of the zone-specific assessments were assessed holistically. For the most part, this holistic assessment was qualitative and focused on overall and cumulative impacts to benthic receptors from all zones combined near the Lower Subase (close to the piers). This spatial analysis is important, since the spatial dimensions of risk aid in the risk characterization and in the final management decisions (Ingersoll et al., 1997).

As discussed in Section 3.5.4.1, only NSB-NLON Phase II RI/Lower Subase RI data from sediment samples collected near the Lower Subase (i.e., around the piers) were suitable for use in COC selection and quantitative risk characterization. For example, it was not suitable to include data from one sample in a zone collected on the west side of the river with data from five samples collected in that zone near the Lower Subase. Yet, additional Thames River sediment chemistry data from areas outside the Lower Subase were available from the historical investigations discussed previously, including the SEAWOLF EIS, Pier 17 EA, and NSB-NLON Phase II RI. These include data from sampling locations upstream, downstream, in the middle of the river, and across the river from the base. The historical data were evaluated in the overall assessment section to provide perspective on the data collected near the Lower Subase.

The zone designations for the historical data set extended from their points of origin along the Lower Subase across the Thames River, as opposed to only near the piers. As a result, the historical data set includes subsets of data for the following areas: upstream of the base, DRMO, each of Zones 5, 6, 7, 1, 2, 3, and 4, Goss Cove, and downstream of the base. Again, those subsets of historical data include data

from sediment samples collected anywhere in the river, including next to the base, within those areas and zones. Biological data from the upstream, downstream, middle, and western shore of the Thames River were also assessed. While the combining of those data is useful to characterize the nature and extent of contamination in the river, it was not appropriate to assess risks to benthos near the Lower Subase. Therefore, the upstream, downstream, DRMO, and Goss Cove historical data sets were used for comparison to the NSB-NLON Phase II RI/Lower Subase RI data in each zone near the Lower Subase. That is, the zone-specific historical data sets from "bank to bank" were not appropriate for assessing the Thames River near the Lower Subase in relation to contamination in other sections of the river; only the data from samples collected near the Lower Subase were appropriate for comparison to other areas. The overall Lower Subase ERA assessment is provided in Section 11.7, and a discussion of the historical data set described above is presented in Section 11.4.

3.5.5 Uncertainty Analysis

Uncertainty is associated with all aspects of the ERA process. This section provides a summary of the general uncertainties involved in this ERA, with a discussion of how they may affect the final risk values and conclusions. Several of the sources of uncertainty discussed below overlap with the risk characterization considerations described above. Some additional discussions of site-specific uncertainties are also contained in zone-specific assessment sections.

Once an ERA is complete, the results must be reviewed and evaluated to identify the types and magnitudes of uncertainties involved. Relying on results from a risk assessment without consideration of uncertainties, limitations, and assumptions inherent in the process can be misleading. If numerous conservative assumptions are combined in the ERA process, the resulting calculations will propagate the uncertainties associated with each of those assumptions. The resulting bias is toward overpredicting risks. Thus, both the results of the risk assessment and the uncertainties associated with those results must be considered when making risk management decisions.

Generally, risk assessments carry two types of uncertainty: measurement and informational. Measurement uncertainty refers to the variability inherent in measured data. The risk assessment reflects the accumulated variances of the individual values used for several different parameters. Informational uncertainty stems from the limited availability of necessary information. Often the gap between what is needed and what is available is significant; information regarding the effects of some contaminants on wildlife receptors, the biological mechanism of a contaminant, the impact of physiological differences on exposure pathways, or the behavior of a contaminant in various environmental media is often absent.

Uncertainty is associated with each of the steps of the risk assessment process:

- Uncertainty in preliminary problem formulation can result from limited information regarding contaminant sources, release mechanisms, and exposure routes.

- Uncertainty in the ecological effects characterization arises from the quality of the existing screening values and toxicity data to support a determination of potential adverse impacts to ecological receptors.

- Uncertainty associated with the exposure assessment includes the methods used and the assumptions made to determine exposure point concentrations or calculate contaminant doses.

- Uncertainty in risk characterization includes that associated with combining conservative assumptions made in earlier activities.

3.5.5.1 Uncertainty in the Preliminary Problem Formulation

The sites investigated in this ERA receive contaminant inputs from more than one source, although initially, contaminants are conservatively assumed to stem directly from activities related to each zone. For example, the Thames River receives contaminant inputs from several other sources near NSB-NLON, including non-Navy sources. Since contaminant concentrations may reflect inputs from many sources, uncertainties exist regarding whether risk characterized at an individual zone or in the Lower Subase as a whole stems from base-related contaminants.

3.5.5.2 Uncertainty in the Ecological Effects Characterization

A great deal of uncertainty in this risk assessment arises from the nature and quality of the available toxicity data used to derive guidelines. This uncertainty is reduced when similar effects are observed across species, strain, sex, and exposure route; when the magnitude of the response is clearly dose related; and when mechanisms of toxicity are similar for laboratory and wildlife species. Most guidelines are based on the most conservative assumptions possible. Although an inherent level of conservatism is needed in a screening-level ecological risk assessment to ensure that the most sensitive receptors are protected, conservative guidelines may heavily overestimate potential risks and the resulting HQ values may be misleading. Both CAWQC and most sediment screening values used in this assessment are based on laboratory studies that do not take into account mitigating or ameliorating physical and chemical conditions in the environment. That is, the most bioavailable (i.e., toxic) form of the contaminant is usually applied to the exposure medium. In reality, bioavailability is rarely, if ever, 100 percent. Therefore, uncertainty is introduced into the assessment, and the results tend to overestimate potential risks. The

AVS/SEM analysis can account for the uncertainty associated with the potential toxicity of several metals and can add perspective to the bulk sediment concentrations of those metals.

Considerable uncertainty is inherent in the use of EqP for the calculation of site-specific sediment guidelines. The three parameters used in EqP, water quality guidelines, TOC, and K_{oc}, all contain their own uncertainties that affect the calculated guidelines. Water quality guidelines can vary in their level or conservatism. For example, the FCV for a given contaminant may be much less than a AWQC. If no AWQC is available and the FCV is used, a certain level of conservatism may be lost. Secondly, if the TOC value used in the calculations is representative of TOC throughout the area of study, uncertainty is reduced. Conversely, if the TOC value used is not representative of current conditions, the guideline may be somewhat over- or underestimated. The K_{oc} values were derived from K_{ow} values. For this assessment, the most recently generated and widely accepted K_{ow} values available were used to generate K_{oc} values. Nonetheless, K_{ow} values may have been generated from studies that use different experimental protocols. Published K_{ow} values for a single compound may vary by several orders of magnitude. This may indicate the variability that occurs in nature, rather than poor analytical techniques.

Several of the site-specific sediment guidelines calculated for PAHs in this ERA were high relative to corresponding ER-L and ER-M values, often by orders of magnitude. For the most part, values for the EqP input parameters used in this ERA were those used in the NSB-NLON Phase II RI ERA. Values were gathered from sources other than those used in the NSB-NLON Phase II RI only when newer data were available from reliable, established sources in the literature. The reasons for the seemingly high PAH guidelines from EqP are unclear. K_{ow} values for most PAHs are high relative to other classes or organics. Small changes in the K_{ow} values can lead to substantial changes in the final EqP guidelines. Also, some of the water quality guidelines used (e.g., from ECOSAR as used in the NSB-NLON Phase II RI ERA) may be somewhat high, resulting in higher sediment guidelines. In general, changes in TOC have less of an effect on the calculated guidelines unless the changes are significant (e.g., two percent compared to five percent).

In addition, ERAs, unlike human health risk assessments, must consider risks to many different species. Calculation of risk values for every potential receptor species is not possible. For this ERA, conservative guidelines protective of a wide range of ecological receptors were sought. The underlying assumption associated with the use of these guidelines is that contaminant concentrations in excess of these values are indicative of potential impacts to actual receptors inhabiting the area. However, species-specific physiological differences that may influence an organism's response to a contaminant or subtle behavioral differences that may increase/decrease a receptor's contact with a contaminant are seldom known. Also, some contaminants were present in sediments for which no suitable guidelines were available, and as a

result, they could not be quantitatively assessed. For these reasons, the use of guidelines, while necessary, will introduce error into the results of an assessment.

3.5.5.3 Uncertainty in the Exposure Assessment

Uncertainty in the exposure assessment arises mainly in the methods used to obtain exposure point concentrations. The maximum detected contaminant concentrations were generally used to represent the highest contaminant concentrations to which ecological receptors might be exposed. If the samples evaluated in this ERA are representative of contaminant concentrations associated with the sites, then this approach is conservative and should overestimate potential risks to ecological receptors. The maximum concentration of a contaminant in a given medium may have been collected in a "hot spot" of contamination and may be much higher than the remaining values in the data set. Again, although use of maximum values is appropriate for screening in an ERA, they may grossly overpredict potential risks. To somewhat mitigate these uncertainties, average concentrations were also used, but they do not fully account for the uncertainties involved in selecting exposure point contaminant concentrations.

3.5.5.4 Uncertainty in the Risk Characterization

Uncertainty in the risk characterization is affected by all aspects of the ERA process described in the above sections. Uncertainty in risk characterization also stems, in part, from the fact that different components of the ERA are combined and compared in this step. Each of those components already contains different types of uncertainty, as discussed above. Thus, uncertainties may be propagated when these components are combined. To try to reduce the overall uncertainty in the risk assessment, the weight of evidence approach is used to make risk decisions. This approach takes the results of all aspects of the assessment into account, including the uncertainties, to make determinations of potential risk/no risk.

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TABLE 3-1

SUMMARY OF REJECTED RESULTS
LOWER SUBASE RI
NSB-NLON, GROTON, CONNECTICUT

Sample	Parameter	Matrix
LS6GW00401	1,1,1-trichloroethane, 1,1,2,2-tetrachloroethane, 1,1,2-trichloroethane, 1,1-dichloroethane, 1,1-dichloroethene, 1,2-dichloropropane, 2-butanone, 2-hexanone, 4-methyl-2-pentanone, benzene, bromodichloromethane, bromoform, bromomethane, carbon disulfide, carbon tetrachloride, chlorobenzene, chloroethane, chloroform, chloromethane, cis-1,3-dichloropropene, dibromochloromethane, ethylbenzene, styrene, tetrachloroethene, toluene, total-1,2-dichloroethene, trans-1,2-dichloropropene, trichloroethene, vinyl chloride, xylenes (total)	GW
LS1SB0020201	2,4,5-trichloropehnol, 2,4,6-trichlorophenol, 2,4-dichlorophenol, 2,4-dimethylphenol, 2,4-dinitrophenol, 2-chlorophenol, 2-methylphenol, 2-nitrophenol, 4,6-dinitro-2-methylphenol, 4-methylphenol, 4-nitrophenol, pentachlorophenol, phenol	SO
LS1SB0060101	2,4,5-trichloropehnol, 2,4,6-trichlorophenol, 2,4-dichlorophenol, 2,4-dimethylphenol, 2,4-dinitrophenol, 2-chlorophenol, 2-methylphenol, 2-nitrophenol, 4,6-dinitro-2-methylphenol, 4-methylphenol, 4-nitrophenol, pentachlorophenol, phenol	SO
LS4SB0010301	2,4,5-trichloropehnol, 2,4,6-trichlorophenol, 2,4-dichlorophenol, 2,4-dimethylphenol, 2,4-dinitrophenol, 2-chlorophenol, 2-methylphenol, 2-nitrophenol, 4,6-dinitro-2-methylphenol, 4-methylphenol, 4-nitrophenol, pentachlorophenol, phenol	SO
LS4SB0050301	2,4,5-trichloropehnol, 2,4,6-trichlorophenol, 2,4-dichlorophenol, 2,4-dimethylphenol, 2,4-dinitrophenol, 2-chlorophenol, 2-methylphenol, 2-nitrophenol, 4,6-dinitro-2-methylphenol, 4-methylphenol, 4-nitrophenol, pentachlorophenol, phenol	SO
LS5SB0020101	1,2,4-trichlorobenzene, 1,2-dichlorobenzene, 1,3-dichlorobenzene, 1,4-dichlorobenzene, 2,2'-oxybis(1-chloropropane), 2,4-dinitrotoluene, 2,6-dinitrotoluene, 2-chloronaphthalene, 2-methylnaphthalene, 2-nitroaniline, 3,3'-dichlorobenzidine, 3 nitroaniline, 4-bromophenyl ether, 4-chloroaniline, 4-chloropheyl phenyl ether, 4-nitroaniline, acenaphthene, acenaphthylene, anthracene, benzo(a)anthracene, benzo(k)fluoranthene, bis(2-chloroethoxy)methane, bis(2-chloroethyl)ether, butylbenzyl phthalate, carbazole, di-n-butyl phthalate, di-n-octyl phthalate, dibenzo(a,h)anthracene, dibenzofuran, dimethyl phthalate, fluorene, hexachlorobenzene, hexachlorobutadiene, hexachlorocylcopentadiene, hexachloroethane, indeno(1,2,3-cd)pyrene, isophrone, n-nitroso-di-n-propylamine, n-nitrosodiphenylamine, naphthalene, nitrobenzene, phenathrene	SO

GW - Groundwater
SO - Soil

TABLE 3-2

PARAMETER-SPECIFIC STANDARD DEVIATIONS FOR GEOSTATISTICAL ANALYSIS
LOWER SUBASE RI
NSB-NLON, GROTON, CONNECTICUT

Parameter	68% Confidence Limit	95% Confidence Limit
TPH is shallow soil	±4 mg/kg	±8 mg/kg
TPH in deep soil	±10 mg/kg	±20 mg/kg
TPH in groundwater	±1.65 µg/L	±3.3 µg/L
Lead in shallow soil	±4 mg/kg	±8 mg/kg
Lead in deep soil	±4 mg/kg	±8 mg/kg
Total Lead in groundwater	±4µg/L	±8 µg/L
Dissolved Lead in groundwater	±2.6 µg/L	±5.2 µg/L
Dissolved Oxygen	±2.5 mg/L	±5.0 mg/L
REDOX Potential	±125 mV	±250 mV
Divalent Iron	±1.5 mg/L	±3 mg/L
Specific Conductivity	±2.8 mS/cm	±5.6 mS/cm

TABLE 3-3

ENVIRONMENTAL FATE AND TRANSPORT PARAMETERS FOR ORGANIC CHEMICALS
LOWER SUBASE RI
NSB-NLON, GROTON, CONNECTICUT
PAGE 1 OF 4

Chemical	Specific Gravity (@ 20/4°C)[2]	Vapor Pressure (mm Hg @ 20°C)[2]	Solubility (mg/L @ 20°C)[2]	Octanol/Water Partition Coefficient[2]	Organic Carbon Partition Coefficient[4]	Henry's Law Constant (atm-m³/mole)[2]	Bioconcentration Factor (mg/L/mg/kg)[4]
KETONES							
Acetone[14]	0.7899	2.66E+2 (25°C)	Miscible	5.75E-1	5.8E-1[13]	4.276E-5 (25°C)	3.81E-1[6]
2-Butanone[14]	0.8054	1.0E+2 (25°C)	2.75E+5	1.82E+0	1.8E+0[13]	4.66E-5 (25°C)	9.3E-1[6]
4-Methyl-2-pentanone	0.7978 (20°C)	1.0E+1 (30°C)	1.91E+4	1.23E+1	5.3E+0[9]	1.49E-5 (25°C)	3.9E+0[6]
2-Hexanone	0.8017[7]	6.0E+1[7]	3.5E+4	NA[1]	2.0E+0[9]	1.75E-3(25°C)	2.5E+0[10]
MONOCYCLIC AROMATICS							
Benzene	0.8765	9.5E+1 (25°C)	1.78E+3	1.35E+2	6.5E+1	5.55E-3 (25°C)	3.7E+1
Chlorobenzene	1.1058	1.18E+1(25°C)	4.88E+2 (25°C)	6.92E+2	3.3E+2	3.93E-3 (25°C)	1.64E+2
4-Chloro-3-methylphenol	NA	5E-2	3.85E+3	1.26E+3	6.0E+2	2.5E-6	4E+2
2-Chlorophenol	1.2634	4.0E+1	2.85E+4	1.41E+2	7.3E+1	1.03E-5	4.1E+1
1,2-Dichlorobenzene	1.3048	1.5E+0 (25°C)	1.45E+2	2.4E+3	1.7E+3	2.951E-3	7.3E+2
1,3-Dichlorobenzene	1.2884	1.0E+0 (12.1°C)	1.23E+2 (25°C)	2.40E+3	1.7E+3	3.241E-3 (25°C)	7.3E+2
1,4-Dichlorobenzene	1.2475	1.8E+0 (30°C)	7.9E+1 (25°C)	2.45E+3	1.7E+3	4.328E-3 (25°C)	7.3E+2
2,4-Dichlorophenol	1.40 (15/4°C)	1E+0 (53°C)	4.5E+3 (25°C)	5.62E+2	3.8E+2	2.8E-6	1.86E+2
2,4-Dimethylphenol	0.965	9.8E+1 (104°C)	7.868E+3 (25°C)	2.63E+2	9.6E+1	6.55E-6 (25°C)	7.5E+1
2,4-Dinitrotoluene	1.3208 (71°)	1.3E-3 (59°C)	2.7E+2 (22°C)	1.02E+2	4.5E+1	8.67E-7	3.9E+1
Ethylbenzene	0.867	1E+1 (25.9°C)	1.52E+2	1.41E+3	1.1E+3	8.043E-3 (25°C)	4.7E+2
2-Methylphenol	1.0273	2.4E-1 (25°C)	3.1E+4 (40°C)	8.91E+1	1.8E+1[8]	8.41E-7	1.8E+1[6]
4-Methylphenol[14]	1.0178	1.1E-1 (25°C)	2.4E+4 (40°C)	8.32E+1	7.7E+1[13]	3.92E-7	1.7E+1[6]
Phenol[14]	1.0576	3.5E-1 (25°C)	8E+4 (25°C)	2.88E+1	2.7E+1[13]	1.3E-6 (25°C)	9.4E+0
Styrene	0.9060	5E+0	3E+2	1.44E+3	1.9E+2[9]	2.633E-3 (25°C)	1.48E+2[6]
Toluene	0.8669	2.8E+1 (25°C)	5.15E+2	4.9E+2	3.0E+2	5.92E-3 (25°C)	1.48E+2
1,2,4-Trichlorobenzene	1.4542	1.0E+0 (38.4°C)	1.9E+1 (22°C)	9.55E+3	9.2E+3	1.42E-3 (25°C)	3.3E+3
Xylenes (Total)	0.86104 - 0.8801	1E+1 (27.3 - 32.1°C)	1.6E+2 - 1.75E+2[5]	5.89E+2 - 1.58E+3	4.8E+1 - 2.6E+2[5]	4.184E-3 - 6.662E-3 (25°C)	7.5E+1 - 1.59E+2[6]

TABLE 3-3

ENVIRONMENTAL FATE AND TRANSPORT PARAMETERS FOR ORGANIC CHEMICALS
LOWER SUBASE RI
NSB-NLON, GROTON, CONNECTICUT
PAGE 2 OF 4

Chemical	Specific Gravity (@ 20/4°C)[2]	Vapor Pressure (mm Hg @ 20°C)[2]	Solubility (mg/L @ 20°C)[2]	Octanol/Water Partition Coefficient[2]	Organic Carbon Partition Coefficient[4]	Henry's Law Constant (atm-m³/mole)[2]	Bioconcentration Factor (mg/L/mg/kg)[4]
HALOGENATED ALIPHATICS							
Bromodichloromethane	1.98	5E+1	4.5E+3 (0°C)	7.59E+1	6.1E+1	2.12E-3 (25°C)	3.5E+1
Bromomethane	1.6755	1.42E+3	1.75E+4	1.26E+1	5.9E+0	2E-1	4.2E+0
Chloroform	1.4832	1.60E+2	9.3E+3 (25°C)	9.33E+1	4.4E+1	3.39E-3 (25°C)	2.6E+1
Chloromethane	0.9159	3.8E+3	6.36E+3	8.13E+0	4.3E+0	8.82E-3 (24.8°C)	3.2E+0
1,1-Dichloroethane	1.1757	2.34E+2 (25°C)	5.5E+3	1.67E+1	3.0E+1	5.871E-3 (25°C)	1.9E+1
1,2-Dichloroethane	1.2351	7.9E+1 (25°C)	8.69E+3	2.82E+1	1.4E+1	1.178E-3 (25°C)	9E+0
1,1-Dichloroethene	1.218	5.91E+2 (25°C)	2.1E+2 (25°C)	3.02E+1	6.5E+1	2.286E-2 (25°C)	5.3E+1
cis-1,2-Dichloroethene	1.2837	2.02E+2 (25°C)	8E+2	NA	1.1E+2[9]	4.08E-3 (24.8°C)	1.4E+1[3]
trans-1,2-Dichloroethene	1.2565	3.31E+2 (25°C)	6E+2	3.02E+1	5.9E+1	6.673E-3 (25°C)	4.8E+1
Methylene chloride	1.3266	4.29E+2 (25°C)	1.67E+4 (25°C)	1.78E+1	8.8E+0	3.19E-3 (25°C)	6E+0
1,1,2,2-Tetrachloroethane	1.5953	4E+0 (25°C)	2.9E+3	2.45E+2	1.2E+2	3.8E-4	9.1E+1
Tetrachloroethene	1.6227	1.9E+1 (25°C)	1.5E+2 (25°C)	3.39E+2	3.6E+2	2.685E-2 (25°C)	2.52E+2
1,1,1-Trichloroethane	1.339	1E+2	4.4E+3	2.95E+2	1.5E+2	4.08E-3 (25°C)	8.1E+1
1,1,2-Trichloroethane	1.4397	2.5E+1 (25°C)	4.5E+3	1.48E+2	5.6E+1	9.607E-4 (25°C)	3.3E+1
Trichloroethene	1.4642	7.7E+1 (25°C)	1.1E+3 (25°C)	3.39E+2	1.3E+2	1.17E-2 (25°C)	9.7E+1
Vinyl chloride	0.9106	2.58E+3	1.1E+3 (25°C)	3.98E+0	1.7E+1	2.78E-2 (25°C)	5.7E+0
HALOGENATED ETHERS							
4-Bromophenyl phenyl ether	1.4208	1.5E-3	3.3E+0 (25°C)[4]	1.91E+4	5.8E+4	1E-4	1.8E+4
MISCELLANEOUS VOLATILE ORGANICS							
Carbon disulfide	1.2632	2.98E+2	2.9E+3	1.45E+2	5.4E+1[9]	1.921E-2 (25°C)	2.6E+1[6]
Methyltert-butylether	0.7405	2.45E+2 (25°C)	4.8E+4	2.88E+1[10]	1.2E+1[9]	5.97E-4[11]	1.4E+1[3]
POLYNUCLEAR AROMATIC HYDROCARBONS (PAHs)							
Acenaphthene[14]	1.0242 (90/4°C)	1E+1 (131°C)	3.42E+0 (25°C)	8.32E+3	7.1E+3[13]	2.41E-4 (25°C)	1.8E+3
Acenaphthylene[14]	0.8988 (16/2°C)	2.9E-2	3.93E+0 (25°C)	1.17E+4	1.0E+4[13]	1.14E-4 (25°C)	1E+3
Anthracene[14]	1.283 (25/4°C)	1.95E-4 (25°C)	1.29E+0 (25°C)	2.82E+4	2.4E+4[13]	8.6E-5 (25°C)	4.7E+3
Benzo(a)anthracene[14]	1.274	5E-9	1E-2 (24°C)	4.07E+5	3.3E+5[13]	6.6E-7	5.3E+4

TABLE 3-3

ENVIRONMENTAL FATE AND TRANSPORT PARAMETERS FOR ORGANIC CHEMICALS
LOWER SUBASE RI
NSB-NLON, GROTON, CONNECTICUT
PAGE 3 OF 4

Chemical	Specific Gravity (@ 20/4°C)[2]	Vapor Pressure (mm Hg @ 20°C)[2]	Solubility (mg/L @ 20°C)[2]	Octanol/Water Partition Coefficient[2]	Organic Carbon Partition Coefficient[4]	Henry's Law Constant (atm-m³/mole)[2]	Bioconcentration Factor (mg/L/mg/kg)[4]
Benzo(b)fluoranthene[14]	NA	5E-7	1.2E-3 (25°C)	3.72E+6	2.9E+6[13]	1.2E-5	1.4E+5
Benzo(k)fluoranthene[14]	NA	9.59E-11	5.5E-4 (25°C)	6.92E+6	5.3E+6[13]	1.04E-3	1.4E+5
Benzo(g,h,i)perylene[14]	NA	1E-10	2.6E-4 (25°C)	1.7E+7	1.3E+7[13]	1.4E-7 (25°C)	3.5E+5
Benzo(a)pyrene[14]	1.351	5E-9	3.8E-3 (25°C)	9.55E+5	7.6E+5[13]	4.9E-7 (25°C)	1.4E+5
Chrysene[14]	1.274 (20°C)	6.3E-9 (25°C)	6E-3 (25°C)	4.07E+5	3.3E+5[13]	1.05E-6 (25°C)	5.3E+4
Dibenz(a,h)anthracene[14]	1.282	1E-10	5E-4 (25°C)	9.33E+5	7.4E+5[13]	7.3E-8 (25°C)	6.9E+5
Fluoranthene[14]	1.252	5.0E-6 (25°C)	2.65E-1 (25°C)	2.14E+5	1.7E+5[13]	6.5E-6 (25°C)	1.2E+4
Fluorene[14]	1.202	1E+1 (146°C)	1.9E+0 (25°C)	1.51E+4	1.3E+4[13]	1.17E-4 (25°C)	3.8E+3
Indeno(1,2,3-cd)pyrene[14]	NA	1E-10 (25°C)	6.2E-2	4.57E+7	3.4E+7[13]	6.95E-8 (25°C)	3.5E+5
2-Methylnaphthalene[14]	1.0058	1E+1 (105°C)	2.6E+1 (25°C)	7.24E+3	6.2E+3[13]	4.99E-4 (25°C)	5.1E+2[6]
Naphthalene[14]	1.162	8.2E-2 (25°C)	3E+1 (25°C)	2.34E+3	2.1E+3[13]	4.83E-4 (25°C)	4.2E+2
Phenanthrene[14]	0.980 (4°C)	1E+0 (118.2°C)	8.16E-1 (21°C)	2.88E+4	2.4E+4[13]	3.93E-5 (25°C)	4.7E+3
Pyrene[14]	1.271 (23/4°C)	2.5E+0 (200°C)	1.6E-1 (26°C)	1.51E+5	1.2E+5[13]	5.1E-6 (25°C)	1.2E+4
PHTHALATE ESTERS							
Bis(2-ethylhexyl)phthalate[14]	0.99 (20/20°C)	1.2E+0 (200°C)	4E-1 (25°C)	2E+5	1.6E+5[13]	3E-7	2.3E+8
Butylbenzylphthalate	1.1 (25/25°C)	8.6E-6	2.9E+0	6.03E+4	1.7E+5	8.3E-6[4]	4.7E+4
Di-n-butylphthalate[14]	1.047 (20/20°C)	1E-1 (115°C)	4E+2 (25°C)	1.58E+5	1.3E+5[13]	2.8E-7 (25°C)	4.7E+4
Diethylphthalate	1.1175	5E-2 (70°C)	1.08E+3 (25°C)	9.12E+2	1.4E+2	8.46E-7	1.07E+2
Dimethylphthalate[14]	1.1905	< 1E-2	5E+3	7.41E+1	6.9E+1[13]	4.2E-7	1.6E+1
Di-n-octylphthalate[14]	0.978	< 2E-1 (150°C)	3E+0 (25°C)	1.58E+9	1.1E+9[13]	1.41E-12 (25°C)	3.9E+8
NITROGEN CONTAINING CHEMICALS							
N-Nitrosodiphenylamine	NA	1E-1	3.5E+1	6.16E+2	6.5E+2	3.13E+0	4.26E+2
MISCELLANEOUS SEMIVOLATILE ORGANICS							
Benzoic acid	1.27[7]	NA	2.9E+3[7]	7.41E+1[7]	5.4E+1[10]	NA	1.55E+1[6]
Carbazole[14]	1.1 (18EC/4°C)	4.0E+2 (323°C)	NA	1.95E+3[7]	1.7E+3[13]	NA	1.86E+2[6]
Dibenzofuran[14]	1.0886 (99°C/4°C)	NA	1E+1	1.32E+4	1.1E+4[13]	NA	7.97E+2[6]

TABLE 3-3

ENVIRONMENTAL FATE AND TRANSPORT PARAMETERS FOR ORGANIC CHEMICALS
LOWER SUBASE RI
NSB-NLON, GROTON, CONNECTICUT
PAGE 4 OF 4

Chemical	Specific Gravity (@ 20/4°C)[2]	Vapor Pressure (mm Hg @ 20°C)[2]	Solubility (mg/L @ 20°C)[2]	Octanol/Water Partition Coefficient[2]	Organic Carbon Partition Coefficient[4]	Henry's Law Constant (atm-m³/mole)[2]	Bioconcentration Factor (mg/L/mg/kg)[4]
PESTICIDES							
Chlordane	1.61 (25°C)	1E-5 (25°C)	5.6E-2	6.03E+2	1.4E+5	4.79E-5 (25°C)	4.0E+4
4,4'-DDD[14]	1.476	1E-6 (30°C)	1.6E-1 (24°C)	1.5E+6[12]	9.1E+5[13]	2.16E-5	1.8E+5
4,4'-DDE[14]	NA	6.5E-6	4E-2	7.5E+6[12]	4.4E+6[13]	2.34E-5	8.9E+5
4,4'-DDT	1.5 (15/4°C)	1.5E-7	3.1E-3 (25°C)	1.55E+6	3.9E+6	3.89E-5 (25°C)	8E+6
Endrin	1.65 (25°C/4°C)	2E-7 (25°C)	2.6E-1 (25°C)	3.98E+5	1.7E+3	4E-7 (25°C)	7.1E+2
Heptachlor	1.57 (9°C)	3E-4 (25°C)	5.6E-2 (25°C)	2.51E+4	1.2E+4	1.48E-3	4.4E+3
Heptachlor epoxide	NA	2.6E-6	3.5E-1 (25°C)	4.47E+3	2.2E+2	3.16E-5 (25°C)	1.1E+2
PCBs							
Aroclor-1016	NA	4E-4 (25°C)[4]	4.2E-1 (25°C)[4]	3.8E+5[4]	1.8E+5	3.3E-4[4]	5.0E+4
Aroclor-1254	1.50 (25°C)[4]	7.71E-5[4]	3.1E-2[4]	1.1E+6[4]	5.3E+5	2.6E-3[4]	1.3E+5
Aroclor-1260	1.58 (25°C)[4]	4.05E-5[4]	2.7E-3[4]	1.4E+7[4]	6.7E+6	7.4E-1[4]	1.3E+6

1 NA - Not Available.
2 USEPA, 1992a.
3 Lyman et al., 1990; Equation 5-3.
4 USEPA, December 1982.
5 ATSDR, 1989.
6 Lyman et al., 1990, Eq. 5-2.
7 Verschueren, 1983.
8 Howard, 1989.
9 Lyman et al., 1990; Equation 4-5.
10 Lyman et al., 1990; Chapter 1.
11 Lyman et al., 1990, Equation 15-8.
12 Karickoff, 1996.
13 Calculated for the ecological risk assessment.
14 Chemical detected in validated sediment samples; therefore, the Octanol/Water and Organic Carbon Partitioning Coefficients were used in the ecological risk assessment.

TABLE 3-4

ENVIRONMENTAL FATE AND TRANSPORT PARAMETERS FOR INORGANICS
LOWER SUBASE RI
NSB-NLON, GROTON, CONNECTICUT

Element	Molecular Weight (g/mole)	Soil/Water Distribution Coefficient (Kd)[1] (mL/g)	Bioconcentration Factor[2] (L/kg)
Antimony	121.75	NR[3]	NR
Arsenic	74.92	1.0 - 8.3	44
Barium	137.34	NR	NR
Beryllium	9.01	NR	NR
Boron	10.81	NR	NR
Cadmium	112.4	1.3 - 27	64
Chromium III	52.0	470 - 150,000	16
Cobalt	58.93	0.2 - 3,800	NR
Copper	63.54	1.4 - 333	36
Cyanide	26.02	NR	NR
Lead	207.19	4.5 - 7,640	NR
Manganese	54.93	0.2 - 10,000	NR
Mercury	200.59	NR	NR
Nickel	58.71	NR	NR
Selenium	78.96	1.2 - 8.6	4.8
Silver	107.87	10 - 1,000	0.5
Thallium	204.37	NR	116
Vanadium	50.94	NR	NR
Zinc	65.38	0.1 - 8,000	47

1 Dragun, 1988.
2 USEPA, 1991f.
3 NR - Not reported.

TABLE 3-5

SUMMARY OF EXPECTED CHANGES IN GROUNDWATER CHEMISTRY DUE TO BIODEGRADATION PROCESSES LOWER SUBASE RI NSB-NLON, GROTON CONNECTICUT

Analyte	Biodegradation Process	Expected Change
Dissolved Oxygen	Aerobic Oxidation	Decreases
Nitrate	Denitrification	Decreases
Iron (II)	Iron (III) Reduction	Increases
Sulfate	Sulfate Reduction	Decreases
Methane	Methanogenesis	Increases
Alkalinity	Aerobic/Anaerobic Oxidation	Increases

TABLE 3-6

SUMMARY OF CONDITIONS INDICATIVE OF BIODEGRADATION PROCESSES
LOWER SUBASE RI
NSB-NLON, GROTON, CONNECTICUT

Parameter	Concentration	Conclusion
Dissolved Oxygen	> 1 mg/L	Aerobic conditions
	< 1 mg/L	Anaerobic conditions
REDOX Potential	< 50 mV	Anaerobic conditions
	> 50 mV	Aerobic conditions
Nitrate	> 1 mg/L	Electron acceptor present, denitrification is probably not occurring.
	< 1 mg/L	Reduced electron acceptor availability, denitrification is probably occurring.
Iron (II)	> 1 mg/L	Reduced electron acceptor availability, Iron (III) reduction is probably occurring.
	< 1 mg/L	Electron acceptor available, Iron (III) reduction is probably not occurring.
Sulfate	> 20 mg/L	Electron acceptor present, sulfate reduction is probably not occurring.
	< 20 mg/L	Reduced electron acceptor availability, sulfate reduction is probably occurring.
Methane	> 0.1 mg/L	Methanogenesis is occurring.
	< 0.1 mg/L	Methanogenesis is not occurring or not occurring at a substantial rate.

TABLE 3-7

RISK-BASED COC SCREENING LEVELS AND OTHER HEALTH-BASED STANDARDS - AQUEOUS MEDIA
LOWER SUBASE RI 1997
NSB-NLON, GROTON CONNECTICUT
PAGE 1 OF 3

Chemical	Media[1]		Groundwater & Surface Water COC Screening Level[2] (µg/L)	Groundwater			Surface Water		
				Drinking Water Standards		State Remediation Standards[5]	Federal AWQC[6]	State WQS[7]	
	GW	SW		Federal MCL/MCLG[3] (µg/L)	State MCL[4] (µg/L)	Groundwater Protection (µg/L)	Consumption of Organisms/Water & Organisms (µg/L)	Salt Water Chronic (µg/L)	Consumption of Organisms/Water & Organisms (µg/L)
VOLATILE ORGANICS									
1,1,1-Trichloroethane	X	ND	5.4	200	200	200	1030000 / 18400	NA	NA
1,1-Dichloroethane	X	ND	81	NA	NA	70	NA	NA	NA
1,1-Dichloroethene	X	ND	0.044	7	7	7	3.2 / 0.057	NA	3.2 / 0.057
Benzene	X	ND	0.36	5	5	1	71 / 1.2	NA	71 / 1.2
Carbon disulfide	X	ND	100	NA	NA	700[14]	NA	NA	NA
Chloroform	X	ND	0.15	100/80	100	6	470 / 5.7	NA	470 / 5.7
Ethylbenzene	X	ND	130	700	700	700	29000 / 3100	NA	29000 / 3100
Methylene chloride	X	ND	4.1	5	5	5	1600 / 4.7	NA	1600 / 4.7
Styrene	X	ND	160	100	100	100	NA	NA	NA
Tetrachloroethene	X	ND	1.1	5	5	5	8.85 / 0.8	NA	8.85 / 0.8
Toluene	X	ND	75	1000	1000	1000	200000 / 6800	NA	200000 / 6800
Trichloroethene	X	X	1.6	5	5	5	81 / 2.7	NA	81 / 2.7
Vinyl chloride	X	ND	0.019	2	2	2	525 / 2	NA	525 / 2
Xylenes, Total	X	ND	1200	10000	10000	530	NA	NA	NA
SEMIVOLATILE ORGANICS									
1,2,4-Trichlorobenzene	X	ND	19	70	70	70[14]	NA / 488	NA	NA
1,3-Dichlorobenzene	X	ND	54	600	NA	600	2600 / 400	NA	2600 / 400
2,4-Dimethylphenol	X	ND	73	NA	NA	140[14]	NA	NA	NA
2-Methylnaphthalene	X	ND	15	NA	NA	280[14]	NA	NA	NA
4-Methylphenol	X	ND	18	NA	NA	35[14]	NA	NA	NA
Acenaphthene	X	ND	220	NA	NA	420[14]	2700 / 1200	NA	2700 / 1200
Acenaphthylene	X	ND	NA	NA	NA	420	0.031 / 0.0028	NA	0.031 / 0.0028
Anthracene	X	ND	1100	NA	NA	2000	110000 / 9600	NA	110000 / 9600
Benzo(a)anthracene	X	ND	0.092	NA	NA	0.06	0.031 / 0.0028	NA	0.031 / 0.0028
Benzo(a)pyrene	X	ND	0.0092	2	0.2	0.2	0.031 / 0.0028	NA	0.031 / 0.0028
Benzo(b)fluoranthene	X	ND	0.092	NA	NA	0.08	0.031 / 0.0028	NA	0.031 / 0.0028
Benzo(g,h,i)perylene	X	ND	NA	NA	NA	100[14]	0.0311 / 0.0028	NA	0.031 / 0.0028
Benzo(k)fluoranthene	X	ND	0.92	NA	NA	0.5	0.031 / 0.0028	NA	0.031 / 0.0028
Benzoic acid	X	ND	15000	NA	NA	NA	NA	NA	NA

TABLE 3-7

RISK-BASED COC SCREENING LEVELS AND OTHER HEALTH-BASED STANDARDS - AQUEOUS MEDIA
LOWER SUBASE RI 1997
NSB-NLON, GROTON CONNECTICUT
PAGE 2 OF 3

Chemical	Media[1]		Groundwater & Surface Water COC Screening Level[2] (µg/L)	Groundwater			Surface Water		
				Drinking Water Standards		State Remediation Standards[5]	Federal AWQC[6]	State WQS[7]	
	GW	SW		Federal MCL/MCLG[3] (µg/L)	State MCL[4] (µg/L)	Groundwater Protection (µg/L)	Consumption of Organisms/Water & Organisms (µg/L)	Salt Water Chronic (µg/L)	Consumption of Organisms/Water & Organisms (µg/L)
Bis(2-ethylhexyl)phthalate	X	ND	4.8	6	6	2	5.9 / 1.8	NA	5.9 / 1.8
Butylbenzyl phthalate	X	X	730	NA	NA	1000	5200 / 3000	NA	5200 / 3000
Carbazole	X	ND	3.4	NA	NA	1.8[14]	0.0311 / 0.0028	NA	NA
Chrysene	X	ND	9.2	NA	NA	4.8[14]	0.031 / 0.0028	NA	0.031 / 0.0028
Di-n-butyl phthalate	X	X	370	NA	NA	700	12000 / 2700	NA	12000 / 2700
Di-n-octyl phthalate	X	ND	73	NA	NA	100	NA	NA	NA
Dibenzofuran	X	ND	15	NA	NA	28[14]	NA	NA	NA
Diethyl phthalate	X	ND	2900	NA	NA	5600[14]	120000 / 23000	NA	120000 / 23000
Fluoranthene	X	ND	150	NA	NA	280	370 / 300	NA	370 / 300
Fluorene	X	ND	150	NA	NA	280	14000 / 1300	NA	14000 / 1300
Indeno(1,2,3-CD)pyrene	X	ND	0.092	NA	NA	0.045[14]	0.031 / 0.0028	NA	0.031 / 0.0028
Naphthalene	X	ND	150	NA	NA	280	0.0311 / 0.0028	NA	NA
Phenanthrene	X	ND	NA	NA	NA	200	0.0311 / 0.0028	NA	0.031 / 0.0028
Phenol	X	ND	2200	NA	NA	4000	4600000 / 21000	NA	4600000 / 21000
Pyrene	X	ND	110	NA	NA	200	11000 / 960	NA	11000 / 960
PESTICIDES/PCBS									
Endrin aldehyde		X	NA	NA	NA	NA	0.81 / 0.76	NA	0.81 / 0.76
METALS									
Aluminum	X	X	3700	50 to 200[10]	NA	NA	NA	NA	NA
Antimony	X	ND	1.5	6	6	6	4300 / 14.0	NA	4300 / 14
Arsenic	X	ND	0.045	50	50	50	0.14 / 0.018	36	0.14 / 0.018
Barium	X	X	260	2000	2000	1000	NA	NA	NA
Beryllium	X	ND	0.016	4	4	4	0.131 / 0.0076	NA	0.13 / 0.0077
Boron	X	X	330	NA	NA	630[14]	NA	NA	NA
Cadmium	X	X	1.8	5	5	5	170 / 10	9.3	170 / 16
Calcium	X	X	NA	NA	NA	NA	NA	NA	NA
Chromium (total)	X	X	18[8]	100	100	50	1200 / 160[8]	50[8]	3400 / 170[8]
Cobalt	X	ND	220	NA	NA	420[14]	NA	NA	NA
Copper	X	ND	150	1300[11]	NA	1300	NA / 1300	2.4	NA / 1300
Iron	X	X	1100	300[10]	NA	NA	NA / 300	NA	NA

TABLE 3-7

RISK-BASED COC SCREENING LEVELS AND OTHER HEALTH-BASED STANDARDS - AQUEOUS MEDIA
LOWER SUBASE RI 1997
NSB-NLON, GROTON CONNECTICUT
PAGE 3 OF 3

Chemical	Media[1]		Groundwater & Surface Water COC Screening Level[2] (µg/L)	Groundwater			Surface Water		
				Drinking Water Standards		State Remediation Standards[5]	Federal AWQC[6]	State WQS[7]	
	GW	SW		Federal MCL/MCLG[3] (µg/L)	State MCL[4] (µg/L)	Groundwater Protection (µg/L)	Consumption of Organisms/Water & Organisms (µg/L)	Salt Water Chronic (µg/L)	Consumption of Organisms/Water & Organisms (µg/L)
Lead	X	X	15	15[11]	NA	15	NA / 50	8.1	NA / 50
Magnesium	X	X	NA	NA	NA	NA	NA	NA	NA
Manganese	X	X	84	50[10]	5000[12]	160[14]	100 / 50	NA	NA
Mercury	X	X	1.1	2	2	2	0.15 / 0.14	0.025	0.15 / 0.14
Nickel	X	ND	73	100	100	100	4600 / 610	8.2	4600 / 610
Potassium	X	X	NA	NA	NA	NA	NA	NA	NA
Selenium	X	ND	18	50	50	50	6800 / 104	71	6800 / 100
Silver	X	ND	18	100[10]	50	36	NA / 91	NA	65000 / 105
Sodium	X	X	NA	NA	28000[13]	NA	NA	NA	NA
Thallium	X	ND	0.26[9]	2	2	5	6.3 / 1.7	NA	6.3 / 1.7
Vanadium	X	X	26	NA	NA	50	NA	NA	NA
Zinc	X	X	1100	5000	NA	5000	NA	81	NA
TOTAL PETROLEUM HYDROCARBONS									
TPH	X	ND	NA	NA	NA	500	NA	NA	NA

1 X - Indicates that chemical was detected in this medium.
2 For residential tap water ingestion, based on current USEPA Region III guidance (USEPA, 1997c).
3 Maximum Contaminant Level/Maximum Contaminant Level Goal (USEPA, 1996e).
4 Title 19, Health and Safety, the Public Health Code of the State of Connecticut, Chapter II Environmental Health.
5 CTDEP, 1996.
6 40 CFR 131.36; USEPA, 1990. Ambient Water Quality Criteria (USEPA, 1996).
7 CTDEP, 1997. Connecticut Water Quality Standards. Chronic values for saltwater bodies and protection of human health values for water and organisms are presented.
8 Hexavalent Chromium.
9 Thallic Oxide.
10 Secondary MCL (SMCL) based on aesthetic water qualities.
11 Action level.
12 Current Connecticut Department of Public Health and Addiction Services Action level.
13 Notification Level.
14 No value promulgated by CTDEP, calculated value used.
ND Not Detected
NA Not available

TABLE 3-8

RISK-BASED COC SCREENING LEVELS AND OTHER HEALTH-BASED STANDARDS - SOLID MEDIA
LOWER SUBASE RI 1997
NSB-NLON, GROTON, CONNECTICUT
PAGE 1 OF 3

Chemical	Media[1]		COC Screening Level[2]		Soil/Sediment				
					USEPA SSLs[3]			State Remediation Standards[4]	
	Soil/ Sed	Fish	Soil/Sediment (mg/kg)	Finfish/Shellfish (mg/kg)	Ingestion (mg/kg)	Inhalation (mg/kg)	Migration to Groundwater (mg/kg)	Residential/ Industrial District Exposure (mg/kg)	GB Pollutant Mobility (mg/kg)
VOLATILE ORGANICS									
1,1,1-Trichloroethane	X	ND	160	12	NA	1200	0.1	500 / 1000	40
2-Butanone	X	X	4700	81	NA	NA	NA	500 / 1000	80
Acetone	X	X	780	14	7800	100000	0.8	500 / 1000	140
Benzene	X	X	22	0.11	22	0.8	0.002	21/ 200	0.2
Carbon Disulfide	X	ND	780	14	7800	720	2	500 / 1000[9]	140
Chloroform	X	X	100	0.52	100	0.3	0.03	100 / 940	1.2
Ethylbenzene	X	X	780	14	7800	400	0.7	500 / 1000	10
Methylene Chloride	X	X	85	0.42	85	13	0.001	82 / 760	1
Tetrachloroethene	X	X	12	0.061	12	11	0.003	12 / 110	1
Toluene	X	X	1600	27	16000	650	0.6	500 / 1000	67
Trichloroethene	X	X	58	0.29	58	5	0.003	56 / 520	1
Xylenes, Total	X	X	16000	270	160000[8]	410[8]	9[8]	500 / 1000	19.5
SEMIVOLATILE ORGANICS									
2,4-Dimethylphenol	X	ND	160	2.7	1600	NA	0.4	1000 / 2500[9]	28
2-Methylnaphthalene	X	X	310	NA	NA	NA	NA	1000 / 2500[9]	56
4-Chloro-3-methylphenol	X	ND	NA	NA	NA	NA	NA	NA	NA
Acenaphthene	X	X	470	8.1	4700	NA	29	1000 / 2500[9]	84
Acenaphthylene	X	ND	NA	NA	NA	NA	NA	1000 / 2500	84
Anthracene	X	ND	2300	41	23000	NA	590	1000 / 2500	400
Benzo(a)anthracene	X	ND	0.88	0.0043	0.9	NA	0.08	1 / 7.8	1
Benzo(a)pyrene	X	ND	0.088	4.3E-4	0.09	NA	0.4	1 / 1	1
Benzo(b)fluoranthene	X	ND	0.88	0.0043	0.9	NA	0.2	1 / 7.8	1
Benzo(g,h,i)perylene	X	ND	NA	NA	NA	NA	NA	1000 / 2500[9]	40
Benzo(k)fluoranthene	X	ND	8.8	0.043	9	NA	2	8.4 / 78	1
Bis(2-ethylhexyl)phthalate	X	X	46	0.23	46	31000	180	44 / 410	1
Butylbenzyl phthalate	X	X	1600	27	16000	930	810	1000 / 2500	200
Carbazole	X	ND	32	0.16	32	NA	0.03	31 / 290[9]	0.36
Chrysene	X	ND	88	0.43	88	NA	8	84 / 780[9]	0.96
Di-n-butyl phthalate	X	X	780	14	7800	2300	270	1000 / 2500	140
Di-n-octyl phthalate	X	X	160	2.7	1600	10000	10000	1000 / 2500	20
Dibenzo(a,h)anthracene	X	ND	0.088	4.3E-4	0.09	NA	0.08	0.084 / 0.78[9]	0.00096
Dibenzofuran	X	X	31	0.54	NA	NA	NA	270 / 2500[9]	5.6

TABLE 3-8

RISK-BASED COC SCREENING LEVELS AND OTHER HEALTH-BASED STANDARDS - SOLID MEDIA
LOWER SUBASE RI 1997
NSB-NLON, GROTON, CONNECTICUT
PAGE 2 OF 3

Chemical	Media[1]		COC Screening Level[2]		Soil/Sediment				
					USEPA SSLs[3]			State Remediation Standards[4]	
	Soil/ Sed	Fish	Soil/Sediment (mg/kg)	Finfish/Shellfish (mg/kg)	Ingestion (mg/kg)	Inhalation (mg/kg)	Migration to Groundwater (mg/kg)	Residential/ Industrial District Exposure (mg/kg)	GB Pollutant Mobility (mg/kg)
Diethyl phthalate	X	X	6300	110	63000	2000	23	1000 / 2500[9]	1100
Fluoranthene	X	X	310	5.4	3100	NA	210	1000 / 2500	56
Fluorene	X	X	310	5.4	3100	NA	28	1000 / 2500	56
Indeno(1,2,3-CD)pyrene	X	ND	0.88	0.0043	0.9	NA	0.7	0.84 / 7.8[9]	0.0096
Naphthalene	X	X	310	5.4	3100	NA	4	1000 / 2500	56
Phenanthrene	X	X	NA	NA	NA	NA	NA	1000 / 2500[9]	56
Phenol	X	ND	4700	81	47000	NA	5	1000 / 2500	800
Pyrene	X	X	230	4.1	2300	NA	210	1000 / 2500	40
PESTICIDES/PCBS									
4,4'-DDD	X	X	2.7	0.013	3	NA	0.8	2.6 / 24[9]	0.029
4,4'-DDE	X	X	1.9	0.0093	2	NA	3	1.8 / 17[9]	0.021
4,4'-DDT	X	X	1.9	0.0093	2	NA	2	1.8 / 17[9]	0.021
Aldrin	ND	X	0.038	1.9E-4	0.04	3	590	0.036 / 0.34[9]	0.00041
Alpha-BHC	ND	X	0.1	5E-4	0.1	0.8	0.00003	0.097 / 0.91[9]	0.0011
Aroclor-1260	X	ND	0.55	4.1E-4	1	NA	NA	1 / 10	NA
Beta-BHC	ND	X	0.35	0.0018	0.4	NA	0.0001	0.34 / 3.2[9]	0.0039
Dieldrin	ND	X	0.04	2E-4	0.04	1	0.0002	0.038 / 0.36	0.007
Endrin	X	ND	2.3	0.041	23	NA	0.05	20 / 610	NA
Endrin aldehyde	ND	X	NA	NA	NA	NA	NA	20 / 610[9]	NE
Gamma-BHC (lindane)	ND	X	0.49	NA	0.5	NA	0.0005	20 / 610	0.04
Gamma-chlordane	X	X	1.8	0.0024	0.5	NA	NA	0.49 / 2.2[10]	0.066
Heptachlor	ND	X	0.14	7E-4	0.1	0.1	1	0.14 / 1.3	0.013
Heptachlor epoxide	X	X	0.07	0.07	0.07	5	0.03	0.067 / 0.63	0.02
METALS									
Aluminum	X	X	7800	140	NA	NA	NA	NA	NA
Antimony	X	ND	3.1	0.054	31	NA	0.3	27 / 8200	0.06[10]
Arsenic	X	X	0.43	0.0021	0.4	750	1	10 / 10	0.5[10]
Barium	X	X	550	9.5	5500	690000	82	4700 / 1.4E+5	10[10]
Beryllium	X	ND	0.15	7.3E-4	0.1	1300	3	2 / 2	0.04[10]
Boron	X	X	700	12	NA	NA	NA	NA	NA
Cadmium	X	X	3.9	0.068	78	1800	0.4	34 / 1000	0.05[10]
Calcium	X	X	NA	NA	NA	NA	NA	NA	NA

TABLE 3-8

RISK-BASED COC SCREENING LEVELS AND OTHER HEALTH-BASED STANDARDS - SOLID MEDIA
LOWER SUBASE RI 1997
NSB-NLON, GROTON, CONNECTICUT
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Chemical	Media[1]		COC Screening Level[2]		Soil/Sediment				
					USEPA SSLs[3]			State Remediation Standards[4]	
	Soil/ Sed	Fish	Soil/Sediment (mg/kg)	Finfish/Shellfish (mg/kg)	Ingestion (mg/kg)	Inhalation (mg/kg)	Migration to Groundwater (mg/kg)	Residential/ Industrial District Exposure (mg/kg)	GB Pollutant Mobility (mg/kg)
Chromium (total)	X	X	39[5]	0.68[5]	390	270	2	100 / 100[5]	0.5[10]
Cobalt	X	X	470	8.1	NA	NA	NA	1000 / 2500[9]	4.2
Copper	X	X	310	5.4	54	150	NA	2500 / 7.6E+4	13[10]
Cyanide	X	X	160	2.7	1600	NA	2	1400 / 4.1E+4	2[10]
Iron	X	X	2300	41	NA	NA	NA	NA	NA
Lead	X	X	400[6]	NA	400	NA	NA	500 / 1000	0.15[10]
Magnesium	X	X	NA	NA	NA	NA	NA	NA	NA
Manganese	X	X	180	0.68	NA	NA	NA	1600 / 47000[9]	0.5
Mercury	X	X	2.3	0.041	NA	NA	NA	20 / 610	0.02[10]
Nickel	X	X	160	2.7	1600	13000	7	1400 / 7500	1.0[10]
Potassium	X	X	NA	NA	NA	NA	NA	NA	NA
Selenium	X	X	39	0.68	390	NA	0.3	340 / 1E+4	0.5[10]
Silver	X	X	39	0.68	390	NA	2	340 / 1E+4	0.36[10]
Sodium	X	X	NA	NA	NA	NA	NA	NA	NA
Thallium	X	X	0.55[7]	0.0095[7]	NA	NA	0.04	5.4 / 160	0.05[10]
Vanadium	X	X	55	0.95	550	NA	300	470 / 1.4E+4	0.5[10]
Zinc	X	X	2300	41	23000	NA	620	2E+4 / 6.1E+5	50[10]
TOTAL PETROLEUM HYDROCARBONS									
TPH	X	ND	NA	NA	NA	NA	NA	500 / 2500	2500

1 X - Indicates that chemical was detected in this medium.
2 Based on current USEPA Region III guidance (USEPA, 1997c). Residential soil ingestion for soil and sediment. Fish ingestion for finfish and shellfish.
3 USEPA Soil Screening Levels (USEPA, 1996d). For migration to groundwater, values associated with a dilution and attentuation factor (DAF) of 1.0 are used.
4 CTDEP, 1996.
5 Hexavalent chromium.
6 Value is based on OSWER soil screening level for residential land use (USEPA, 1994e).
7 Thallic oxide.
8 O-xylene.
9 No value promulgated by CTDEP, calculated or surrogate value is used. Ceiling limit is used if calculated or surrogate value exceeds the ceiling limit.
10 Criteria in mg/L for Toxicity Characteristic Leaching Procedure (TCLP) or Synthetic Precipitation Leaching Procedure (SPLP) analytical results.
ND Not Detected
NA Not Available

TABLE 3-9

CANCER SLOPE FACTORS FOR CHEMICALS OF CONCERN
LOWER SUBASE RI
NSB-NLON, GROTON, CONNECTICUT

Chemical	Weight of Evidence	CSF Oral $(mg/kg/day)^{-1}$	CSF Inhalation $(mg/kg/day)^{-1}$	Gastrointestinal Absorption Factor	CSF Dermal $(mg/kg/day)^{-1}$
Arsenic	A	1.5E+0[4]	1.51E+1[4]	0.95[7]	1.6E+0
Benzene	A[2]	2.9E-2[2]	2.9E-2[2]	1.0[8]	2.9E-2
Benzo(a)anthracene	B2[2]	7.3E-1[6]	3.1E-1[5]	0.89[17]	8.2E-1
Benzo(b)fluoranthene	B2[2]	7.3E-1[6]	3.1E-1[5]	0.89[17]	8.2E-1
Benzo(k)fluoranthene	B2[2]	7.3E-2[6]	3.1E-2[5]	0.89[17]	8.2E-2
Benzo(a)pyrene	B2[2]	7.3E+0[2]	3.1E+0[5]	0.89[17]	8.2
Beryllium	B2[2]	-	8.4E+0[2][16]	0.05[11]	-
Bis(2-ethylhexyl)phthalate	B2[2]	1.4E-2[2]	1.4E-2[5]	0.55[9]	2.5E-2
Cadmium	B1[2]	-	6.3E+0[2]	0.05[12]	-
Chloroform	B2[2]	6.1E-3[2]	8.05E-2[2]	1.0[10]	6.1E-3
Chromium	A[2][15][23]	-	4.2E+1[2][15]	NA	-
Dibenz(a,h)anthracene	B2[2]	7.3E+0[6]	3.1E+0[5]	0.89[17]	8.2
1,1-Dichloroethene	C[2]	6E-1[2]	1.75E-1[2]	NA	6E-1
Indeno(1,2,3-cd)pyrene	B2[2]	7.3E-1[6]	3.1E-1[5]	0.89[17]	8.2E-1
Lead	B2[2]	-	-	0.5[13]	-
Methylene chloride	B2[2]	7.5E-3[2]	1.65E-3[2]	NA	7.5E-3
Tetrachloroethene	-	5.2E-2[5]	2.0E-3[5]	NA	5.2E-2
Vinyl chloride	-	1.9E+0[3]	3.0E-1[3]	NA	1.9E+0

1 NA - Not Available
2 IRIS, USEPA, 1998.
3 USEPA, 1997b.
4 Proposed based on carcinogenicity.
5 ECAO provisional value, USEPA, Region III, 1997c.
6 USEPA, 1993b and 1994f.
7 ATSDR, 1991a, Arsenic.
8 ATSDR, 1991b, Benzene.
9 ATSDR, 1991e, Bis(2-ethylhexyl)phthalate.
10 ATSDR, 1991d, Chloroform.
11 ATSDR, 1991c, Beryllium.
12 ATSDR, 1993b, Cadmium.
13 ATSDR, 1988 value for children.
14 Withdrawn from IRIS; no other toxicity criteria available.
15 Hexavalent chromium.
16 Used if air concentration is less than 4 $\mu g/m^3$.
17 USEPA Region I, 1998.

TABLE 3-10

ESTIMATED ORDERS OF POTENTIAL POTENCY FOR CARCINOGENIC PAHs[1]
LOWER SUBASE RI
NSB-NLON, GROTON, CONNECTICUT

Chemical	Weight-of-Evidence	Order of Potential Potency
Benzo(a)anthracene	B2	0.1
Benzo(b)fluoranthene	B2	0.1
Benzo(k)fluoranthene	B2	0.01
Benzo(a)pyrene	B2	1.0
Chrysene	B2	0.001
Dibenzo(a,h)anthracene	B2	1.0
Indeno(1,2,3-cd)pyrene	B2	0.1

1 USEPA, 1993b; USEPA Region I, 1994f.

TABLE 3-11

REFERENCE DOSES AND ENDPOINTS/TARGET ORGANS FOR CHEMICALS OF CONCERN
LOWER SUBASE RI
NSB-NLON, GROTON, CONNECTICUT

Chemical	RfD Oral-Chronic (mg/kg/day)	RfD Inhalation-Chronic (mg/kg/day)	Gastrointestinal Absorption Factor	RfD Dermal-Chronic (mg/kg/day)	Toxic Endpoints or Target Organs
Antimony	4E-4[2]	-	0.95[17]	4E-4	Whole body, blood
Arsenic	3E-4[2]	-	0.95[7]	2.8E-4	Skin
Barium	7E-2[2]	1.43E-4[6]	0.05[4]	3.5E-3	Cardiovascular (oral) Fetus (inhalation)
Benzene	3E-3[5]	1.71E-3[5]	1.0[15]	3E-3	Not Reported
Beryllium	5E-3[2]	-	0.05[16]	2.5E-4	Not Reported
Bis(2-ethylhexyl)phthalate	2E-2[2]	-	0.55[13]	1.1E-2	Liver
Boron	9E-2[2]	5.71E-3[6]	0.05[4]	4.5E-3	Testes (oral) Respiratory (inhalation)
Cadmium	5E-4[2]	5.71E-5[5]	0.05[8]	2.5E-5	Kidney
Chloroform	1E-2[2]	-	1.0[9]	1E-2	Liver
Chromium	5E-3[2][20]	-	0.02[11]	1E-4	Not Reported
1,1-Dichloroethene	9E-3[2]	-	NA	9E-3	Liver
Manganese (water)	2.4E-2[19]	-	0.03[10]	7.2E-4	CNS
Manganese (soil)	1.4E-1[19]	1.43E-5[2]	0.03[10]	4.2E-3	CNS
Mercury	3E-4[6]	8.57E-5[6]	0.05[11]	1.5E-5	Kidney (oral) CNS (inhalation)
Methylene chloride	6E-2[2]	8.57E-1[6]	1.0[14]	6E-2	Liver (oral and inhalation)
Nickel	2E-2[2]	-	0.10[12]	2E-3	Whole body, major organs
Selenium	5E-3[2]	-	0.20[18]	1E-3	Whole body
Tetrachloroethene	1E-2[2]	-	NA	1E-2	Liver
Thallium	8E-5[3]	-	0.05[4]	4E-6	Liver, blood, hair
Vanadium	7E-3[6]	-	0.05[4]	3.5E-4	Not Reported

1 NA - Not Available.
2 USEPA, 1998.
3 Value for thallic carbonate.
4 Default value, USEPA, 1989d.
5 ECAO provisional value; USEPA Region III, 1997c.
6 USEPA, 1997b.
7 ATSDR, 1991a, Arsenic.
8 ATSDR, 1993b, Cadmium.
9 ATSDR, 1991d, Chloroform.
10 ATSDR, 1992e, Manganese.
11 ATSDR, 1994a, Mercury.
12 ATSDR, 1991f, Nickel.
13 ATSDR, 1991e, bis(2-ethylhexyl)phthalate.
14 ATSDR, 1993e, Methylene chloride.
15 ATSDR, 1991b, Benzene.
16 ATSDR, 1991c, Beryllium.
17 ATSDR, 1992a, Antimony.
18 USEPA, 1994b.
19 USEPA Region I, 1996f.
20 Hexavalent chromium.

TABLE 3-12

SUMMARY OF RECEPTORS BY SITE
LOWER SUBASE
NSB-NLON, GROTON, CONNECTICUT

Site	Full-Time Employees	Construction Workers	Adult Recreational Users	Future Residents (Adult/Child)
Zone 1	X	X	NA	X
Zone 2	X	X	NA	X
Zone 3	X	X	NA	X
Zone 4	X	X	NA	X
Zone 5	X	X	NA	X
Zone 6	X	X	NA	X
Zone 7	X	X	NA	X
Thames River	NA	NA	X	NA

Notes:

X - Applicable
NA - Not Applicable

TABLE 3-13

SUMMARY OF EXPOSURE ROUTES EVALUATED QUANTITATIVELY
LOWER SUBASE
NSB-NLON, GROTON, CONNECTICUT

Receptors	Exposure Routes[1]
Potentially Complete Exposure Pathways	
Construction Workers	• Soil Ingestion (subsurface and surface) • Inhalation of Air/Dust (subsurface and surface) • Dermal Contact with Groundwater
Full-Time Employees	• Soil Ingestion (surface) • Inhalation of Air/Dust (surface)
Adult Recreational Users[2]	• Surface Water Ingestion (skiing) • Surface Water Dermal Contact (skiing) • Ingestion of Finfish/Shellfish
Incomplete Exposure Pathways	
Future Residents (Adult/Child)[2]	• Soil Ingestion (surface and subsurface) • Inhalation of Air/Dust (surface and subsurface)

1 Dermal risks associated with soil exposures are not addressed quantitatively since cadmium, PCBs, and dioxins were not identified as COCs for the Lower Subase RI sites. A quantitative evaluation of exposure to other COCs is not provided since USEPA Region I does not advocate this type of evaluation.

2 Exposure to groundwater is not evaluated for sites along Thames River because of saline conditions.

TABLE 3-14

EXPOSURE PARAMETERS FOR POTENTIAL FUTURE RESIDENTS[1]
LOWER SUBASE RI
NSB-NLON, GROTON, CONNECTICUT

Exposure Scenario	Parameter (units)	Future Residents[2]			
		Adult		Child	
		RME	CTE	RME	CTE
Soil Ingestion	Exposure Concentration (mg/kg)	95% UCL	95% UCL	95% UCL	95% UCL
	Ingestion Rate (mg/day)	100	50	200	100
	Exposure Frequency (days/yr)	150	150	150	150
	Exposure Duration (yrs)	24	7	6	2
	Body Weight (kg)	70	70	15	15

1 USEPA Region I, 1994f, unless otherwise noted.
2 A 30- and 9-year future resident evaluated (RME AND CTE). Age-adjusted ingestion and dermal contact rates will be used for soil exposures.

TABLE 3-15

EXPOSURE PARAMETERS FOR FULL-TIME EMPLOYEES AND CONSTRUCTION WORKERS[1]
LOWER SUBASE RI
NSB-NLON, GROTON, CONNECTICUT

Exposure Scenario	Parameter (units)	Full-Time Employee		Construction Worker	
		RME	CTE	RME	CTE
Soil Ingestion	Exposure Concentration (mg/kg)	95% UCL	95% UCL	95% UCL	95% UCL
	Ingestion Rate (mg/day)	100	50	480	240[2]
	Exposure Frequency (days/yr)	150	150	120[3]	80[3]
	Exposure Duration (yrs)	25	6[3]	1[3]	1[3]
	Body Weight (kg)	70	70	70	70
Soil Dermal Contact	Exposure Concentration (mg/L)	95% UCL	95% UCL	95% UCL	95% UCL
	Body Surface Area (cm^2)	20000[5]	20000[5]	20000[5]	20000[5]
	Fraction Exposed (forearms, head, hands)	0.19[6]	0.19[6]	0.19[6]	0.19[6]
	Adherence Factor (mg/cm^2)	1.0[5]	0.2[5]	1.0[5]	0.2[5]
	Exposure Frequency (days/yr)	150	150	120[3]	80[3]
	Exposure Duration (yr)	25	6[3]	1[3]	1[3]
	Body Weight (kg)	70	70	70	70
Groundwater Dermal Contact	Exposure Concentration (mg/kg)	NA[4]	NA	Maximum	Average
	Body Surface Area (cm^2)	NA	NA	20000[5]	20000[5]
	Fraction Exposed (forearms, head, hands)	NA	NA	0.19[6]	0.19[6]
	Event Frequency (events/day)	NA	NA	1	1
	Duration of Event (hr/event)	NA	NA	8[2]	8[2]
	Exposure Frequency (days/yr)	NA	NA	120[3]	80[3]
	Exposure Duration (yr)	NA	NA	1[3]	1[3]
	Body Weight (kg)	NA	NA	70	70

1 USEPA Region I, 1994f, unless otherwise noted.
2 Professional judgement.
3 Based on Phase I RI (Atlantic, 1992).
4 NA - Exposure route not evaluated.
5 USEPA, 1992b.
6 USEPA, 1989a.

TABLE 3-16

EXPOSURE PARAMETERS FOR RECREATIONAL USERS[1]
LOWER SUBASE RI
NSB-NLON, GROTON, CONNECTICUT

Exposure Scenario	Parameter (units)	Recreational Users Adult	
		RME	CTE
Surface Water Dermal Contact	Exposure Concentration (mg/L)	95% UCL	95% UCL
	Body Surface Area (cm^2)	20000[2]	20000[2]
	Fraction Exposed (whole body)	1.0[3]	1.0[3]
	Event Frequency (event/day)	1	1
	Duration of Event (hr/event)	4[4] 2.6[5]	2[4] 2.6[5]
	Exposure Frequency (day/yr)	22[4] 16[5]	22[4] 8[5]
	Exposure Duration (yr)	30	9
	Body Weight (kg)	70	70
Surface Water Ingestion	Exposure Concentration (mg/L)	95% UCL	95% UCL
	Contact Rate (L/hr)	0.05[6]	0.05[6]
	Exposure Time (hr/day)	4[4] 2.6[5]	2[4] 2.6[5]
	Exposure Frequency (day/yr)	22[4] 16[5]	22[4] 8[5]
	Exposure Duration (yr)	30	9
	Body Weight (kg)	70	70
Finfish/Shellfish Ingestion	Exposure Concentration (mg/kg)	95% UCL[7] BCF X UCL[8]	95% UCL[7] BCF X UCL[8]
	Ingestion Rate (kg/day)	0.055[7] 0.054[8]	0.003[7] 0.0095[8]
	Exposure Frequency (day/yr)	350	234
	Exposure Duration (yr)	30	9
	Body Weight (kg)	70	70

1 USEPA Region I, 1994f, unless otherwise noted.
2 USEPA, 1992b.
3 Conservative assumption.
4 Professional judgment for swimming.
5 Professional judgment for waterskiing.
6 USEPA, 1988.
7 For shellfish.
8 For finfish. (BCF multiplied by surface water 95% UCL to estimate chemical concentration in finfish tissue.)

TABLE 3-17

RECOMMENDED DERMAL ABSORPTION FACTOR FROM SOIL
LOWER SUBASE RI
NSB-NLON, GROTON, CONNECTICUT

Compound	Dermal Absorption Factor	Reference
Arsenic	0.03	Wester, *et al.* (1993a)
Cadmium	0.01	Wester, *et al.* (1992a) U.S. EPA (1992a)
Chlordane	0.04	Wester, *et al.* (1992b)
2,4,-Dichlorophenoxyacetic acid	0.05	Wester, *et al.* (1996)
DDT	0.03	Wester, *et al.* (1990)
Dioxins TCDD <10% organic soil >10% organic soil	 0.03 0.001	 U.S. EPA (1992a)
Lindane	0.04	Duff & Kissel (1996)
PAHs Benzo(a)pyrene	 0.13	 Wester, *et al.* (1990)
PCBs Aroclor 1254 & 1242	 0.14	 Wester, *et al.* (1993b)
Pentachlorophenol	0.25	Wester, *et al.* (1993c)
Generic defaults *for screening*		
Semivolatile organic compounds	0.1	
Inorganics	0.01	

Source: EPA Region I

TABLE 3-18

SEDIMENT GUIDELINES FOR INORGANICS
LOWER SUBASE RI
NSB-NLON, GROTON, CONNECTICUT

Analyte	Sediment Guideline (mg/kg)	Sediment Guideline Source
Aluminum	27,000	WSDE, 1994
Antimony	2	ER-L (Long et al. 1995)
Arsenic	8.2	ER-L (Long et al. 1995)
Barium	20	Region 5 USEPA (FW)
Berillium	NA	NA
Boron	NA	NA
Cadmium	1.2	ER-L (Long et al. 1995)
Chromium	81	ER-L (Long et al. 1995)
Cobalt	NA	NA
Copper	34	ER-L (Long et al. 1995)
Iron	20,000	MOE LEL (1992) (FW)
Lead	46.7	ER-L (Long et al. 1995)
Manganese	460	MOE LEL (1992) (FW)
Mercury	0.15	ER-L (Long et al. 1995)
Nickel	20.9	ER-L (Long et al. 1995)
Selenium	0.1	WSDE, 1994
Silver	1.0	ER-L (Long et al. 1995)
Thallium	NA	NA
Vanadium	NA	NA
Zinc	150	ER-L (Long et al. 1995)

NA = Not Available
WSDE = Washington State Department of Ecology
MOE = Ontario Ministry of the Environment
LEL = Lowest Effects Level
FW = Fresh water

TABLE 3-19

WATER QUALITY GUIDELINES AND OCTANOL/ WATER PARTITION COEFFICIENTS
FOR EQUILIBRIUM PARTITIONING
LOWER SUBASE RI
NSB-NLON, GROTON, CONNECTICUT
PAGE 1 OF 2

Analyte	Water Quality Guideline (ug/L)	Water Quality Guideline Source	K_{ow} (log)	K_{ow} Source
Acenaphthene	40	Final Chronic Value (USEPA,1996a)	3.92	USEPA, 1992a
Acenaphthylene	230	ECOSAR (USEPA, 1994b)	4.07	USEPA, 1992a
Anthracene	130	ECOSAR (USEPA, 1994b)	4.45	USEPA, 1992a
Benzo(a)anthracene	16	ECOSAR (USEPA, 1994b)	5.61	USEPA, 1992a
Benzo(a)pyrene	0.01	ECOTOX (USEPA, 1995b)	5.98	USEPA, 1992a
Benzo(b)fluoranthene	3	ECOSAR (USEPA, 1994b)	6.57	USEPA, 1992a
Benzo(g,h,i)perylene	3	ECOSAR (USEPA, 1994b)	7.23	USEPA, 1992a
Benzo(k)fluoranthene	1	ECOSAR (USEPA, 1994b)	6.84	USEPA, 1992a
Carbazole	1200	ECOSAR (USEPA, 1994b)	3.29	USEPA, 1992a
Chrysene	16	CAWQC	5.61	USEPA, 1992a
Di-n-butyl phthalate	33	ECOTOX (USEPA, 1995b)	5.2	USEPA, 1992a
Dibenzo(a,h)anthracene	9	ECOSAR (USEPA, 1994b)	5.97	USEPA, 1992a
Dibenzofuran	20	ECOTOX (USEPA, 1995b)	4.12	USEPA, 1992a
Fluoranthene	11	Final Chronic Value (USEPA,1996a)	5.33	USEPA, 1992a
Fluorene	3.9	CAWQC	4.18	USEPA, 1992a
Indeno(1,2,3-cd)pyrene	3	ECOSAR (USEPA, 1994b)	7.66	USEPA, 1992a
Naphthalene	24	ECOTOX (USEPA, 1995b)	3.37	USEPA, 1992a
Phenanthrene	8.3	Final Chronic Value (USEPA,1996a)	4.46	USEPA, 1992a
Pyrene	33	CAWQC	5.18	USEPA, 1992a
2-butanone	220000	ECOSAR (USEPA, 1994b)	0.26	USEPA, 1992a
Acetone	490000	ECOSAR (USEPA, 1994b)	0.24	USEPA, 1992a
Phenol	58	Acute AWQC/100	1.46	USEPA, 1992a
2-methylnapthalene	330	ECOSAR (USEPA, 1994b)	3.86	USEPA, 1992a
4-methylphenol	NA	NA	NA	NA

TABLE 3-19

WATER QUALITY GUIDELINES AND OCTANOL/ WATER PARTITION COEFFICIENTS
FOR EQUILIBRIUM PARTITIONING
LOWER SUBASE RI
NSB-NLON, GROTON, CONNECTICUT
PAGE 2 OF 2

Analyte	Water Quality Guideline (ug/L)	Water Quality Guideline Source	K_{ow} (log)	K_{ow} Source
Dimethyl phthalate	580	USEPA Region 4 (USEPA, 1995e)	1.87	USEPA, 1992a
Bis(2-ethylhexyl)phthalate	32	ECOTOX (USEPA, 1995b)	5.3	USEPA, 1992a
Di-n-octyl phthalate	62	ECOSAR (USEPA, 1994b)	9.2	USEPA, 1992a
4,4'-ddt	0.001	CAWQC	6.8	Karickoff, 1996
4,4'-ddd	0.001	CAWQC	6.06	Karickoff, 1996
4,4'-dde	0.001	CAWQC	6.76	Karickoff, 1996
Gamma-bhc (lindane)	0.08	ECOSAR (USEPA, 1994b)	3.24	USEPA, 1992a
Aldrin	0.03	CAWQC	5.11	USEPA, 1992a
Aroclor-1248	0.03	CAWQC	5.76	USEPA, 1992a
Aroclor-1254	0.03	CAWQC	6.04	USEPA, 1992a
Aroclor-1260	0.03	CAWQC	7.15	USEPA, 1992a
Beta-bhc	0.08	CAWQC for Gamma BHC	3.8	USEPA, 1992a
Delta-bhc	0.08	CAWQC for Gamma BHC	6.14	USEPA, 1992a
Dieldrin	0.11	Final Chronic Value (USEPA,1996a)	5.37	Karickoff, 1996
Endosulfan i	0.051	CAWQC for Endosulfan II	4.2	USEPA, 1992a
Endosulfan sulfate	0.051	CAWQC for Endosulfan II	4.52	USEPA, 1992 a
Endrin	0.01	Final Chronic Value (USEPA,1996a)	5.2	Karickoff, 1996
Endrin aldehyde	0.01	Final Chronic Value (USEPA,1996a)	5.6	USEPA, 1992a
Heptachlor epoxide	0.0036	CAWQC	4.95	Karickoff, 1996
Methoxychlor	0.03	CAWQC	4.68	USEPA, 1992a
Hexachlorocyclopentadiene	NA	NA	NA	NA

K_{ow} - octanol/water partition coefficient
CAWQC - Chronic abient water quality critieria
NA - Not available

TABLE 3-20

PERCENT TOTAL ORGANIC CARBON (TOC) VALUES USED FOR SEDIMENT GUIDELINE CALCULATION LOWER SUBASE RI NSB-NLON, GROTON, CONNECTICUT

Zone	Phase II RI/Lower[1] Subase RI Data Set
1	4.23 (0.13 - 6.1)
2	4.30 (1.20 - 6.4)
3	3.67 (0.11 - 6.7)
4	3.33 (0.12 - 7.0)
5	2.63 (0.18 - 4.7)
6	2.73 (0.20 - 5.9)
7	6.00 (5.20 - 6.8)

1 Average value per zone (range in parentheses)

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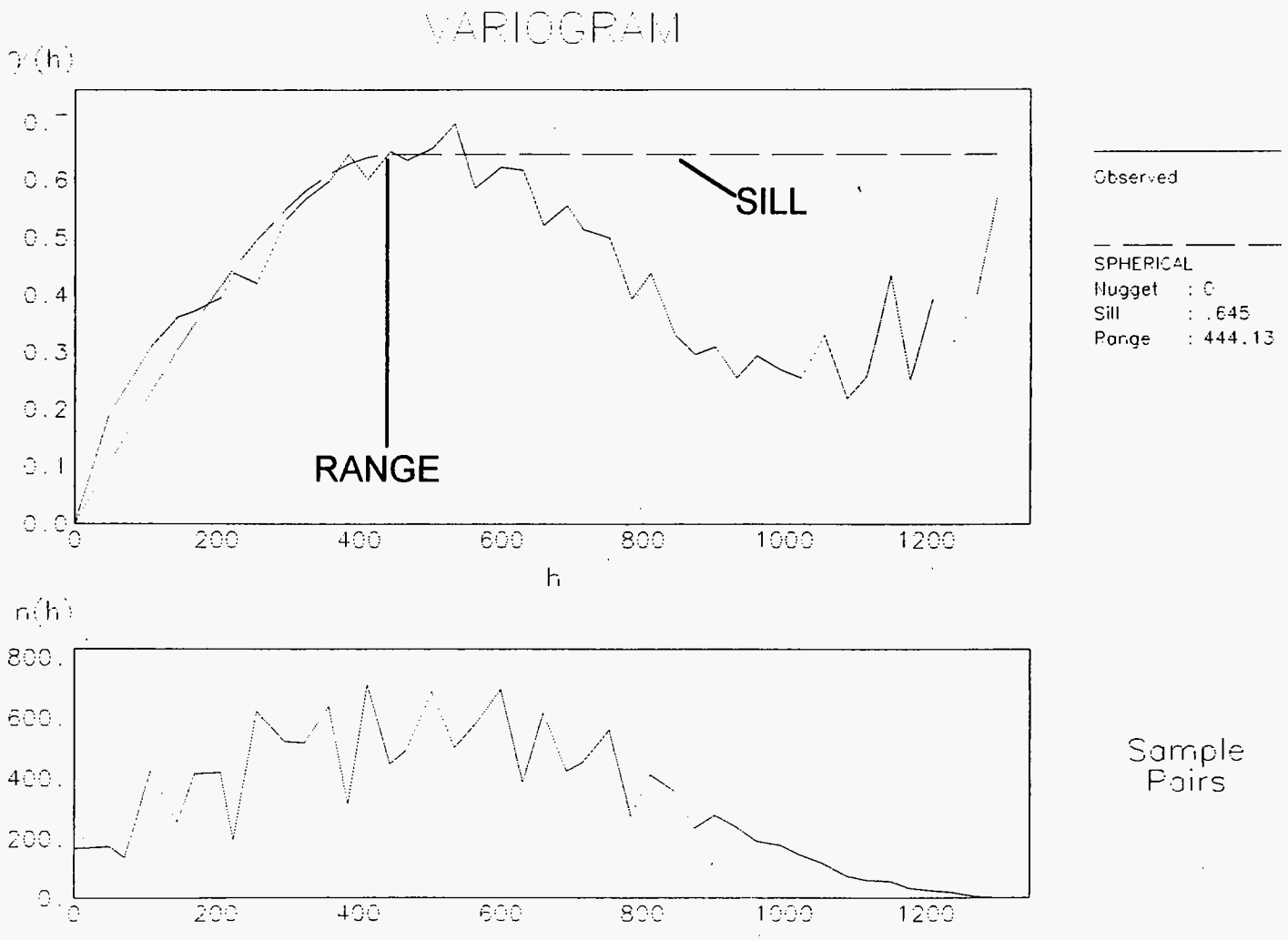

MODELED VERSUS OBSERVED VARIOGRAMS
LOWER SUBASE RI
NSB-NLON, GROTON, CONNECTICUT

FIGURE 3-1

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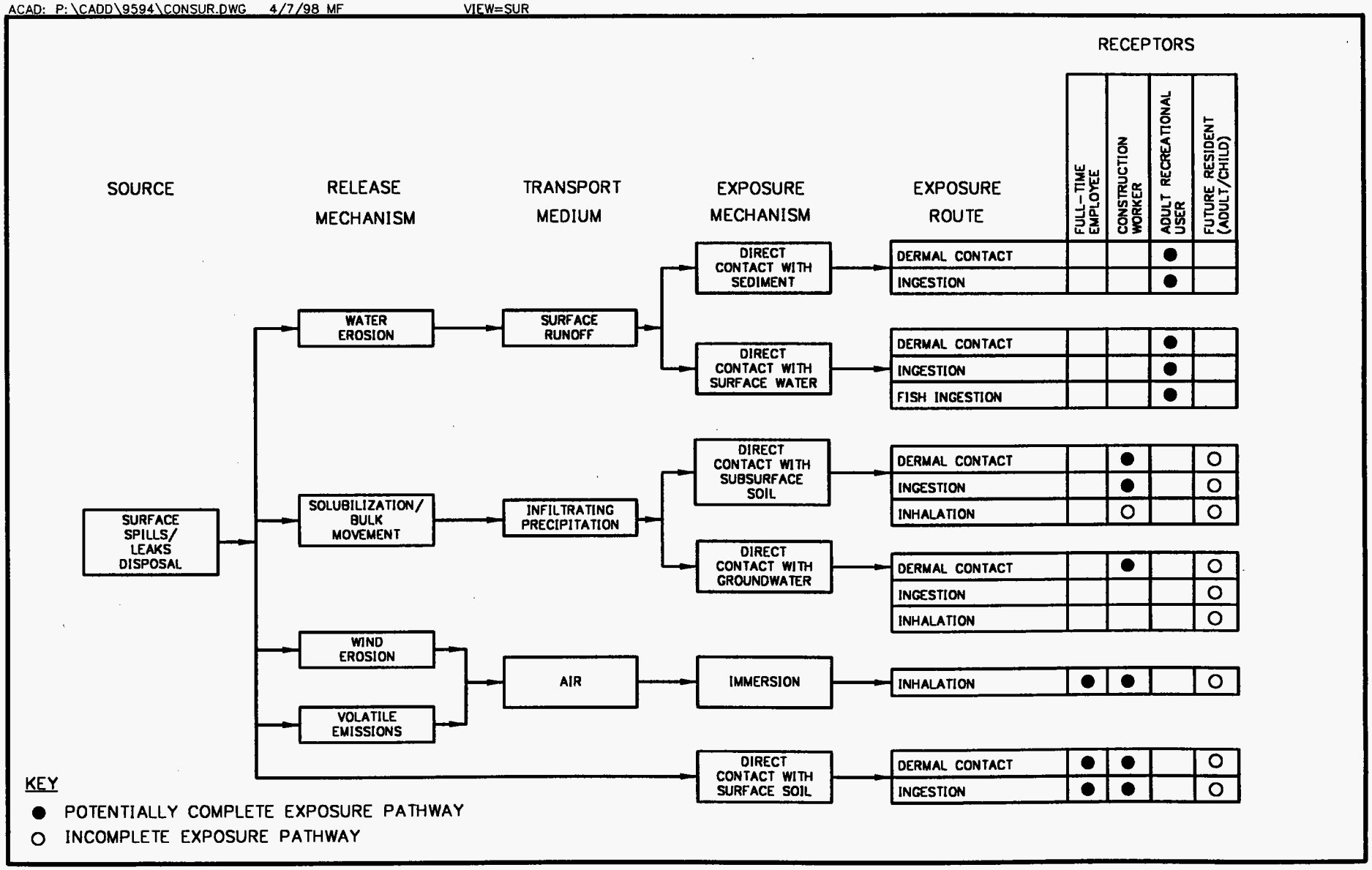
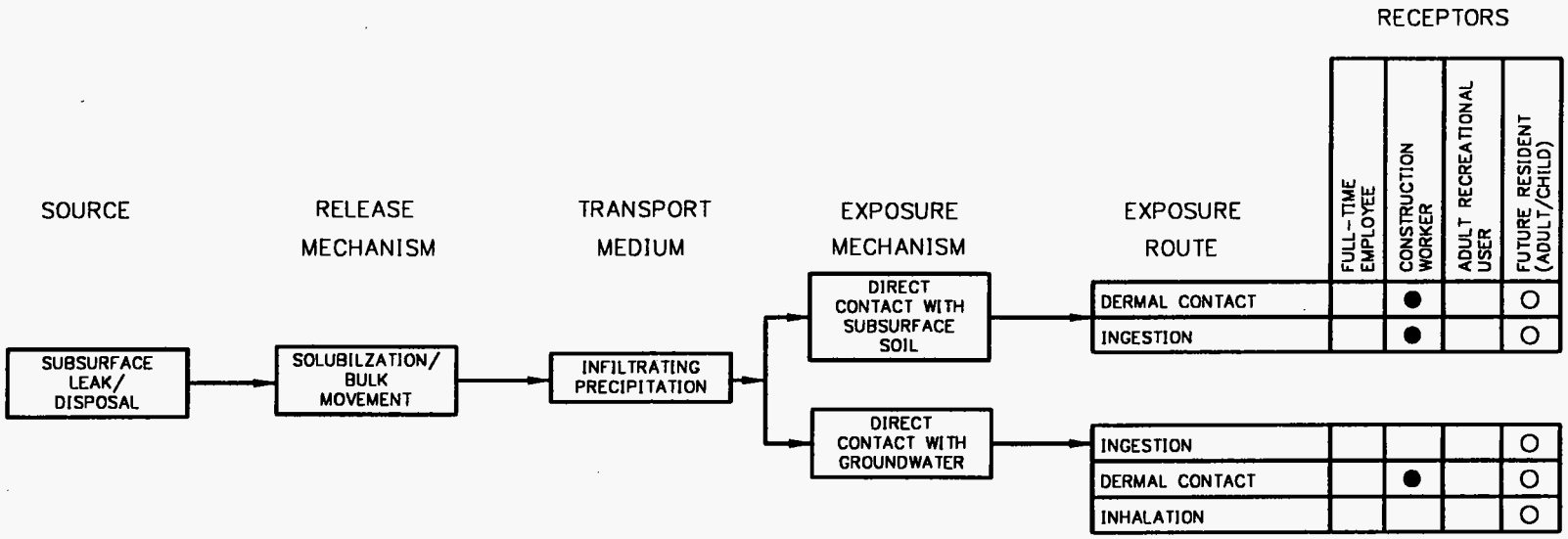


CONCEPTUAL SITE MODEL – SURFACE SOURCES
LOWER SUBASE RI
NSB-NLON, GROTON, CONNECTICUT

FIGURE 3-2

Brown & Root Environmental



KEY

● POTENTIALLY COMPLETE EXPOSURE PATHWAY

○ INCOMPLETE EXPOSURE PATHWAY

CONCEPTUAL SITE MODEL – SUBSURFACE SOURCES
LOWER SUBASE RI
NSB-NLON, GROTON, CONNECTICUT

FIGURE 3-3

Brown & Root Environmental

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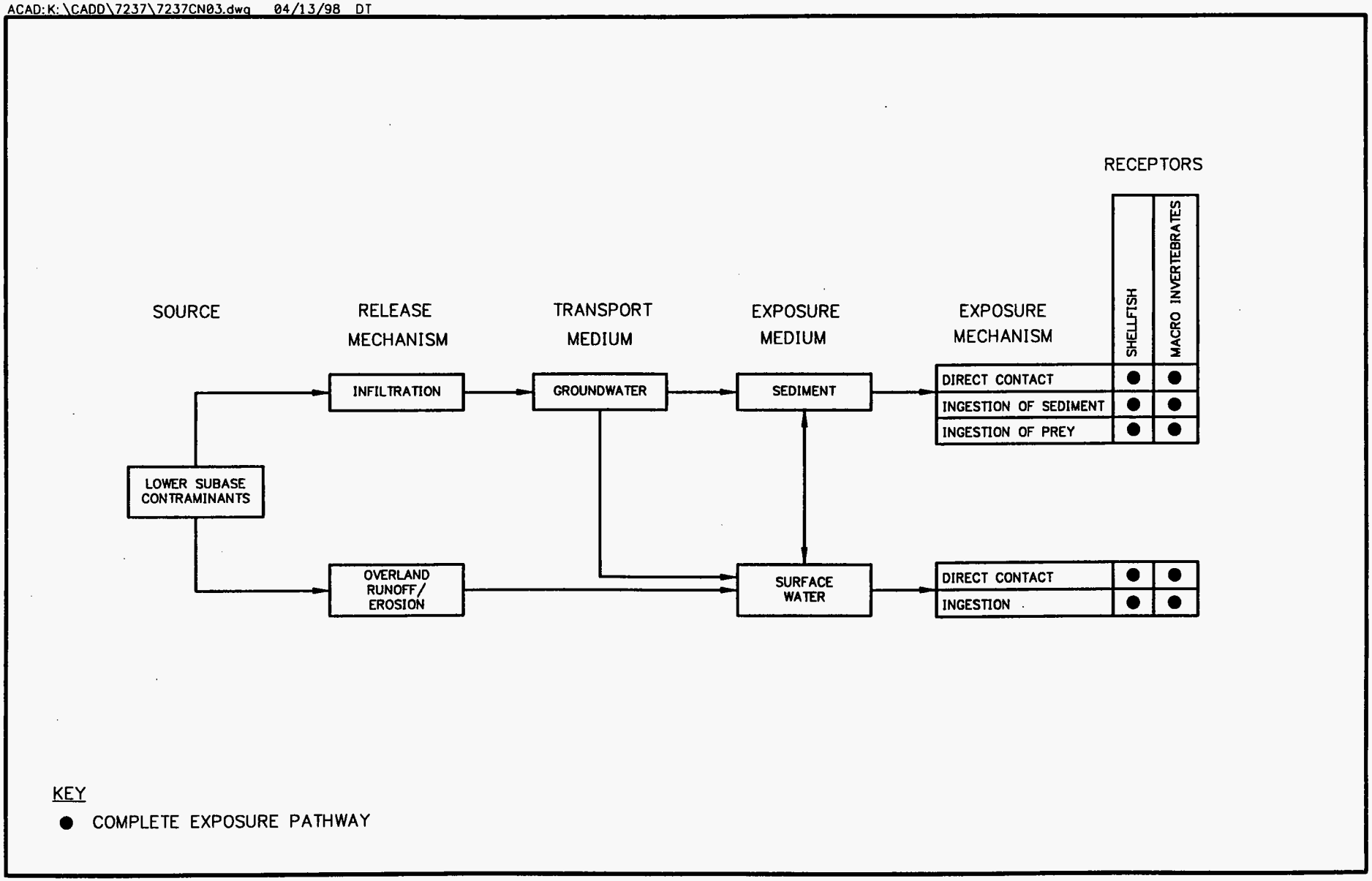

FIGURE 3-4

CONCEPTUAL SITE MODEL – ZONES 1-7
LOWER SUBASE RI
NSB-NLON, GROTON, CONNECTICUT

Brown & Root Environmental

4.0 ZONE 1

4.1 SITE DESCRIPTION

Zone 1 extends from Darter Road, south of Building 89, to the south side of Corvina Road. The principal building within Zone 1 is the power plant (Building 29). Environmental investigations have been performed at two sites within this zone (Site 10 - Fuel Storage Tanks and Tank 54-H and Site 11 - Power Plant Oil Tanks) and one site adjacent to this zone (Building 89 UST). The Building 89 UST site is located directly adjacent to Zone 1 and is considered a Zone 1 site for purposes of this RI even though, technically, it falls outside the Zone 1 boundary. Zone 1 and the site boundaries are shown on Figure 4-1. Fuel oil distribution lines and steam, condensate, and electrical ducts within Zone 1 are also illustrated in Figure 4-1. Photographs of Zone 1 sites are provided in Appendix G.

4.1.1 Site 10 - Lower Subase - Fuel Storage Tanks and Tank 54-H

Five concrete USTs, located southwest of Building 107 were placed in service during World War II. Three of the tanks (E, F, and G) had 125,000-gallon capacities and were used to store diesel fuel from 1942 to 1987. Tanks K and L were used to store lubrication and hydraulic oils from 1954 to 1989; each had a 25,000-gallon capacity. A sixth tank (Tank 54-H) was located adjacent to and north of Tank E. This tank had a 30,000-gallon capacity and was used as a reclamation tank for the other five tanks. Tanks E, F, and G were decommissioned in 1987. Tank 54-H has also been decommissioned. Tanks K and L were decommissioned in 1989, and new steel tanks have been installed within the shells of these two tanks.

4.1.2 Site 11 - Lower Subase - Power Plant Oil Tanks

Four underground tanks (A, B, C, and D) were located adjacent to and east of the power plant (Building 29); each had a 170,000-gallon capacity. Tanks A and B were used to store No. 6 fuel oil, which was pumped from the tank farm at the south end of NSB-NLON. Tank C was used to store diesel oil, and Tank D was used to store waste oil generated by the bilge water oil recovery system at the power plant. The tanks have been in place since World War II. 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 150,000-gallons steel tanks.

4.1.3 Building 89 UST

UST Z01 was installed adjacent to the southwestern corner of Building 89 in 1982. The tank was used to store No. 2 fuel oil for power motors operated in Building 89. The tank was constructed of lined steel and

had a capacity of 3,000 gallons. The bottom of the tank was approximately 8 feet below ground surface. Because of the shallow groundwater (approximately 7 feet below ground surface) in the vicinity, the tank was attached to a concrete tie-down pad with steel tie downs to prevent flotation. The tank was tested twice: once in 1992 when the tightness testing results were inconclusive and once in 1993 when the tank failed tightness testing. The tank was drained of its contents and, in early 1994, the tank and the associated piping were excavated and removed from the site. Post-excavation sampling was conducted by Brown & Root Environmental (B&R Environmental, 1996).

4.1.4 Fuel Oil Distribution Lines and Utility Ducts

Fuel oil distribution lines and utility ducts and trenches run through Zone 1. A description of the fuel oil distribution system is provided in Section 1.4.1.3 and a description of the utility (steam, condensate, and electrical) ducts and trenches is provided in Section 1.4.1.4. The locations of the fuel distribution lines and the utility ducts are shown in Figure 4-1. In 1996, pressure leak testing was performed on the lines and valves in the fuel distribution system within and adjacent to Zone 1. The results of this testing program are presented in Section 4.2.7.

4.1.5 Storm Sewers

As can be seen on Figure 4-1, three storm sewers discharge to the Thames River from Zone 1 and the area immediately north of Zone 1. Invert elevations for the storm sewer outfalls to the Thames River were not readily available; however, invert elevations for several catch basins upgradient of the outfalls were available. The invert elevations for the catch basins ranged from 1.68 feet msl (Catch Basin No. 919 on the north side of Building 29) to 3.79 feet msl [Catch Basin 513 (BLDG89) on the south side of Building 89]. These elevations were taken from the Navy drawing, *Utility Map, Storm Drainage* (Drawing Number 1142295, Sheet 2 of 19, July 27, 1967). The elevation of the Thames River fluctuates daily and seasonally, but the elevation of the river typically ranges between approximately 0.00 feet msl to 4.00 feet msl. Therefore, the storm sewer system will be submerged to varying degrees depending on the time of day and time of year. A typical cross-section for Zones 1 through 4, showing the storm sewer system and the variation in the tides, is provided on Figure 1-4 in Section 1.0.

In accordance with the requirements of the basewide General NPDES Stormwater Permit, the storm sewer adjacent to the southeastern corner of Building 89 is monitored annually. This storm sewer sampling location, referred to as BLDG 89 and shown on Figure 4-1, was last sampled during a storm event on October 2, 1996. Results of the chemical and toxicity testing performed on this storm water are presented in Section 4.2.11.

4.2 SITE INVESTIGATIONS

The following investigations were conducted at Zone 1 and are discussed in the subsections that follow:

- Oil Contamination of Groundwater at Subase New London (NESO, 1979)
- Final Initial Assessment Study (Envirodyne, 1983)
- Final Site Investigation - Subsurface Oil Contamination (Wehran, 1987)
- Hydrogeologic Investigation Underground Storage Tanks OT-4, OT-7, OT-8, OT-9, and Tank 54-H (Fuss & O'Neill, 1989)
- Phase I Remedial Investigation (Atlantic, 1992)
- Site Characterization Report for OT-10, Building 325, and Building 89 (B&R Environmental, 1996)
- Leak Testing Investigation for Fuel Oil Distribution System (Heitkamp, 1996)
- Existing Data Summary Report for Lower Subase Remedial Investigation (B&R Environmental, 1997a)
- Phase II Remedial Investigation (B&R Environmental, 1997b)
- Site Investigation Report for Tank Farm Investigation (B&R Environmental, 1997c)
- Annual NPDES Stormwater Monitoring Program (Navy, 1997)

4.2.1 Oil Contamination of Groundwater at Subase New London

In 1979, the Navy Environmental Support Office (NESO) conducted a study to identify the source and extent of oil found in soils along the Thames River at three sites on the Lower Subase. The three sites are Building 29 Power Plant Oil Tanks (Site 11), Building 107/345 Fuel Storage Tanks (Site 10), and Building 79 Waste Oil Pit (Site 13). NESO drilled a total of 12 soil borings and installed piezometers in each soil boring. Soil samples collected from each boring were analyzed for oil content. Groundwater samples were collected from each piezometer to check for the presence of oil and, where oil was present, to measure product thickness.

Four borings/piezometers were installed during this study at Zone 1 (NESO2, 3, 4, and 7). One boring/ piezometer, NESO1, was installed just north of Zone 1. Sample locations are shown on Figure 4-1. Oil and grease content in soils ranged from 400 ppm to 32,900 ppm. Oil content in groundwater samples ranged from 20 ppm to 670 ppm. The study found oil extending toward the Thames River near the Power Plant Oil Tanks (Site 11). Significant contamination was not detected at Building 107/345 (Site 10); however, the report recommended monitoring of the groundwater around Building 107.

4.2.2 Final Initial Assessment Study

In 1982, Envirodyne Engineers performed an Initial Assessment Study (IAS) at NSB-NLON as part of the Navy Assessments and Control of Installation Pollutants (NACIP) program. The purpose of this study was to identify and evaluate past waste disposal practices and to assess the potential for environmental impacts. Envirodyne reviewed installation records, interviewed long-term and former employees, toured the installation, and photographed sites as part of the IAS.

Envirodyne identified 11 sites at NSB-NLON as having contained hazardous material; two sites are located within Zone 1 (Sites 10 and 11). The IAS concluded that there was some measurable leakage from the tanks at Site 10 and recommended monitoring of the tank levels to see if the tanks were leaking. For Site 11, the report concluded that there was leakage from the tanks, and the petroleum had migrated to the groundwater, the steam, the fuel pipeline tunnels and the underground vaults. The IAS recommended replacing the tanks at Site 11 and implementing oil recovery.

4.2.3 Final Site Investigation - Subsurface Oil Contamination

In 1987, Wehran Engineering Corporation completed an investigation to identify and delineate the sources of heavy oils in the subsurface of the Lower Subase (Sites 10, 11, and 13). Activities during the investigation included collecting soil samples from soil borings, oil samples from manholes and trenches, and groundwater samples from monitoring wells. These samples were tested to identify the type, degree of weathering, and general concentrations of oil contamination at the three sites. One oil sample (MH-5) and one groundwater sample from an existing monitoring well (NESO4) were collected in Zone 1. Soil borings and groundwater monitoring wells were not installed in Zone 1 as part of this investigation.

Wehran identified one area within Zone 1 that was contaminated with heavy oil. This area, electrical conduits and manholes along Corvina Road, contained a mixture of No. 5 and No. 6 fuel oils. Wehran recommended that further review of the operation and distribution of oil in Building 29 be conducted.

4.2.4 Hydrogeologic Investigation, USTs OT-4, OT-7, OT-8, OT-9, and Tank 54-H

In 1989, Fuss & O'Neill conducted a hydrogeologic investigation of two UST areas at NSB-NLON: one at the tank farm located southeast of the Lower Subase (OT-4, OT-7, OT-8, and OT-9) and the other in Zone 1 (Tank 54-H) of the Lower Subase. The study was initiated as a result of subsurface soil contamination encountered during construction activities in the two areas. At Zone 1, four monitoring wells (FOMW-13 through 16) were installed around Tank 54-H. Soil samples were collected from each well and field screened with an organic vapor analyzer (OVA). Groundwater samples from each of the

monitoring wells were analyzed by a laboratory for volatile aromatic hydrocarbons and scanned for petroleum products.

No. 2 fuel oil was detected in monitoring wells at Tank 54-H ranging in concentrations from 21 mg/L to 1100 mg/L. In addition, low concentrations (less than 15 µg/L) of benzene and xylene were detected in FOMW13. Fuss & O'Neill concluded that petroleum contamination had impacted groundwater in the area.

4.2.5 Phase I Remedial Investigation

An investigation of 11 sites was completed at NSB-NLON by Atlantic Environmental Services from 1990 through 1992. One site, identified as the Lower Subase - Site 13, included the area represented by Zones 1 through 4.

The Lower Subase Phase I field investigation consisted of a utility manhole inspection and waterfront bulkhead inspection for evidence of contamination sources. Also included were a soil gas survey, test boring completion, monitoring well installation, and soil and groundwater sampling.

During the utility manhole inspection, manhole covers were removed and inspected for visual evidence of oil. Four areas of significant petroleum accumulation were observed during the manhole inspection. One of these areas, consisting of three manholes west of Building 29 (the power plant), was located within Zone 1. Possible sources for the accumulation were noted as previous product releases from underground fuel lines or storage tank leaks. No evidence of petroleum contamination was noted along the fuel oil lines that run along Corvina Road. The report indicated that there was no evidence of an ongoing release; the petroleum contamination appeared to be related to previous releases.

Inspection of the waterfront bulkhead was conducted from a boat during low tide. Seeps or sheens have been historically observed at the waterfront near the power plant; however, no oil seeps or sheens or evidence of such were observed anywhere along the waterfront at the Lower Subase during the inspection.

A shallow soil gas survey (at depths of 12 to 18 inches) was also conducted within Zones 1 through 4. The results for Zone 1 indicated low concentrations of VOCs on the western side of Building 29 near the three manholes, high concentrations of VOCs in an area south of Building 29, and low concentrations of VOCs near the Building 29 storage tanks. These areas were further characterized by the subsurface investigation.

Eight borings, converted to monitoring wells, were installed within Zone 1 (13MW1 through 13MW5 and 13MW7 through 13MW9) and are shown on Figure 4-1. A previously installed well (NESO4) was also sampled during the Phase I RI. Soil and groundwater samples collected from the monitoring wells were analyzed for VOCs, inorganics, TPH, and fluorescence.

Based on TPH and fluorescence soil analysis, the report indicated that No. 2 fuel oil and lubricating oil have leaked from USTs near Buildings 29 and 107. Since USTs and fuel lines have been replaced, ongoing releases were believed to have been predominately corrected. Measurable free product was only detected in 13MW5, at a thickness of less than 1/16 inch. The oil was bailed from this well and an oil layer was not evident 3 hours later.

4.2.6 Site Characterization Report for OT-10, Building 325, and Building 89

Halliburton NUS conducted site investigations at OT-10, Building 325, and Building 89 in 1994 to determine whether the USTs at these sites had impacted the surrounding soil and groundwater. The UST (Tank Z01) at Building 89 is included within Zone 1. In June 1994, M&G Associates removed this tank. Field activities were performed by Halliburton NUS to assess the quality of soil in the vicinity of the tank to support permanent closure of the tank site. Three soil samples were collected from the tank excavation by Halliburton NUS and analyzed for TPH and benzene, toluene, ethylbenzene, and xylenes (BTEX). One of these samples was also analyzed for Target Compound List (TCL) VOCs and SVOCs, Target Analyte List (TAL) inorganics plus boron, and TCLP characterization. M&G Associates also collected two soil samples, one from the tank excavation and one from the excavated material, and one groundwater sample. The samples collected by M&G Associates were analyzed for lead, TPH, and aromatic volatiles. In addition, the soil samples were analyzed for TCLP characterization.

At Building 89, the detections in the soil samples were below CTDEP cleanup standards. Although TPH exceeded CTDEP groundwater standards, the results were inconclusive because the sampling and analysis protocols used by M&G Associates were questionable. Although groundwater in the vicinity of Building 89 may have been impacted by petroleum related to the tank, it was recommended that no further action be taken as part of the tank closure and that groundwater be addressed as part of the Phase II RI investigation.

4.2.7 Leak Testing Investigation for Fuel Oil Distribution System

In April and May 1996, Heitkamp performed pressure leak testing on the lines and valves in the fuel distribution system within and adjacent to Zone 1. A section of PVC or fiberglass pipe in the diesel oil line at Pier 12 was deemed to be porous because it failed to hold air at 20 psi during the pneumatic test. This

section of pipeline has since been replaced by the Navy's Public Works Department. All other sections of line and various valves tested in the portion of the distribution system within or adjacent to Zone 1 passed the pressure testing procedures.

4.2.8 Site Investigation Report for Tank Farm Investigation

B&R Environmental conducted an investigation in 1995 of the UST farm along Crystal Lake Road. The primary objectives of the investigation were to define the extent of soil and groundwater contamination from the UST farm, evaluate the impact of the UST farm on the stormwater discharge, and recommend remedial alternatives, if needed. As part of the tank farm investigation, underground pipelines from the fuel loading dock (Pier 1), throughout a portion of the Lower Subase (Zones 1 through 4), and the gate valve (Building 322) to tanks within the tank farm were investigated. Soil samples were collected along the new and old diesel underground pipelines at approximately 100-foot intervals. The samples were analyzed for TPH. The No. 6 fuel oil lines were not included as part of the investigation because they were installed within concrete-lined trenches, which would prevent or minimize any potential soil and groundwater impact from leaks. Seven samples were collected within Zone 1 (GS-25L, GS-26L, and GS-28L through GS-32L). TPH was detected in all the samples collected in Zone 1 (up to a maximum of 26,800 mg/kg); however, the TPH contamination is suspected to be associated with the USTs located at Building 29 and not a result of leaking pipelines.

The report recommended that additional integrity inspections be performed to determine the locations of previous line leaks on the active and inactive product lines throughout the Lower Subase. In addition, a records review should be performed to identify previous leaks based on the results of line inspections and tightness tests.

4.2.9 Phase II Remedial Investigation

B&R Environmental conducted a Phase II RI at 13 sites at NSB-NLON. The Lower Subase was included in this investigation. Soil boring and groundwater well installation and soil and groundwater sampling at Zone 1 were conducted as part of the investigation. Nine soil samples were collected from five borings (13TB13, 13TB15 through 13TB17, and 13MW18) and analyzed for lead, TPH, and TCLP metals. Four monitoring wells were installed (13MW18 through 13MW21) and 10 groundwater samples were collected from new and existing monitoring wells (13MW1 through 13MW3, 13MW8, 13MW9, 13MW18 through 13MW21, and NESO4). The groundwater samples were analyzed for VOCs, SVOCs, metals (total and dissolved), and TPH.

Relatively high concentrations of TPH (maximum - 51,600 mg/kg) were found in Zone 1 soil, particularly in the vicinity of Sites 10 and 11. In addition, manganese was detected at 2,290 µg/L in a groundwater sample collected at 13MW8 during Round 2 of sampling for the Phase II RI.

The Phase II RI recommended that further characterization of the Lower Subase be performed during a separate RI. This characterization effort should emphasize evaluation of the nature and extent of lead, TPH, and semivolatile organic compounds in soil. Continued groundwater sampling and analyses were also recommended to monitor contamination levels. In addition, a focused data collection effort was recommended that would provide information relevant to an FS to evaluate potential remedial options for the site.

4.2.10 Existing Data Summary Investigation for Lower Subase

The Existing Data Summary Report for the Lower Subase Remedial Investigation was developed as part of the first tier of data collection to accumulate data from several studies, including the Phase II RI, and to identify potential data gaps that would then be filled in during the Lower Subase RI.

With respect to Zone 1, the Existing Data Summary Report recommended that SVOC concentrations in the soil be characterized, the two TPH hot spots in the vicinity of tanks at Sites 10 and 11 and along Albacore Road at Corvina Road be delineated, the mobility of lead in shallow soil be determined through sampling and analysis using the SPLP method, and groundwater contamination levels continue to be monitored and field measurements taken to determine if natural attenuation is occurring. The report also recommended that further characterization activities at Zone 1 be coordinated with sediment sampling in the Thames River in the vicinity of Zone 1 to aid in the identification of source areas and contaminants of concern.

With respect to the fuel oil distribution lines, utility ducts, and storm sewers located in Zone 1, the report recommends that fuel line leak detection systems be evaluated to ensure against leakage, past and present fuel line leaks be identified and repaired, and utility ducts and trenches and storm sewers be inspected and repaired if necessary and any contaminated material found be removed.

4.2.11 Annual NPDES Stormwater Monitoring Program

In accordance with the requirements of the basewide General Stormwater NPDES Permit, the storm sewer adjacent to the southeastern corner of Building 89 is monitored annually during a storm event. During a 1.86-inch storm of 8-hour duration on October 8, 1996, the Building 89 storm sewer, referred to as BLDG 89, was sampled and analyzed. The analyses indicated that the storm sewer contained 11,000

colonies per 100 ml of fecal coliform. Analytical results also indicated concentrations of oil/grease (less than 1.0 mg/L), suspended solids (9 mg/L), copper (0.10 mg/L), lead (0.09 mg/L), and zinc (0.50 mg/L). The pH was measured at 4.32. Toxicity tests run on the same sample indicated a 48-hour mortality for *Daphnia Pulex* to be 30 percent. This storm sewer was not sampled during the designated 1997 storm event sampling that took place on June 19, 1997.

The pH of the storm water is consistent with the pH of rainfall as measured at NSB-NLON and the Northeast Region in general. Two rainfall samples, one collected in 1996 and another in 1997 as part of the NPDES sampling, were analyzed for pH by a certified laboratory. The pHs of the samples were 6.81 and 4.01, respectively. The pH of 4.32 at the Building 89 sampling location is within the range of measured pH values.

The storm water at this location has been within the criteria of the NPDES permit. Based on the permit, sampling locations can be eliminated if they are in compliance with the criteria. Subsequently, NSB-NLON with the approval of the CTDEP removed the Building 89 sampling location in 1997 from their sampling program.

4.2.12 Lower Subase Remedial Investigation

Nine test borings (TB1-1RI through TB9-1RI) were installed to the water table in Zone 1 using DPT. Boring locations are illustrated in Figure 4-1. Boring log sheets are provided in Appendix A. Two soil samples were collected from each boring from shallow (0 to 5 feet) and deep (greater than 5 feet) depths. SVOC analysis was performed on both shallow and deep samples. TPH and metals analyses were performed on shallow soil samples collected at locations TB1-1RI, TB2-1RI, and TB6-1RI. SPLP for lead was performed on samples collected from TB1-1RI and TB2-1RI. Soil sample log sheets are included in Appendix B.1.

Groundwater samples were collected from 13 existing monitoring wells: 13MW1, 13MW2, 13MW3, 13MW8, 13MW9, 13MW18, 13MW19, 13MW20, 13MW21, FOMW13, FOMW14, FOMW15, and FOMW16. Samples were not collected from monitoring wells 13MW7, 13MW14, and NESO7 because these wells have been destroyed or could not be located. Monitoring well 13MW18 was added for sampling to replace NESO7. Monitoring well NESO4 was not sampled because no water was in the well during low tide. Groundwater samples were collected using low-flow purging and sampling techniques, as described in Section 2.3.2. Groundwater parameters were not measured in 13MW18 because of the presence of free product (black, sticky, tar-like substance) and possible damage to the monitoring instruments. Samples were analyzed for TPH, TCL SVOCs, filtered and unfiltered TAL metals, and

natural attenuation parameters. Groundwater sample log sheets and purge data sheets are provided in Appendix B.2.

Four sediment samples (SD1-1RI through SD4-1RI) were collected from locations in the Thames River along Zone 1. Sediment sampling locations are illustrated on Figure 4-1. Surface water quality measurements were taken from each sediment sampling location at the surface and the bottom of the water column. Sediment samples were analyzed for TCL SVOCs, TAL metals, TOC, grain size, AVS/SEM, pH, and ammonia. Surface water quality parameters that were measured include temperature, salinity, turbidity, pH, specific conductance, and dissolved oxygen. Sediment sample log sheets with surface water measurements are provided in Appendix B.3.

4.3 PHYSICAL CHARACTERISTICS

General physical characteristics of the Lower Subase are discussed in Sections 1.3 and 1.4. Site-specific physical characteristics for Zone 1 are discussed in the following subsections.

4.3.1 Topography, Surface Features, and Surface Water Features

Approximately 90 to 95 percent of Zone 1 is paved or covered with buildings. The land surface of Zone 1 slopes gently toward the Thames River. The Providence and Worcester Railroad runs along the eastern border of the zone, and the Thames River forms the western border of the zone.

No unique surface water features are located within or adjacent to Zone 1. All surface runoff from Zone 1 is collected by catch basins within the zone and directed to the Thames River by storm sewers. The storm sewer system in Zone 1 is shown on Figure 4-1. Storm water from the east side of NSB-NLON is also directed through the storm sewer system in Zone 1.

4.3.2 Soil Characteristics, Geology, and Hydrogeology

The soils of Zone 1 are classified as Urban Land (USDA, 1983), and surficial units are artificial fill (USGS, 1960). A north-south cross-section of Zone 1 is illustrated in Drawing 7, and a west-east cross-section of Zone 1 is illustrated in Figure 4-2. Based on nine borings drilled during this investigation and 28 borings drilled during previous investigations, Zone 1 is underlain by 15 to 20 feet of sand and gravel backfill. The sand and gravel backfill is underlain by sand with trace to some gravel underlies in the eastern part of Zone 1 and sand and silt with trace shell fragments in the western part. The depth to the bottom of the sand and silt unit is unknown. In addition, borings in Zone 1 were not advanced to bedrock, and the bedrock depth in Zone 1 is unknown. However, the USGS bedrock map (USGS, 1967) identifies the

Mamacoke Formation underlying Zone 1, and the Phase II RI report (B&R Environmental, 1997b) estimates the bedrock to be approximately 60 feet below msl (70 feet bgs).

The unconfined water table in Zone 1 lies within the sand and gravel backfill with depths ranging from approximately 4 to 10 feet. Groundwater flow is generally west toward the Thames River at low tide (Drawing 3); however, during the high tide, a groundwater flow reversal occurs and flow is to the east (Drawing 1). A groundwater high exists at the northern end of Building 29, influencing groundwater flow patterns in this zone.

Based on a slug test conducted by Atlantic Environmental (Atlantic, 1992) in 13MW7 in Zone 1, the hydraulic conductivity of the sand and gravel fill material is 158 feet per day. Based on the water-level data collected during low tide on October 27, 1997, the hydraulic gradient across Zone 1 is 0.00476 (from 13MW18 to 13MW8).

The volumetric rate of groundwater discharge through the sand and gravel fill material in Zone 1 to the Thames River was calculated to be 4,242 cubic feet per day, using Darcy's Law $Q = - KA (dh/dl)$, where Q = the volumetric discharge rate, K = the hydraulic conductivity, A = the cross-sectional area (i.e., the saturated fill thickness by the width of the fill material along the Thames River), and dh/dl = the hydraulic gradient. An average saturated fill thickness of 12 feet and a width of 470 feet of fill along the Thames River in Zone 1 were assumed.

Generic contaminant loading rates for groundwater discharge into the Thames River from Zone 1 were generated using an estimated groundwater discharge rate (Q, discounting tidal effects) of 4,242 cubic feet/day; a 0.75 factor applied to this flux rate to account for the lack of groundwater discharge during periods of high tide (assumed to be about 6 hours/day over two tidal cycles); hypothetical solute concentrations (C) of 10, 100, and 1,000 μg/L; and the following mass flux equation: Mass flux = Q x 0.75 x C. The corresponding daily discharge rates from Zone 1 into the Thames River are 0.00198, 0.0198, and 0.198 lbs/day for solute concentrations of 10, 100, and 1,000 μg/L, respectively. Actual discharge rates for individual dissolved constituents can be approximated by using these generic discharge rates and the average concentration of the constituent. For example, a compound present at an average concentration of 25 μg/L in groundwater would have a loading rate 2.5 times the generic rate calculated for a solute present at the 10 μg/L concentration. This loading estimate does not factor in retardation and degradation of solutes, which may be substantial in some cases and would reduce the loading rate.

4.4 NATURE AND EXTENT OF CONTAMINATION

This section is a discussion of the nature and extent of contamination of Zone 1 at the Lower Subase. The general site location of Zone 1 is shown on Figure 1-2, and a detailed drawing of this zone is shown on Figure 4-1. Soil, groundwater, and storm sewer surface water sampling was conducted at Zone 1 during the Phase I, Phase II, and Lower Subase RIs, as well as during the other investigations discussed in Section 4.2. Tables 4-1 through 4-7 summarize the sampling and analytical programs for each investigation. The complete database for Zone 1 is contained in Appendix H of this report, including both chemical and physical parameters for all investigative samples.

4.4.1 Soil

Positive analytical results for Zone 1 soil samples from all investigations are presented in Table 4-8. Positive TCLP results for all soils are presented in Table 4-9. Table 4-10 provides a summary of analytical results for all Zone 1 soil samples. Background concentrations of inorganics in soil, as presented in Table 1-4 and used for comparison with on-site soil concentrations, were taken from the Background Concentrations of Inorganics in Soil Report (Atlantic, 1995b). Observations made based on fluorescence spectroscopy of the Phase I RI soil samples are summarized in Table 4-11; these observations were obtained from the text of the Phase I RI report (Atlantic, 1992).

Figures 4-3 and 4-4 depict, for Zone 1 shallow and deep soil samples, respectively, the locations and concentrations of parameters that were detected in excess of COC selection criteria used in the risk assessment. Drawings 8 through 11, located in Volume III of this RI report, delineate TPH and lead concentrations in soil in all zones, including Zone 1, being investigated as part of the Lower Subase RI. Drawings 8 and 9 depict TPH isoconcentration contours for shallow soil and deep soil, respectively, and Drawings 10 and 11 show lead isoconcentration contours in shallow soil and deep soil, respectively.

4.4.1.1 Shallow Soil

Four Zone 1 shallow soil samples (0 to 4 feet bgs) were analyzed for the full list of TAL metals. Four additional Zone 1 shallow soil samples were analyzed for lead only. As shown on Table 4-10, 21 metals were detected in Zone 1 shallow soil samples. The locations associated with the maximum detected concentrations varied among the metals. Arsenic, cadmium, calcium, copper, lead, manganese, mercury, nickel, silver, sodium, and zinc were detected in shallow soil samples at maximum concentrations exceeding NSB-NLON background levels. However, arsenic, cadmium, copper, manganese, mercury, and silver were each detected at concentrations exceeding background levels in only one shallow soil sample. Calcium and sodium, which were detected at concentrations exceeding background levels in all

four of the shallow soil samples analyzed for TAL metals, are naturally occurring, abundant constituents of soil. A notable result is that for mercury (83.4 mg/kg), reported for the shallow soil sample collected from location TB2-1RI.

Lead was detected in all eight of the Zone 1 shallow soil samples, at concentrations ranging from 7.7 mg/kg to 112 mg/kg. All but one reported concentration for lead exceeded the associated background level (17.5 mg/kg). The maximum concentration of lead was detected in the shallow soil sample collected from boring 13TB15, located just north of Building 29. Drawing 10 shows isoconcentration contours for lead for the shallow soil samples collected from Zone 1.

TCLP extraction followed by RCRA metals analysis was performed for five shallow soil samples collected from Zone 1. In addition, analyses for TCLP organics (volatiles, semivolatiles, pesticides, and herbicides) were performed for one of the shallow soil TCLP leachates. Barium, cadmium, chromium, lead, and selenium were detected in the TCLP leachates of the Zone 1 shallow soil samples. The concentration of lead in the TCLP leachate of the shallow soil sample from location 13TB17 (0.195 mg/L), located northeast of Building 29, exceeded the associated Connecticut remediation standard pollutant mobility criterion for GB area but was less than the Federal toxicity characteristic regulatory level for lead. All other metals concentrations in the TCLP leachates were less than both the Connecticut remediation standard pollutant mobility criteria and the Federal toxicity characteristic regulatory levels.

SPLP extraction followed by analysis for lead was performed for shallow soil samples collected from two locations (TB1-1RI and TB2-1RI, located south and west of Building 29, respectively). Lead was not detected in the SPLP leachates of these samples. The concentrations of lead detected in the shallow soil samples from these locations (34.3 mg/kg and 98.8 mg/kg) are in the same order of magnitude as the concentration of lead detected in the shallow soil sample collected from location 13TB17 (62.5 mg/kg). Therefore, concerning potential migration, even though the locations of the samples collected for SPLP extraction and analysis are not near location 13TB17, the results of the recent SPLP analyses do not support the results of the historical TCLP analyses.

Only one Zone 1 shallow soil sample, which was collected from the excavation site of a UST located west of Building 89 (labeled as PC on Figure 4-1), was analyzed for VOCs. Acetone (54 µg/kg), methylene chloride (15 µg/kg), and total xylenes (1.29 µg/kg) were detected in this sample.

Several SVOCs, primarily PAHs, were detected in Zone 1 shallow soil samples. Concentrations of SVOCs in shallow soil samples ranged from 18 µg/kg (benzo(a)pyrene) to 45,000 µg/kg (pyrene). The maximum concentrations of all but four of the 23 detected SVOCs were reported for the shallow soil

sample from boring TB2-1RI, located west of Building 29 (Power Plant). Concentrations of SVOCs detected in the shallow soil sample from boring TB4-1RI, located east of Building 29 and just north of Site 11 (Power Plant Oil Tanks), ranged from 50 µg/kg (dibenzofuran) to 7,500 µg/kg (pyrene). The maximum SVOC concentration detected in any of the other Zone 1 shallow soil samples was 310 µg/kg.

The results of the SVOC analyses of Zone 1 shallow soil samples indicate that two specific areas of SVOC contamination exist within Zone 1. Contamination in the area of boring 13TB17 is likely to be associated with past oil leaks in the former USTs in Site 11. SVOC contaminants from the past oil leaks at Sites 10 and 11 may have migrated beneath Building 29 and may also be the cause of the contamination noted in the area of boring TB2-1RI. However, SVOC contamination in the area of boring TB2-1RI could also be associated with the fuel pipeline, which is located north of the boring location, or with activities at Building 29.

TPH was detected in 10 of 12 shallow soil samples at concentrations ranging from 23.8 mg/kg to 2,300 mg/kg. As shown in Drawing 8, the maximum TPH concentration was detected in the shallow soil sample from boring TB6-1RI, located along the southwestern edge of Site 10 (Fuel Storage Tanks and Tank 54-H). Drawing 8 also indicates an area of elevated TPH contamination in the shallow soils west of Building 29 at the location of boring TB2-1RI, where TPH was detected at a concentration of 760 mg/kg.

4.4.1.2 Deep Soil

Twenty metals were detected in Zone 1 deep soil samples (greater than 4 feet bgs). Eleven of 20 maximum concentrations of metals were detected in the deep soil sample collected during the installation of well 13MW4. Monitoring well 13MW4, which has been destroyed since the time of its sampling, was located northwest of Site 11 and northeast of Building 29 at the intersection of an existing fuel pipeline and a sanitary sewer line. With the exception of mercury, concentrations of metals in Zone 1 deep soil samples were generally similar (i.e., at the same order of magnitude) to concentrations of metals detected in Zone 1 shallow soil samples. Mercury was detected in the deep soil samples collected during the installation of well 13MW4 (0.48 mg/kg) and well 13MW7 (0.12 mg/kg). It should be noted that well 13MW7, which has since been destroyed, was located in the same area as boring TB2-1RI, the sampling location of the shallow soil sample that contained mercury at a concentration of 83.4 mg/kg.

Concentrations of arsenic, mercury, nickel, potassium, silver, and zinc each exceeded NSB-NLON background levels (presented in Table 1-4) in from one to three of eight deep soil samples. Concentrations of cadmium, calcium, and sodium exceeded background levels for all deep soil samples. As previously mentioned, calcium and sodium are naturally occurring, abundant constituents of soil. Lead

was detected in all 13 deep soil samples analyzed for this parameter, with concentrations ranging from 2.6 mg/kg to 383 mg/kg. Concentrations of lead in five deep soil samples exceeded the associated background level. The maximum concentration of lead was detected in the deep soil sample from location 13MW4. Drawing 11 shows isoconcentration contours of lead concentrations measured in Zone 1 deep soil samples.

Thirteen Zone 1 deep soil samples were collected for TCLP extraction followed by RCRA metals analysis. Arsenic, barium, cadmium, chromium, lead, selenium, and silver were detected in the TCLP leachates of these soil samples. The concentrations of lead detected in four TCLP leachates exceeded Connecticut remediation standard pollutant mobility criteria for a GB area. All TCLP leachate concentrations were less than Federal toxicity characteristic regulatory levels. Zone 1 deep soil samples were not subjected to SPLP extraction followed by metals analysis.

As shown on Table 4-10, carbon disulfide (5 µg/kg) and total xylenes (0.657 µg/kg) were each detected in one deep Zone 1 soil sample. Several SVOCs, primarily PAHs, were detected in Zone 1 deep soil samples. SVOC results for Zone 1 deep soil samples generally mirrored SVOC results for Zone 1 shallow soil samples in terms of the SVOCs determined to be present and the detected concentrations (i.e., in general, the same SVOCs were detected in both deep and shallow soils with concentrations at the same order of magnitude). Concentrations of SVOCs in deep soil samples ranged from 18 µg/kg (acenaphthylene) to 42,000 µg/kg (phenanthrene). The maximum concentrations of all but four of the 22 detected SVOCs were reported for the deep soil sample from boring TB2-1RI, located west of Building 29 (Power Plant). Concentrations of SVOCs detected in the deep soil sample from boring TB4-1RI, located east of Building 29 and just north of Site 11, ranged from 22 µg/kg (butylbenzyl phthalate) to 2,600 µg/kg (fluoranthene). The maximum SVOC concentration detected in any of the other Zone 1 deep soil samples was 1,300 µg/kg (fluoranthene in the deep soil sample from location TB1-1RI). The results of the SVOC analyses of Zone 1 deep soil samples confirm the presence of the two specific areas of SVOC contamination discussed in Section 4.4.1.1.

TPH was detected in 22 of 24 Zone 1 deep soil samples at concentrations ranging from 23.5 mg/kg to 51,600 mg/kg. As shown in Drawing 9, widespread petroleum contamination is apparent throughout most of Zone 1, with the greatest TPH concentrations detected in deep soil samples collected in the vicinity of the tanks at Sites 10 and 11. A significant area of petroleum contamination was also identified, based on the TPH results for deep soil samples collected in the vicinity of the fuel pipeline along Corvina Road, near the intersection of Albacore Road. Fuel pipeline leaks or ducts acting as preferential flow pathways may be the source of this contamination. A comparison of the isoconcentration contours for Zone 1 deep soil samples (Drawing 9) and Zone 1 shallow soil samples (Drawing 8) indicates that the source(s) of TPH

contamination are likely to be fuel line or UST leaks rather than surface spills since TPH contamination is present at much greater concentrations in deep soils than in shallow soils.

Fluorescence spectroscopy data (Table 4-11) for the deep soil samples collected from locations 13MW1, 13MW5, and 13MW7 indicate the presence of waste lubricating oils. Adjacent to and coincident with the area of lubricating oil contamination is an area of No. 2 fuel/diesel oil contamination, as indicated by the fluorescence spectroscopy results for deep soil samples from locations 13MW2, 13MW3, and 13MW8. Therefore, based upon the results of the fluorescence spectroscopy analyses, it appears that both No. 2 fuel/diesel oil and waste lubricating oils have leaked from the tanks formerly and/or currently located within Sites 10 and 11 and that the resulting contamination extends from the area of the tanks to the Thames River.

4.4.2 Groundwater

Positive analytical results for all groundwater samples collected from Zone 1 are presented in Table 4-12. Table 4-13 summarizes analytical results for groundwater samples collected from Zone 1 during historical investigations (i.e., prior to the Lower Subase RI) and during the Lower Subase RI. Observations made based on the fluorescence spectroscopy of Zone 1 groundwater samples are summarized in Table 4-14; these observations were obtained from the text of the Phase I RI report (Atlantic 1992). Table 4-15 provides a summary of natural attenuation and water quality parameters for Zone 1 groundwater samples; these data are discussed in Section 4.5.3.

Figure 4-5 shows, for data collected during the Lower Subase RI only, the locations and concentrations of parameters that were detected in excess of COC selection criteria used in the risk assessment. Drawings 12 through 14 (Volume III) show the distribution of TPH and lead contamination in groundwater for all zones, including Zone 1, of the Lower Subase using data collected during the Lower Subase RI. Drawing 12 depicts isoconcentration contours of TPH in groundwater, whereas Drawings 13 and 14 show lead isoconcentration contours for unfiltered and filtered groundwater, respectively (i.e., for total and dissolved lead).

4.4.2.1 Historical Data

Table 4-13 indicates that 22 metals were detected in unfiltered groundwater samples collected from Zone 1 in the Lower Subase. Although maximum concentrations of metals were detected in unfiltered groundwater samples from 10 different monitoring wells within the zone, about 60 percent of the maxima were associated with samples from wells 13MW19 (located along the northern edge of Building 29) and 13MW9 (located along the fuel line southwest of Building 29). Lead was detected in 14 of 31 unfiltered

samples. The maximum concentration of lead (39.3 µg/L) was detected in 13MW19. It should be noted that beryllium and silver were each detected in only one of 31 unfiltered groundwater samples, and mercury and selenium were each detected in only two of 31 unfiltered groundwater samples.

Eighteen metals were detected in Zone 1 filtered groundwater samples. Although maximum concentrations of metals were detected in filtered groundwater samples from seven different monitoring wells within the zone, about 65 percent of the maxima were once again associated with samples from wells 13MW19 and 13MW9. Lead was detected in only three of 21 filtered samples. The reduction in detections when compared to unfiltered samples is most likely related to suspended solids. The maximum concentration of lead (13.5 µg/L) was detected in 13MW21. Antimony and beryllium were each detected in only one of 21 filtered groundwater samples, and mercury was only detected in two of 21 filtered groundwater samples. In general, the concentrations of metals detected in filtered and unfiltered groundwater samples were similar (i.e., at the same order of magnitude).

Seven VOCs were detected in the Zone 1 historical groundwater samples. Total xylenes were detected at a concentration of 44 µg/L in the groundwater sample collected from well 13MW19. All other VOC concentrations ranged from 1 µg/L to 11 µg/L.

Five monocyclic aromatic compounds were detected in from one to three of approximately 35 groundwater samples. Carbon disulfide and 1,1-dichloroethane were also detected. Benzene was detected at a concentration of 3 µg/L in the samples collected from well 13MW2, located east of Site 10, during Rounds 1 and 2 of the Phase II RI. Maximum concentrations of xylenes, ethylbenzene, and 1,1-dichlorethane were detected in the sample collected from well 13MW19, located along the fuel pipeline southwest of Building 29, during Round 1 of the Phase II RI.

Nine PAHs were infrequently detected in Zone 1 historical groundwater samples. PAH concentrations generally ranged from 0.5 µg/L and 10 µg/L, although 2-methylnaphthalene (C_{max} = 47 µg/L), fluorene (C_{max} = 15 µg/L), and naphthalene (C_{max} = 28 µg/L) concentrations were slightly higher. Positive results for PAHs were mainly associated with samples collected from well 13MW2 (located east of Site 10) and from well 13MW20 (located north of Site 11). Chlorinated benzenes, benzoic acid, phthalates, carbazole, dibenzofuran, and phenolic compounds were also infrequently detected in the historic Zone 1 groundwater samples. With the exception of phenol (28 µg/L in one sample), all concentrations of these compounds ranged from 0.5 µg/L to 11 µg/L, with many results at concentrations less than 1 µg/L.

Concentrations of TPH in Zone 1 historic groundwater samples ranged from 600 µg/L to 2,100 µg/L, with the maximum TPH concentration detected in the groundwater sample collected from well 13MW19

(located in the northern edge of Building 29). No. 2 diesel fuel oil was detected at concentrations ranging from 21,000 µg/L to 1,100,000 µg/L in four groundwater samples collected in the vicinity of Tank 54-H (north of Site 10). Fluorescence spectroscopy (Table 4-14) performed on the Phase I RI groundwater samples identified the presence of a mixture of waste oil or diesel fuel and heavy residual fuel oil (i.e., No. 6 fuel oil) in groundwater samples collected from wells 13MW1, 13MW2, 13MW3, and 13MW7. Fluorescence spectroscopy also indicated the presence of waste lubricating oil and No. 2 diesel oil in groundwater samples collected from wells 13MW5 and 13MW4, respectively. In addition, fluorescence data indicated the presence of residual fuel oil in the groundwater sample from well NESOMW4. Trace levels of petroleum hydrocarbons were detected in groundwater samples from wells 13MW8 and 13MW9, but concentrations were too low to identify the type of oil. Therefore, fluorescence data indicate that widespread petroleum contamination in the groundwater beneath Sites 10 and 11 extends from the eastern side of Zone 1 all the way to the Thames River.

4.4.2.2 Lower Subase RI

Table 4-13 indicates that 21 metals were detected in unfiltered groundwater samples collected from Zone 1 during the Lower Subase RI. The locations where maximum concentrations of metals were detected varied among metals. Antimony was detected in only one of 14 groundwater samples, and mercury, selenium, and thallium were each detected in only two unfiltered groundwater samples.

Twenty metals were detected in filtered groundwater samples collected from Zone 1 during the Lower Subase RI. In general, metals results for filtered groundwater samples were slightly lower but at the same order of magnitude as the results for unfiltered groundwater samples. Although maximum concentrations of metals were detected in groundwater samples from nine different locations, one-half of the maxima were associated with samples from wells 13MW20 and 12MW9. Mercury and selenium were each detected in only one filtered groundwater sample, and antimony, silver, and zinc were each detected in only two of 14 filtered groundwater samples.

The concentrations of metals detected in filtered and unfiltered Zone 1 groundwater samples collected during the Lower Subase RI are similar (i.e., at the same order of magnitude) to metals concentrations detected in the Zone 1 historical groundwater samples. The distribution of lead in unfiltered and filtered groundwater samples is shown on Drawings 13 and 14, respectively. These drawings indicate that an area of lead contamination exists between Building 89 and Site 11.

Analysis for VOCs was not performed for groundwater samples collected during the Lower Subase RI. Fifteen SVOCs, primarily PAHs, were infrequently detected in Zone 1 groundwater, as indicated in Table

4-13. With the exception of naphthalene (which was detected in one sample at a concentration of 23 µg/L), SVOCs were detected at concentrations ranging from 0.6 µg/L to 12 µg/L. Maximum concentrations of 11 of 15 SVOCs were detected in the groundwater sample collected from well 13MW2, located east of Site 10.

TPH (16,000 µg/L) was detected in only one of the 14 groundwater samples collected during the Lower Subase RI. This sample was collected from well FOMW14, located at the northern edge of Site 10. During the field investigation, well FOMW14 also contained suds indicating the presence of detergents. Monitoring well 13MW18 contained a thin layer of a black tar-like substance suggesting the presence of free-phase product. Based on the sensitivity of the method used for analysis, the reporting limits for TPH were greater than the Connecticut remediation criterion of 500 µg/L. The presence of TPH below the reporting limits could not be confirmed for the other groundwater samples collected from Zone 1 since TPH at concentrations less than the reporting limits would not have been reported. Based on convention, one-half the reporting limit is shown on Drawing 12 for each sample in which TPH was not detected. The values provided for these wells on Drawing 12 (500 µg/L, with an exception for one sample of 550 µg/L) for the remaining Zone 1 samples are equal to or slightly greater than the Connecticut remediation criterion of 500 µg/L.

4.4.3 Surface Water/Sediment

Surface water and sediment samples were collected from the Thames River adjacent to Zone 1. The nature and extent of contamination in Thames River surface water and sediment samples, as well as the impact of the activities and contamination at the Lower Subase (including Zone 1) on Thames River surface water and sediments, are discussed in Section 11.4.

As part of the basewide General NPDES Stormwater Monitoring Program, three annual storm sewer surface water samples were collected from the storm sewer located adjacent to the southeastern corner of Building 89 (Figure 4-1). As shown on Table 4-16, each of these samples were analyzed for copper, lead, zinc, oil and grease, and several miscellaneous parameters. Table 4-16 presents the positive analytical results for these storm sewer surface water samples.

Copper, lead, and zinc were detected in all three surface water samples. The maximum concentrations of all three metals were detected in the first annual sample (October 1992), although the concentrations of all three metals increased from the second (February 1995) sampling event to the most recent (October 1996) sampling event. The concentrations of copper, lead, and zinc detected in the 1996 surface water sample were 100 µg/L, 90 µg/L, and 500 µg/L, respectively.

Concentrations of oil and grease have decreased over time. Oil and grease was detected at concentrations of 4,000 µg/L and 1,500 µg/L in the 1993 and 1995 surface water samples, respectively, but was not detected in the 1996 surface water sample. Concentrations of the miscellaneous parameters appear to fluctuate over time. These parameters will be further discussed in Section 11.7. A notable detection among the miscellaneous parameters is that of fecal coliform at 11,000 colonies per 100 mL.

4.5 CONTAMINANT FATE AND TRANSPORT

4.5.1 General Contaminant Fate and Transport Processes

The major area of concern for Zone 1 is impacted soil, as evidenced by widespread detection of TPH (which is comprised of PAHs and other compounds). Zone 1 soil also contains several metals (arsenic, cadmium, lead, manganese, mercury, silver and zinc) at elevated concentrations relative to background concentrations.

PAHs are generally considered to be fairly immobile in the environment. As noted in Section 3.3.2.4, PAHs have very low solubilities, vapor pressures, and Henry's Law constants, and high K_{oc}s and K_{ow}s. The low-molecular weight PAHs (e.g., acenaphthene, anthracene, fluorene, phenanthrene) are more mobile (higher solubilities, etc.) than the high-molecular-weight PAHs (e.g., benzo(a)pyrene, benzo(a)anthracene, chrysene, etc.). PAHs in soil are much more likely to bind to soil and be transported via mass transport mechanisms than go into solution. PAHs can be degraded via aerobic bacteria, but may be relatively persistent in the absence of microbial population or macronutrients such as phosphorous and nitrogen.

Within Zone 1, TPH, as well as the PAHs, were found in both shallow and deep soils. The presence of these compounds at depth appears to be related more to leakage from the underground storage tanks and fuel pipelines in the area than from downward migration of the compounds from the surface. The highest concentrations of TPH are located in the immediate vicinity of the underground storage tanks at Site 10 and Site 11 and the fuel line along Corvina Road and Albacore Road.

PAHs have also been detected in some of the groundwater samples at Zone 1. As noted above, PAHs have very low solubilities and generally do not enter into solution. However, the PAHs that have been detected in the groundwater are the low-molecular weight PAHs that would have the highest solubilities and highest mobility of the PAHs detected. In addition, the concentrations that were detected were in the range of 0.6 to 10 µg/L. These low concentrations indicate that the PAHs detected in the groundwater

samples may be the result of soil particles present in the groundwater samples (i.e., samples with high turbidity).

As noted in Section 3.3.2.9, metals are highly persistent environmental contaminants. They do not biodegrade, photolyze, hydrolyze, etc. The major fate mechanisms for metals are adsorption to the soil matrix (as compared to being part of the soil structure) and bioaccumulation.

In addition, under normal conditions, metals are not very mobile in the environment. Because metals frequently remain bound to particulate matter, the major transport mechanism for metals is bulk movement processes (erosion). However, metals can become mobile in the environment under certain conditions. The mobility of metals is influenced primarily by their physical or chemical properties in conjunction with the physical and chemical properties of the soil matrix. Factors that assist in predicting the mobility of metals are the soil/pore water pH, REDOX potential, and cation exchange capacity. The mobility of metals generally increases with decreasing soil pH and cation exchange capacity. The effect of REDOX potential varies for each metal.

Within Zone 1, metals were detected in shallow soil samples and deep soil samples at elevated levels. The presence of metals in the soil samples may be indicative of the fill material used to construct the Lower Subase. However, the presence of lead in deep soil samples and groundwater samples is more likely the result of handling of lead batteries used in submarines for underwater propulsion until the 1950's. Because of the low pH acid present in the batteries, the lead in the batteries would have been extremely mobile, and if the batteries had been spilled on the ground surface, the lead would have migrated much farther than under normal conditions.

Because the use of the lead acid batteries was discontinued in the 1950's, it is likely that the pH of the media in the area of Zone 1 has increased to its present level (groundwater pH between 6.33 and 10.25 and soil pH unknown). In soil with a pH of 6-8, lead may form insoluble organic lead complexes, or if the soil has less organic matter at the same pH, hydrous lead oxide complexes may form or lead may precipitate out with carbonate or phosphate ions. This may explain why the concentrations of lead in the groundwater are not as high as would be expected given the concentrations in the soil and the results of the TCLP analyses. As long as the pH in the soil remains above 6, the lead present in the soil may continue to be relatively immobile and the lead concentration in the groundwater may decrease over time as it is flushed out.

Another factor that may be limiting the concentration of lead and other metals in the groundwater is the presence of paving over most of the site. The paving serves to limit the amount of infiltration passing

through the soil. With limited infiltration, the amount of metals that can be leached out of the soil and transported to the groundwater is minimized.

4.5.2 Effects of Cross Contamination on Other Zones and the Thames River

TPH is an indicator of petroleum hydrocarbon contamination. PAHs are the primary components of fuel oils No. 2 and No. 6, which were stored at the site in various USTs. The TPH contamination detected at the site is therefore assumed to be comprised mainly of PAHs and other semivolatile organic compounds. As shown in Drawings 8 and 9 in Volume III, concentrations of TPH in surface and subsurface soil, respectively, are highest in the vicinity of the USTs and in the area adjacent to the quay wall. The area of elevated TPH concentrations extends slightly beyond the boundary of Zone 1, indicating that cross contamination to Zone 2 may have occurred. However, the contamination noted in the northwest corner of Zone 2 along the quay wall is located along a fuel pipeline. Consequently, the contamination noted in the northwest corner of Zone 2 may be the result of leakage from this fuel pipeline.

Both high molecular weight PAHs [e.g., benzo(a)anthracene, benzo(a)pyrene] and low molecular weight PAHs (e.g., acenaphthene, anthracene) were detected in shallow and deep soil at Zone 1. TPH (including low molecular weight PAHs) was also detected in groundwater in the vicinity of the underground storage tanks. However, during the latest sampling round, TPH was not detected in monitoring wells located adjacent to the Thames River. Low and high molecular weight PAHs were detected in Thames River sediment samples collected near Zone 1. Detected concentrations of PAHs in Zone 1 soil samples are generally less than those detected in the sediment samples. Also, concentrations of PAHs in Zone 1 sediment samples are generally higher then those detected in sediment samples collected upstream and downstream of the Lower Subase. This suggests that migration of petroleum hydrocarbons from Zone 1 to the Thames River may have occurred.

Several inorganics (i.e., arsenic, cadmium, copper, lead, manganese, mercury, nickel, silver, and zinc) were detected in surface and subsurface soil samples at concentrations exceeding background levels. These inorganics were also detected in groundwater samples and in the Thames River sediment samples. Reported concentrations of many of these chemicals in the sediment samples exceeded background concentrations, indicating that migration of some inorganics to the Thames River may have occurred.

As shown in Drawings 10 and 11 lead, was detected at concentrations exceeding background levels in shallow and deep soils. These drawings show that soil concentrations of lead in Zone 1 are similar to soil lead concentrations in adjacent zones, which suggests that lead in Zone 1 is not cross contaminating other zones. As shown in Drawings 13 and 14, concentrations of total and dissolved lead in the

groundwater are comparable. In addition, the drawings, which for Zone 1 are based on data clustered in the northern and eastern part of the Zone near the sources of contamination, show that lead does not appear to be migrating with groundwater to adjacent zones, but may be migrating toward the Thames River. However, the lead isoconcentration contours, developed by kriging, suggest that the concentrations of lead that will reach the Thames River will be low (i.e., less than 6 µg/L).

A storm sewer that discharges to the Thames River in Zone 1 has been sampled and analyzed as part of the NPDES permit. Oil and grease, copper, lead, and zinc were detected at elevated levels in storm sewer surface water samples. This indicates that the storm sewer may be a source of contamination to the Thames River.

There may be other off-property sources contributing to the contamination detected in Thames River sediments. The Thames River is tidally influenced and contaminants may be migrating in the river from upstream and downstream sources. Also, the contamination may be a result of spillage that may have occurred during historical refueling of submarines and tugboats at the Lower Subase.

4.5.3 Evaluation of Natural Attenuation Data

Soil and groundwater samples were collected in Zone 1 and analyzed in the field or by a fixed-base laboratory. The resulting data provide the information necessary to answer the three following questions:

- Are contaminants present in either medium that could be remediated via natural attenuation or bioremediation?
- Is natural attenuation currently in progress in the groundwater?
- Are the conditions in the groundwater favorable for natural attenuation or bioremediation?

For Zone 1, TPH concentrations in soil and groundwater were contoured and the results are presented on Drawings 8, 9, and 12. Drawings 8 (shallow soil) and 9 (deep soil) show that high levels of TPH (i.e., indicative of petroleum hydrocarbons) are present in the soil of Zone 1. The maximum TPH concentrations were detected in TB-6RI (2,300 mg/kg, shallow soil) and 13MW18 (51,600 mg/kg, deep soil). As discussed in Section 4.4, PAHs were also frequently detected in the shallow and deep soil of Zone 1, which confirms the TPH concentrations. TPH was detected in only one monitoring well, FOMW14, at a concentration of 16,000 µg/L. PAHs and some BTEX compounds were also detected in the groundwater. These results indicate that petroleum hydrocarbons are present in both the soil and groundwater, and as discussed previously, petroleum hydrocarbons in either media can be treated successfully via natural attenuation or bioremediation.

The procedure for evaluating natural attenuation data for groundwater was previously outlined in Section 3.3.4 and is followed in this section. Table 4-15 summarizes the parameters that were measured to determine if natural attenuation is occurring in the groundwater of Zone 1. Other information in the table includes parameter-specific concentration ranges and frequency of detections. Drawings showing the distribution of key parameters were also prepared to aid in the interpretation of the data. The drawings that were prepared include the following:

- Drawing 1 - High Tide Potentiometric Surface Map
- Drawing 3 - Low Tide Potentiometric Surface Map
- Drawing 15 - Dissolved Oxygen
- Drawing 16 - REDOX potential
- Drawing 17 - Divalent Iron
- Drawing 18 - Specific Conductivity

The following conclusions were reached after review and evaluation of the data presented in Table 4-15 and Drawings 1, 3, and 15 through 18.

- Dissolved oxygen levels varied significantly within the zone. Several results are suspect because they are near the saturated concentration for water. For Zone 1, water quality measurements were taken during sampling of monitoring wells on 3 different days. Measurements were taken at 13MW1, 13MW3, FOMW14, FOMW15, and FOMW16 on November 10, 1997; 13MW19, 13MW20, and 13MW21 on November 11, 1997; and 13MW8, 13MW9, 13MW18, and FOMW13 on November 12, 1998. Because the data was collected on different days, it is possible that the variation in the Zone 1 data shown on Drawing 15 is related to a faulty DO probe or improper calibration of the DO probe. For example, the DO probe was not able to be calibrated on November 12, 1998 due to an electrical short in the probe. No valid DO readings were able to be obtained at wells 13MW8, 13MW9, 13MW18, and FOMW13 on that day. The dissolved oxygen results are therefore inconclusive.

- REDOX potential measurements were consistently negative, indicating an anaerobic environment. REDOX potential is typically easier to measure accurately in the field in comparison to dissolved oxygen; therefore, because the dissolved oxygen measurements are suspect, the REDOX potential measurements alone were used to conclude that the shallow groundwater beneath Zone 1 is anaerobic.

- Ten of 14 measured concentrations of nitrate (0.05 UJ to 0.47 J mg/L) were below 1 mg/L. Concentrations of nitrate detected in 13MW1, FOMW15, and FOMW13 ranged from 0.97 J mg/L to 1.5 J mg/L. These wells are on the upgradient side of Zone 1 and the nitrate concentrations detected in the wells are consistent with the concentration measured in monitoring well MW1-6RI (i.e., 1.4 mg/L). Based on this information, it appears that denitrification may be occurring.

- Concentrations of divalent iron greater than 1 mg/L were detected in five wells (13MW1, 13MW3, 13MW18, FOMW14, and FOMW15). Divalent iron was not detected in monitoring well MW1-6RI. This information indicates that iron reduction is occurring in a localized area of Zone 1 (i.e., near Site 10).

- A broad range of sulfate concentrations were detected in Zone 1 groundwater. Concentrations of sulfate in excess of 20 mg/L were detected in 10 monitoring wells and concentrations of sulfate below 20 mg/L were detected in three wells (13MW2, 13MW18, and FOMW15). Sulfate was detected in MW1-6RI at a concentration of 25 mg/L. These results indicate that sulfate reduction is probably occurring in a localized area of Zone 1 (i.e., near Site 10).

- High concentrations (greater than 0.1 mg/l) of methane were detected in eight of 13 monitoring wells. Methane was either detected at low concentrations (less than 0.1 mg/L) or was not detected in five Zone 1 monitoring wells including 13MW1, 13MW3, 13MW21, FOMW13, and FOMW16. Methane was not detected in monitoring well MW1-6RI. The detections of methane suggest that methanogenesis is occurring in areas near Sites 10 and 11.

- Concentrations of alkalinity (61 to 440 mg/L) and hardness (16 to 2,600 mg/L) detected in Zone 1 groundwater were typically higher than concentrations in other zones. The levels of alkalinity and hardness measured in MW1-6RI were nondetect (20 U mg/L) and 45 mg/L, respectively. Increases in alkalinity are an indication of aerobic or anaerobic oxidation.

- High pH was measured in the groundwater of three monitoring wells including 13MW19 (9.09), 13MW20 (9.08), and 13MW21 (10:25). The pH measured in the remaining Zone 1 monitoring wells was near neutral (6.33 to 7.52). The pH in MW1-6RI was 5.81.

- High groundwater temperatures were measured in three Zone 1 monitoring wells including 13MW19 (42.59°C), 13MW20 (38.51°C), and 13MW21 (64.63°C). These are the same wells that had groundwater with high pH. The temperature of the groundwater in the remaining wells ranged from 17.2°C to 18.99°C. The temperature of the groundwater in MW1-6RI was 12°C. Based on Drawings 1 and 3, a groundwater high occurs in this area during both low and high tide conditions. This

information, in conjunction with the high pH levels detected in these wells, may indicate that there is a leak in the steam/condensate lines in this area.

- The detection of ammonia in 13 of 14 samples further collaborates the idea that denitrification is occurring because ammonia is an intermediate product of denitrification.

- Phosphorous was detected in the groundwater and is available as a nutrient.

- The maximum salinity and chloride concentrations were detected in 13MW9 (14ppt and 5900 mg/L, respectively). This well is located near the western boundary of Zone 1 and the Thames River which has salinity levels as high as approximately 29 ppt. In addition, salinity levels were high in monitoring wells 13MW20 (2.65 ppt) and 13MW21 (1.03 ppt) that are in the north-central portion of Zone 1. Drawings 1 and 3 show that there is a gradient from the Thames River toward monitoring wells 13MW20 and 13MW21 under both high and low tide conditions resulting in the salinity and chloride levels being higher in these wells. All monitoring wells in Zone 7 had salinity and chloride concentrations in excess of the levels detected in MW1-6RI (0.08 ppt and 29 mg/L, respectively). The data indicate that a significant portion of Zone 1 groundwater is tidally influenced to some degree. In addition, it appears that there is a strong hydraulic connection between the groundwater at 13MW9 and the Thames River.

The information provided above indicates that natural attenuation is occurring in the groundwater of Zone 1 in the vicinity of Sites 10 and 11. The limited size of the TPH plume and the infrequent detections of PAHs and BTEX compounds in the groundwater are most likely the result of a variety of factors (i.e., condition, type, and age of sources, natural attenuation, mobility of contaminants, unique hydrogeologic conditions, and tidal flushing). Due to the variety of factors influencing Zone 1 and the limited contaminant plume, it is unlikely that bioremediation or other more active remedial technologies are practical or necessary for the groundwater of this zone. It is likely that a combination of monitored natural attenuation and/or a tiered groundwater monitoring program and source control would be a viable remedial strategy for this zone. If monitored natural attenuation is selected as part of the remedial strategy for Zone 1, additional investigations would need to be completed to provide the preliminary data required for the remedial alternative and to monitor the progress of the alternative. Monitoring of the non-tidally influenced areas of Zone 1 would provide the best indication that natural attenuation processes are working in the groundwater.

4.6 BASELINE HUMAN HEALTH RISK ASSESSMENT

This section contains the baseline risk assessment performed for soil and groundwater exposures at Zone 1 of the Lower Subase. Section 4.6.1 contains a discussion on the selection of COCs, Section 4.6.2 contains information on the potential receptors considered and the routes by which they might be exposed, Section 4.6.3 contains the numerical results of the risk assessment, and Section 4.6.4 presents site-specific uncertainties associated with the risk assessment.

4.6.1 Data Evaluation

COCs were identified for Zone 1 of the Lower Subase using risk-based COC screening levels, as described in Section 3.4.3. All validated data collected during the Phase I and II RIs, the Lower Subase RI, and additional investigations, except soil data collected from depths greater than 10 feet, were used to identify COCs. Table 4-17 presents a summary of the COCs for Zone 1. Appendix I.5 contains the COC summary screening tables for the site.

A medium-specific discussion of COCs is presented in the following subsections. Within a given medium, discussions of direct exposure COCs (i.e., those chemicals detected at concentrations in excess of Federal and state direct exposure criteria) and additional COCs are provided. Additional COCs are identified based on contaminant migration tendencies: migration from soil to groundwater and groundwater to the Thames River. These additional COCs are not quantitatively addressed in the human health risk assessment (i.e., numerical risk estimates are not developed) because they are not considered to be significant contributors to the direct exposure pathways identified for potential human receptors.

4.6.1.1 Soil Chemicals of Concern

The following chemicals were identified as direct exposure COCs for soil based on a comparison of maximum detected concentrations to USEPA Region III COC screening levels for residential land use and Connecticut RSRs for direct exposure (residential and industrial land use):

- PAHs [benzo(a)anthracene, benzo(a)pyrene, benzo(b)fluoranthene, benzo(k)fluoranthene, dibenzo(a,h)anthracene, and indeno(1,2,3-cd)pyrene].
- Inorganics (arsenic, beryllium, iron, manganese, and mercury).
- TPH.

Benzo(k)fluoranthene was selected as a COC for the "all soils" (soil from depths of 0 to 10 feet) category only. TPH was qualitatively identified as a COC for shallow soil because the maximum detected

concentration exceeded the Connecticut RSR for residential direct exposure. Detected concentrations of TPH in subsurface soil exceeded the Connecticut RSRs for residential and industrial direct exposure.

Maximum detections in soil were also compared to generic USEPA SSLs for migration from soil to groundwater and Connecticut RSRs for pollutant mobility in a GB classified area. Maximum concentrations of the following chemicals exceeded the generic soil pollutant mobility criteria, indicating the potential for these chemicals to migrate to groundwater and potentially impact the quality of groundwater:

- PAHs [benzo(a)anthracene, benzo(a)pyrene, benzo(b)fluoranthene, benzo(k)fluoranthene, carbazole, chrysene, dibenzo(a,h)anthracene, indeno(1,2,3-cd)pyrene, phenanthrene, and pyrene].
- Inorganics (arsenic, cadmium, chromium, lead, nickel, and silver).
- TPH.

Under the Connecticut RSR (CTDEP, 1996), concerns regarding the mobility of inorganics in soil are addressed using TCLP and SPLP data. A comparison of site-specific TCLP data and state RSRs for pollutant mobility is provided in Table 4-9. Lead concentrations in the TCLP extracts from several subsurface soil samples exceeded the state criteria. However, lead was not detected in the SPLP extracts associated with recent sample collection efforts.

Although the use of generic mobility criteria (rather than site-specific criteria) results in a conservative identification of additional COCs for soil, the mobility of TPH and several other chemicals (including lead) is supported by the groundwater data available for the site. Of the chemicals previously identified as migration COCs for soil, a few PAHs (carbazole, phenanthrene, and pyrene), several inorganics (arsenic, cadmium, chromium, lead, nickel, and silver) and TPH were detected in groundwater samples collected from the site. Although they were frequently detected in the Zone 1 soil samples, the migration of PAHs may not be as significant as the qualitative comparison indicates since exceedances of the generic mobility criteria are limited to only a few samples at a few locations (i.e., in less than 25 percent of the samples at primarily two locations). The results of the confirmatory SPLP analyses do not support the conclusion that lead is migrating from the site at concentrations of potential concern as previously indicated by the TCLP results. However, it should be noted that SPLP analyses were performed for only two soil samples collected at the site; therefore, there is still some uncertainty regarding the mobility of lead. A discussion of COCs for groundwater is provided in the following subsection.

4.6.1.2 Groundwater Chemicals of Concern

COCs for groundwater were selected using unfiltered and filtered data. Although groundwater at the site is not currently used or expected to be used in the future as a drinking water supply because of saline conditions, a conservative list of direct exposure COCs was developed for this medium based on a comparison of maximum detected concentrations to USEPA Region III COC screening levels for tap water, Federal and state Maximum Contaminant Levels (MCLs), and Connecticut RSRs for the protection of groundwater. Chemicals retained as direct exposure COCs include the following:

- Benzene
- Bis(2-ethylhexyl)phthalate
- Inorganics (aluminum, antimony, arsenic, beryllium, boron, cadmium, copper, iron, lead, manganese, sodium, selenium, thallium, and vanadium)
- TPH

Selenium and thallium were identified as COCs for the unfiltered sample matrix only. Reported concentrations of selenium in the filtered groundwater samples were less than direct exposure criteria. Cadmium and thallium were not detected in the filtered groundwater samples. Sodium was retained as a COC because the maximum detections for this chemical in unfiltered and filtered groundwater samples were in excess of the State Notification Level. However, elevated levels of sodium in groundwater are anticipated because of nearby saltwater intrusion from the Thames River.

Since Zone 1 borders the Thames River, maximum concentrations in groundwater were also compared to the Connecticut Water Quality Standards (WQS) for aquatic life (chronic saltwater criteria) and for the protection of human health (water and organisms). These criteria were used to evaluate the potential for contaminant migration to the water body. The following chemicals were detected at maximum concentrations in excess of the state WQSs:

- Benzene
- Bis(2-ethylhexyl)phthalate
- PAHs (acenaphthylene and phenanthrene)
- Inorganics (arsenic, beryllium, cadmium, copper, lead, mercury, nickel, silver, thallium, and zinc)

Cadmium, thallium, and zinc were identified as additional COCs for the unfiltered sample matrix only. Cadmium and thallium were not detected in the filtered groundwater samples. Reported concentrations of zinc in the filtered groundwater samples were less than Connecticut WQSs.

The actual impact on the water quality in the Thames River is not expected to be as significant as the qualitative comparison implies since significant dilution and tidal mixing are anticipated, thereby reducing contaminant concentrations. For example the maximum detected concentrations of most of the chemicals previously identified as migration COCs (benzene, bis(2-ethylhexyl)phthalate, cadmium, lead, nickel, silver, thallium, and zinc) are within one order of magnitude of the Connecticut WQSs. Appropriate alternative surface water protection criteria can be calculated by multiplying the lower of the human health or aquatic life criterion in the latest Connecticut WQSs by a site-specific dilution factor. Recently calculated site-specific dilution factors for the DRMO (Site 6) and Goss Cove Landfill (Site 8), other NSB-NLON IRP sites located along the Thames River, were 226 and 118, respectively. Consequently, these chemicals are not considered to be problematic since the maximum concentration of these chemicals would be less than the alternative SWPC. In addition, most organic migration COCs were detected infrequently in groundwater samples (i.e., less than 10 percent of the samples). A separate evaluation of the water and sediment quality in the Thames River is provided in Section 11.0.

4.6.1.3 Exposure Point Concentrations

Exposure point concentrations were developed for direct exposure COCs only using the methodologies presented in Section 3.4.1. The average and maximum detected concentrations for soil and groundwater were typically used for the RME and CTE, respectively. The 95 percent UCL was not used for soil either because of the limited amount of validated data available for a given data set or because the distribution of the data set could not be defined. Groundwater exposure concentrations were developed using USEPA Region I guidance (USEPA, 1994f). A summary of the exposure point concentrations used to estimate potential risks associated with direct exposure COCs for Zone 1 is provided in Table 4-18.

Because of a lack of published dose-response parameters, some essential human nutrients (calcium, magnesium, potassium, and sodium) detected in the site media were not identified as COCs or quantitatively evaluated in the risk assessment. TPH was identified as a direct exposure COC based on a qualitative analysis. However, exposure to this chemical could not be quantitatively evaluated because of the lack of dose-response parameters. In addition, USEPA Region I does not advocate a quantitative evaluation of exposure to aluminum, copper, and iron, although they may be identified as COCs, because the only available toxicity criteria for these chemicals are provisional reference doses based on daily allowable intakes rather than adverse effect levels. Exposure to these chemicals is addressed in the general uncertainty section of the baseline human health risk assessment, Section 3.4.5.

4.6.2 Exposure Assessment

This section presents a summary of the persons potentially exposed to soil and groundwater at Zone 1 of the Lower Subase and describes the routes by which they might be exposed. Details on the exposure parameters used in the quantitative risk assessment were provided in Section 3.4.3.

The most likely receptors at this site include any full-time adult employees or military personnel assigned to the various buildings. These persons could be exposed to shallow soil via direct contact (incidental ingestion or dermal contact). They are assumed to be exposed 150 days/year for 6 years for the CTE and for 25 years for the RME.

A construction worker scenario was also evaluated for the Zone 1. A construction project is assumed to take between 80 (CTE) and 120 (RME) days in a 1-year period. These persons could come into contact with "all soil" (soil from depths of 0 to 10 feet) via dermal contact and incidental ingestion. These receptors may also be dermally exposed to groundwater during ground-intrusive activities.

Since the site is located along the Thames River and waterfront property is typically regarded as an attractive location for residential development, future residents were evaluated as potential receptors. This exposure scenario is dependent upon Base closure, which is considered to be highly unlikely because of the critical nature of the facility with respect to support of the submarine fleet and national defense. Therefore, this scenario is primarily evaluated for informational purposes only (i.e., to aid in decision making and risk management decisions). Future potential residents are not assumed to come in contact with groundwater at the site because saline conditions that exist near the river would preclude domestic use of groundwater. Receptors are assumed to be exposed to "all soil" (soil from depths of 0 to 10 feet) via incidental ingestion and dermal contact. Soil exposures were assumed to occur 150 days/year for a total of 7 years under the CTE and 30 years for the RME.

There are no dermal absorption factors available for beryllium, manganese, and mercury. As requested by EPA Region I, dermal exposures to these COCs will be evaluated using a generic absorption factor of 0.01 and the results will be discussed in the uncertainty analysis presented in Section 4.6.4.

The identified potential receptors could also be exposed to chemicals in soil via inhalation of fugitive dust and volatile emissions. This exposure pathway is evaluated in a qualitative fashion by a comparison of maximum soil concentrations to generic USEPA SSLs for the inhalation pathway, as summarized in the site-specific COC summary screening tables in Appendix I.5. Maximum detections for all soil chemicals were below the inhalation SSLs, indicating that the inhalation pathway is not expected to be a significant

exposure route. Consequently, this exposure route was eliminated from further quantitative risk evaluation.

4.6.3 Risk Characterization

A summary of the quantitative risk assessment for Zone 1 is provided in this section. Total noncarcinogenic and carcinogenic risks for each exposure route, as well as the cumulative risks for the RME and CTE scenarios, are outlined in Table 4-19 for the construction worker, full-time employee, and future resident. Sample calculations are provided in Appendix I.3. Appendix I.5 contains the chemical-specific risks for Zone 1.

4.6.3.1 Noncarcinogenic Risks

Cumulative Hazard Indices (HIs) for the full-time employee and the future resident under both the RME and CTE scenarios were less than unity, indicating that toxic effects are not anticipated for these receptors. Although the cumulative HI for the construction worker under the CTE (0.16) was also less than unity, the cumulative HI for this receptor under the RME is 1.5.

Although all chemical- and route-specific Hazard Quotients (HQs) for the RME construction worker are less than unity, the cumulative HI slightly exceeded unity. Noncarcinogenic hazards for the construction worker under the RME are similar for incidental ingestion of soil and dermal contact with groundwater and are attributable to inorganics (manganese, thallium, and vanadium in soil and mercury in groundwater). To identify whether toxic effects are likely under the RME scenario, a discussion of target organ effects is necessary for those chemicals contributing significantly to the cumulative risks. Chemical-specific HQs are not truly cumulative unless similar target organs or mechanisms of action are observed. Toxicological studies indicate that the primary target organs for exposure to those chemicals contributing the most to the cumulative risk for the construction worker are as follows:

Chemical	Hazard Quotient	Target Organ
Manganese	0.31	Central nervous system
Mercury	0.63	Kidney
Thallium	0.22	Liver, Blood, Hair
Vanadium	0.10	None reported

Based on the information presented above, it is unlikely that a total HI for a single target organ would exceed unity. Therefore, no toxic effects are anticipated for the construction worker under the RME scenario.

4.6.3.2 Carcinogenic Risks

Cumulative incremental cancer risks for Zone 1 ranged from 1.5E-6 for the construction worker (CTE) to 5.2E-4 for the future resident (RME). The cumulative incremental cancer risk for the full-time employee (2.9E-4) and future resident (5.2E-4) under the RME scenario exceeded the upper limit of the USEPA target risk range (1E-4 to 1E-6), as well as the CTDEP target cancer risk of 1E-5. Although the cumulative incremental cancer risk for the construction worker (1.5E-5) under the RME scenario and future resident (2.3E-5) under the CTE scenario are within the USEPA target risk range, the cancer risks for these receptors exceeds the CTDEP target cancer risk of 1E-5. Cumulative incremental cancer risks for all other receptor scenarios were either less than 1E-6 or less than 1E-5 and within the USEPA target risk range.

The exposure routes of concern for the full-time employee and future resident under the RME scenario are incidental ingestion and dermal contact with soil. As summarized in Table 4-20, PAHs and benzo(a)pyrene in particular are the major contributors to the elevated cancer risks. For the RME full-time employee and future resident, the chemical-specific incremental cancer risks associated with benzo(a)anthracene, benzo(b)fluorene, dibenzo(a,h)anthracene, indeno(1,2,3-cd)pyrene, and arsenic exceeded 1E-5 or 1E-6 and cancer risks for benzo(a)pyrene exceeded 1E-4.

4.6.3.3 Exposure to Lead

Lead was identified as a potential COC for groundwater at Zone 1. Maximum detections of the chemical in unfiltered and filtered groundwater samples exceeded the 15 µg/L Federal Drinking Water Action Level and the state RSR for the protection of groundwater. However, the average concentration of lead in the groundwater plume, 7.2 µg/L (Table 4-18), is less than 15 µg/L. Quantitative risks resulting from exposures to lead in groundwater were not evaluated since this medium is not expected to be used as a potable water supply because of saline conditions.

4.6.4 Uncertainties

A detailed discussion of uncertainties associated with the various aspects of risk assessment, in general, was provided in Section 3.4.5. Site-specific uncertainties for Zone 1 risk evaluation are presented below.

There were no dermal absorption values available for beryllium, manganese, and mercury, therefore, as requested by EPA Region I, dermal exposures to soil for these COCs were evaluated using a generic absorption value of 0.01. Cancer risks could not be calculated for these COCs since there are no oral cancer slope factors available for these compounds. Hazard indices were as follows:

	Scenario	
Receptor	**RME**	**CTE**
Construction Worker	1.03	0.02
Full-time Employee	1.24	0.084
Future Resident	1.65	0.05

All cumulative hazard indices for all receptors under the RME scenario exceeded the acceptable level of 1.0. Mercury was the main contributor to the hazard index for all receptors. The hazard index for dermal contact with mercury in soil was 0.97 for construction workers, 1.24 for full-time employees, and 1.63 for future residents. It should be noted that the above hazard indices are based on the maximum detected concentration of mercury in soil. In addition, mercury was detected in only one of four surface soil samples and two of eight subsurface soil samples. The use of a generic absorption factor for mercury may either underestimate or overestimate the noncarcinogenic health effects resulting from dermal exposures to mercury in soil since the actual absorption factor may be higher or lower than the generic value.

Some inorganic chemicals detected in site soil samples may be attributable to naturally occurring background levels. Background levels for metals in soil at NSB-NLON, developed by Atlantic Environmental Services, were presented in Table 1-4. All reported concentrations of aluminum, barium, beryllium, chromium, cobalt, iron, and vanadium in the site soils were less than the established background levels. Most of the soil samples collected from Zone 1 were obtained from locations that are currently beneath pavement. All soil samples (currently exposed and beneath pavement) were used to conservatively evaluate potential risks for the site. Therefore, actual exposure under current site conditions is less than exposure that is assumed for this risk assessment.

4.7 SUMMARY AND RECOMMENDATIONS

This section presents a summary of major findings for Zone 1 of the Lower Subase. A summary of the nature and extent of contamination is provided in Section 4.7.1. Section 4.7.2 includes a summary of contaminant fate and transport information and Section 4.7.3 provides a synopsis of the baseline human health risk assessment for Zone 1. Section 4.7.4 provides recommendations regarding additional action

and investigatory efforts for the soil and groundwater of Zone 1. A summary of the ecological risks for the Thames River adjacent to Zone 1 and the corresponding recommendations for the river are provided in Section 11.0.

4.7.1 Nature And Extent Of Contamination

Metals, petroleum hydrocarbons, SVOCs, and VOCs were detected in Zone 1 soils. The types and concentrations of shallow and deep soil contaminants do not vary significantly. Maximum concentrations of a majority of deep soil metal contaminants were detected in the deep soil sample collected from well 13MW4, located northeast of Building 29 at the intersection of an existing fuel pipeline and a sanitary sewer line. Two areas of SVOC contamination exist within Zone 1. One area is located north of Site 11, and the other is located west of Building 29. TPH contamination is widespread in both the shallow and deep soils and is most likely the result of leaking tanks in the areas of Sites 10 and 11.

Metals, petroleum hydrocarbons, SVOCs, and VOCs were also detected in the groundwater at Zone 1. The distribution of lead indicates that a small plume of lead contamination exists in the area between Building 89 and Site 11. VOCs and SVOCs were infrequently detected at low concentrations in the Zone 1 groundwater samples. The majority of SVOCs were detected in groundwater samples collected from well 13MW2, located east of Site 10. TPH and historical fluorescence data indicate that petroleum contamination exists in the groundwater beneath Sites 10 and 11, and the contamination may extend from the eastern side of Zone 1 to the Thames River. Free-phase product was detected in well 13MW18.

Storm sewer surface water samples, collected annually from Zone 1 as part of an NPDES monitoring program, were analyzed for copper, lead, zinc, oil and grease, and several miscellaneous parameters. The analyses shows a decrease in oil and grease concentrations over time. Copper, lead, and zinc were detected in all three surface water samples.

4.7.2 Contaminant Fate and Transport

High concentrations of petroleum hydrocarbons and SVOCs, as well as inorganic concentrations in excess of background, have been detected in both the soil and the groundwater of Zone 1. Data from the Thames River, which is a downgradient receptor of Zone 1, indicates that mobile PAHs may have migrated from Zone 1 to the river. An evaluation of natural attenuation indicated that this process may be viable for the soil and groundwater because of the presence of biodegradable contaminants (i.e., petroleum hydrocarbons and SVOCs) and because key parameters indicate that the process is currently occurring in a portion of the groundwater. Therefore, a combination of monitored natural attenuation and a

tiered groundwater monitoring program should be evaluated further as part of the remedial strategy for Zone 1.

The purpose of a tiered groundwater monitoring program is to monitor contaminant migration routes (e.g., the groundwater) from a site to determine if site-specific contaminants are impacting downgradient receptors via contaminant migration. A tiered groundwater monitoring program is typically implemented at a site, like Zone 1, that poses little risk to human health or the environment due to direct exposure, but has remaining source area concentrations that pose a potential contaminant migration problem. These programs have action levels, that if exceeded, trigger additional sampling activities in the media of downgradient areas (e.g., surface water and sediment of the Thames River) to verify if these media are being impacted by the site. The programs also include "decision trees" that provide the steps that will be taken to evaluate monitoring data, to make changes to the monitoring program, and to modify the remedial strategy for the site. The end goal of a tiered groundwater monitoring program is to provide the long-term information that is necessary to determine if the selected remedial action for the site is acceptable.

4.7.3 Baseline Human Health Risk Assessment

The baseline human health risk assessment for Zone 1 focused on three potential receptor groups: construction workers, full-time employees, and future residents. Noncarcinogenic risks for all receptor groups except one were less than the USEPA and CTDEP acceptable limit of one. The only noncarcinogenic risk exceedance was for the construction worker under the RME scenario, where the associated HI (1.5) slightly exceeded unity. However, based on an evaluation of target organ effects, toxic effects are not anticipated for the construction worker under the RME scenario. With the exception of the full-time employee and the future resident under the RME scenario, carcinogenic risks for all receptors were either less than 1E-6 or within the USEPA acceptable target risk range of 1E-4 to 1E-6. Cancer risks for the construction worker, full-time employee, and future resident under the RME scenario and future resident under the CTE scenario exceed the CTDEP acceptable cumulative risk level of 1E-5. PAHs and arsenic contribute significantly to the elevated cancer risks for these receptors. Benzo(a)pyrene and, to a lesser degree, dibenzo(a,h)anthracene are the major contributors to the elevated cancer risks.

Maximum detected concentrations of PAHs, metals, and TPH in soil exceeded their respective generic mobility criteria which indicates the potential exists for these chemicals to migrate from soil to groundwater. Although the maximum detected concentrations of benzo(a)anthracene, benzo(a)pyrene, benzo(b)fluoranthene, benzo(k)fluoranthene, and dibenzo(a,h)anthracene exceeded the generic mobility criteria, these chemicals were not detected in groundwater samples collected at Zone 1. The mobility of a few other PAHs and several inorganics may be supported by the groundwater data, but the SPLP results

indicate that lead may not be mobile. The maximum detected concentration of chromium exceeded the generic mobility criteria but was within background levels.

Maximum concentrations in groundwater were compared to Connecticut salt water WQSs since Zone 1 borders the Thames River. Several migration COCs in groundwater were identified as exceeding the Connecticut salt water WQSs. Use of the Connecticut salt water WQSs to determine groundwater impacts on the Thames River is very conservative since the WQSs do not account for the dilutional effects of the groundwater mixing with the river. Appropriate alternative surface water protection criteria can be calculated by multiplying the lower of the human health or aquatic life criterion in the latest Connecticut WQSs by a site-specific dilution factor. Recently calculated site-specific dilution factors for the DRMO (Site 6) and Goss Cove Landfill (Site 8), other NSB-NLON IRP sites located along the Thames River, were 226 and 118, respectively. The maximum detected concentrations of most migration COCs (benzene, bis(2-ethylhexyl)phthalate, cadmium, lead, nickel, silver, thallium, and zinc) are within one order of magnitude of the Connecticut WQSs. Therefore, the actual impact on water quality in the Thames River is expected to be minimal because significant dilution is anticipated, thereby reducing chemical concentrations in the Thames River.

4.7.4 Recommendations

It is recommended that this zone, which includes Site 10 - Fuel Storage Tanks and Tank 54-H and Site 11 - Power Plant Oil Tanks, proceed to a feasibility study for evaluation of appropriate remedial alternatives for the soil. Because of the extensive amount of underground utilities in Zone 1 and the nature of the activities conducted at this location (i.e., national security), the feasibility study for this zone should evaluate to the extent possible passive and/or in-situ remedial alternatives and the use of institutional controls. In addition, "hot spot" removal actions, in lieu of full-scale excavation, should also be considered in the Zone 1 Feasibility Study. It is also recommended that the feasibility study evaluate limited action scenarios for the groundwater and storm sewer system of Zone 1 in conjunction with the soil remedial alternatives. The scenarios evaluated for the groundwater should include free-phase product removal from monitoring well 13MW18 and a monitored natural attenuation/tiered groundwater monitoring program. The scenario for the storm sewer system should include cleaning and repair of the system. These recommendations are based on the following information:

- The nature and extent of organic and inorganic contamination in the soil is well defined to the extent practical considering infrastructure limitations.

- The baseline human health risk assessment indicates that noncarcinogenic risks for the construction worker under the RME scenario slightly exceed 1.0. The assessment also shows that the carcinogenic risks for the construction worker, full-time employee and the hypothetical future resident under the RME scenario and for the hypothetical future resident under the CTE scenario are in excess of the CTDEP cumulative target risk level. In addition, the carcinogenic risk for the full-time employee and hypothetical future resident under the RME scenario exceeds the USEPA target risk range.

- Based on a comparison of analytical results with conservative, generic mobility criteria, organic and inorganic contamination in the soil has the potential to migrate and impact the groundwater at this site. Groundwater analytical data confirm these screening results and indicate that limited migration is currently occurring.

- Monitored natural attenuation or bioremediation could be feasible alternatives for the petroleum contamination in the soil.

- Significant amounts of petroleum contamination remain in the soils of Zone 1; however, the historical source(s) of petroleum contamination have been eliminated (i.e., the leaking Site 10 and 11 USTs, the Building 89 UST, and the fuel distribution line have been removed and/or repaired). The Navy has implemented leak detection systems for all USTs and conducts regular pressure testing and repairs on the fuel distribution lines.

- The zone is generally covered with pavement or buildings, which minimizes direct exposure to the contaminated soil by human receptors.

- The groundwater at Zone 1 is not currently or anticipated to be used in the future as a potable water source because it is brackish; therefore, there is no imminent threat to human health.

- The ecological risk assessment for the Thames River adjacent to Zone 1 (see Section 11.0) and the baseline human health risk assessment for Zone 2 (see Section 5.0), which are both downgradient receptors of Zone 1, show that the risks to ecological and human receptors in these adjacent areas are currently minor. In addition, the Thames River provides significant dilution and mixing which minimizes the impact of any contaminant migration from Zone 1.

- Free-phase petroleum product was only detected in well 13MW18 during the latest round of sampling.

- Key parameters indicate that natural attenuation processes are at work in the groundwater of Zone 1 and these processes can reduce concentrations of petroleum contamination that reach the aquifer and convert the petroleum contamination to a less toxic form. Monitored natural attenuation should be further evaluated as part of the remedial strategy for the Zone 1 to confirm the effectiveness of these processes. The monitored natural attenuation program should include or be part of a tiered groundwater monitoring program, similar to the ones currently being implemented at other NSB-NLON IRP sites. These programs confirm or disprove that contamination present in the soil is mobile and impacting other media and allow for further actions to be completed if the results show significant impacts.

- The storm sewer system in Zone 1 may be acting as a migration pathway for contaminants present in the groundwater. Analytical results from one catch basin sampled as part of the NPDES permit indicate that several inorganics (i.e., copper, lead, and zinc) are frequently present in the surface water discharged from Zone 1 and these three metals were identified as groundwater COCs for Zone 1. A limited evaluation of the invert elevations of the storm sewer system indicate that portions of the system are submerged by varying amounts during a given day or time of year. Because of the age of parts of the system (i.e., greater than 40 years) and the material that it was constructed with (i.e., vitrified clay), it is likely that the system is cracked and groundwater will infiltrate into the storm sewers.

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TABLE 4-1

SUMMARY OF SAMPLING AND ANALYTICAL PROGRAM - ZONE 1
HYDROGEOLOGIC INVESTIGATION UST OT-4, OT-7, OT-8, OT-9, AND TANK 54-H
LOWER SUBASE
NSB-NLON, GROTON, CONNECTICUT

Sample ID	Sample Depth (feet below ground)	Analysis								
		Target Compound List (TCL)		TAL Metals		RCRA Metals[3]	Lead	TPH[4]	Fluorescence	Misc
		Volatiles[1]	Semivolatiles[2]	Total	Dissolved					
GROUNDWATER										
MW-13	NA	●	●					●		
MW-14	NA	●	●					●		
MW-15	NA	●	●					●		
MW-16	NA	●	●					●		

1 Analysis for benzene, chlorobenzene, toluene, ethyl benzene, and total xylenes only.
2 Analysis for 1,2-dichlorobenzene, 1,3-dichlorobenzene, and 1,4-dichlorobenzene only.
3 Toxicity Characteristic Leaching Procedure (TCLP) extraction followed by analysis for RCRA metals.
4 Analysis for diesel fuel #2.
NA = Not applicable.
● = Sample was analyzed for this parameter.
Blank cell indicates that this analysis was not performed for this sample.

TABLE 4-2

SUMMARY OF SAMPLING AND ANALYTICAL PROGRAM - ZONE 1
PHASE I REMEDIAL INVESTIGATION
LOWER SUBASE
NSB-NLON, GROTON, CONNECTICUT

Sample ID	Sample Depth (feet below ground)	Analysis								
		Target Compound List (TCL)		TAL Metals[1] + Cyanide		RCRA Metals[2]	Lead	TPH	Fluorescence	Misc
		Volatiles	Semivolatiles	Total	Dissolved					
SOIL										
13MW1(12-14)	12-14	●		●		●		●	●	
13MW2(10-12)	10-12	●		●		●		●	●	
13MW3(12-14)	12-14	●		●		●		●	●	
13MW4(6-8)	6-8	●		●		●		●	●	
13MW5(10-12)	10-12	●		●		●		●	●	
13MW7(8-10)	8-10	●		●		●		●	●	
13MW8(8-10)	8-10	●		●		●		●	●	
13MW9(6-8)	6-8	●		●		●		●	●	
GROUNDWATER										
011591-13MW7S	NA	●		●				●	●	
011591-13MW27S[3]	NA	●		●				●		
011691-13MW1S	NA	●		●				●	●	
011691-13MW2S	NA	●		●				●	●	
011691-13MW3S	NA	●		●				●	●	
011791-13MW4S	NA	●		●				●	●	
011791-13MW5S	NA	●		●				●	●	
011791-13MW9S	NA	●		●				●	●	
011891-NESOMW4S	NA	●		●				●	●	
021191-13MW8	NA	●		●				●	●	

1 Analysis for boron was also performed.
2 Toxicity Characteristic Leaching Procedure (TCLP) extraction followed by analysis for RCRA Metals.
3 01SS91-13MW27S is a field duplicate of 011591-13MW7S.
NA = Not applicable.
● = Sample was analyzed for this parameter.
Blank cell indicates that this analysis was not performed for this sample.

TABLE 4-3

SUMMARY OF SAMPLING AND ANALYTICAL PROGRAM - ZONE 1
SITE CHARACTERIZATION REPORT FOR OT-10, BUILDING 325, AND BUILDING 89
LOWER SUBASE
NSB-NLON, GROTON, CONNECTICUT

Sample ID	Sample Depth (feet below ground)	Analysis								
		Target Compound List (TCL)		TAL Metals[1]		RCRA Toxicity Characteristics[2]	Lead	TPH	Fluorescence	Misc
		Volatiles	Semivolatiles	Total	Dissolved					
SOIL										
Pipe Chase	2-2	●	●	●		●		●		
Tank Grave-S	7-7	●[3]						●		
Tank Grave-N	7-7	●[3]						●		

1 Analysis for boron was also performed.
2 Toxicity Characteristic Leaching Procedure (TCLP) extraction followed by analysis for RCRA metals, volatiles, semivolatiles, pesticides, and herbicides.
3 Analysis for benzene, ethylbenzene, toluene, and total xylenes only.
● = Sample was analyzed for this parameter.
Blank cell indicates that this analysis was not performed for this sample.

TABLE 4-4

SUMMARY OF SAMPLING AND ANALYTICAL PROGRAM - ZONE 1
TANK FARM INVESTIGATION
LOWER SUBASE
NSB-NLON, GROTON, CONNECTICUT

Sample ID	Sample Depth (feet below ground)	Analysis								
		Target Compound List (TCL)		TAL Metals		RCRA Metals	Lead	TPH	Fluorescence	Misc
		Volatiles	Semivolatiles	Total	Dissolved					
SOIL										
FPTB13L-07	7-7							●		
DUP04-100795[1]	7-7							●		
FPTB25L-06	6-6							●		
FPTB26L-05	5.8-6.8							●		
FPTB28L-04	4-4							●		
FPTB30L-07	7-8							●		
FPTB31L-07	7-8							●		
FPTB32L-11	11-12							●		

1 DUP04-100795 is a field duplicate of FPTB13L-07.
● = Sample was analyzed for this parameter.
Blank cell indicates that this analysis was not performed for this sample.

TABLE 4-5

SUMMARY OF SAMPLING AND ANALYTICAL PROGRAM - ZONE 1
PHASE II REMEDIAL INVESTIGATION
LOWER SUBASE
NSB-NLON, GROTON, CONNECTICUT
PAGE 1 OF 2

Sample ID	Sample Depth (feet below ground)	Analysis								
		Target Compound List (TCL)		TAL Metals[1]		RCRA Metals[2]	Lead	TPH	Fluorescence	Misc[3]
		Volatiles	Semivolatiles	Total	Dissolved					
SOIL										
13MW18-0911	9-11					●	●	●		
13TB13-0305	3-5					●	●	●		
13TB13-0911	9-11					●	●	●		
13TB15-0305	3-5					●	●	●		
13TB15-0709	7-9					●	●	●		
13TB16-0204	2-4					●	●	●		
13TB16-0810	8-10					●	●	●		
13TB17-0406	4-6					●	●	●		
13TB17-0608	6-8					●	●	●		
GROUNDWATER - ROUND 1										
13GW1	NA	●	●	●	●			●		●
13GW2	NA	●	●	●	●			●		●
13GW3	NA	●	●	●	●			●		●
13GW8	NA	●	●	●	●			●		●
13GW9	NA	●	●	●	●			●		●
13GW18	NA	●	●	●	●			●		●
13GW19	NA	●	●	●	●			●		●
13GW20	NA	●	●	●	●			●		●
13GW20-D[4]	NA	●	●	●	●			●		●
13GW21	NA	●	●	●	●			●		●
NESO4	NA	●	●	●	●			●		●
GROUNDWATER - ROUND 2										
13GW1-2	NA	●	●	●	●			●		●
13GW2-2	NA	●	●	●	●			●		●
13GW3-2	NA	●	●	●	●			●		●

TABLE 4-5

SUMMARY OF SAMPLING AND ANALYTICAL PROGRAM - ZONE 1
PHASE II REMEDIAL INVESTIGATION
LOWER SUBASE
NSB-NLON, GROTON, CONNECTICUT
PAGE 2 OF 2

Sample ID	Sample Depth (feet below ground)	Analysis								
		Target Compound List (TCL)		TAL Metals[1]		RCRA Metals[2]	Lead	TPH	Fluorescence	Misc[3]
		Volatiles	Semivolatiles	Total	Dissolved					
13GW8-2	NA	●	●	●	●			●		●
13GW9-2	NA	●	●	●	●			●		●
13MW18-2	NA	●	●	●	●			●		●
13MW19-2	NA	●	●	●	●			●		●
13MW20-2	NA	●	●	●	●			●		●
13MW21-2	NA	●	●	●	●			●		●
NESO4-2	NA	●	●	●	●			●		●

1 Analysis for boron was also performed.
2 Toxicity Characteristic Leaching Procedure (TCLP) extraction followed by analysis for RCRA metals.
3 Miscellaneous parameter includes: Hardness (as $CaCO_3$).
4 13GW20-D is a field duplicate of 13GW20.
NA = Not applicable.
● = Sample was analyzed for this parameter.
Blank cell indicates that this analysis was not performed for this sample.

TABLE 4-6

SUMMARY OF SAMPLING AND ANALYTICAL PROGRAM - ZONE 1
ANNUAL NPDES STORMWATER MONITORING PROGRAM
LOWER SUBASE
NSB-NLON, GROTON, CONNECTICUT

Sample ID	Date of Collection	Analysis								
		Target Compound List (TCL		TAL Metals		RCRA Metals	Lead	TPH[2]	Fluorescence	Misc[3]
		Volatiles	Semivolatiles	Total[1]	Dissolved					
SURFACE WATER										
BLDG 89	09/21/93			●				●		●
BLDG 89	02/28/95			●				●		●
BLDG 89	10/08/96			●				●		●

1 Analysis for copper, lead, and zinc only.
2 Oil and grease analysis performed.
3 Miscellaneous parameters include: Chemical Oxygen Demand, Fecal Coliform, Nitrate (as Nitrogen), pH, Total Dissolved Solids, Total Kjeldahl Nitrogen, Total Phosphorous, and Total Suspended Solids.
● = Sample was analyzed for this parameter.
Blank cell indicates that this analysis was not performed for this sample.

TABLE 4-7

SUMMARY OF SAMPLING AND ANALYTICAL PROGRAM - ZONE 1
LOWER SUBASE REMEDIAL INVESTIGATION
LOWER SUBASE
NSB-NLON, GROTON, CONNECTICUT
PAGE 1 OF 2

Sample ID	Sample Depth (feet below ground)	Analysis								
		Target Compound List (TCL)		TAL Metals		SPLP Lead[1]	Lead	TPH	Fluorescence	Misc[2]
		Volatiles	Semivolatiles	Total	Dissolved					
SOIL										
LS1SB0010101	1.5-3.5		●	●		●		●		
LS1SB0010201	5-6		●							
LS1SB0020101	2-3.5		●	●		●		●		
LS1SB0020201	7-7.5		●							
LS1SB0030101	2-4		●							
LS1SB0030201	5-8		●							
LS1SB0040101	2-4		●							
LS1SB0040301	9-11		●							
LS1SB0050101	2-4		●							
LS1SB0050301	10-12		●							
LS1SB0060101	2-4		●	●				●		
LS1SB0060301	9-10		●							
LS1SB0070101	2-4		●					●		
LS1SB0070401	13-14		●					●		
SBFD008[3]	13-14		●							
LS1SB0080101	2-4		●					●		
LS1SB0080301	10-11		●					●		
LS1SB0090101	2-4		●					●		
LS1SB0090201	5.5-6.5		●							
GROUNDWATER										
LS1GW13MW101	NA		●	●	●			●		●
DUP005[4]	NA		●	●	●			●		●[5]
LS1GW13MW1801	NA		●	●	●			●		●[6]
LS1GW13MW1901	NA		●	●	●			●		●
LS1GW13MW2001	NA		●	●	●			●		●
LS1GW13MW201	NA		●	●	●			●		●

TABLE 4-7

SUMMARY OF SAMPLING AND ANALYTICAL PROGRAM - ZONE 1
LOWER SUBASE REMEDIAL INVESTIGATION
LOWER SUBASE
NSB-NLON, GROTON, CONNECTICUT
PAGE 2 OF 2

Sample ID	Sample Depth (feet below ground)	Analysis								
		Target Compound List (TCL)		TAL Metals		SPLP Lead[1]	Lead	TPH	Fluorescence	Misc[2]
		Volatiles	Semivolatiles	Total	Dissolved					
LS1GW13MW2101	NA		●	●	●			●		●
LS1GW13MW301	NA		●	●	●			●		●
LS1GW13MW801	NA		●	●	●			●		●
LS1GW13MW901	NA		●	●	●			●		●
LS1GWFOMW1301	NA		●	●	●			●		●
LS1GWFOMW1401	NA		●	●	●			●		●
LS1GWFOMW1501	NA		●	●	●			●		●
LS1GWFOMW1601	NA		●	●	●			●		●

1 Synthetic Precipitation Leaching Procedure (SPLP) extraction followed by analysis for lead.
2 Unless otherwise noted, miscellaneous parameters include: Alkalinity (as $CaCO_3$), Ammonia (as Nitrogen), Chloride, Dissolved Oxygen, Divalent Iron, Hardness (as $CaCO_3$), Nitrate (as Nitrogen), pH, Phosphorous, Redox Potential, Salinity, Specific Conductivity, Sulfate, Temperature, Total Organic Carbon, Turbidity, and Dissolved Methane.
3 SBFD008 is a field duplicate of LS1SB0070401.
4 DUP005 is a field duplicate of LS1GW13MW101.
5 Miscellaenous parameters include: Alkalinity (as $CaCO_3$), Ammonia (as Nitrogen), Chloride, Hardness (as $CaCO_3$), Nitrate (as Nitrogen), Phosphorous, Sulfate, Total Organic Carbon, and Dissolved Methane.
6 Miscellaenous parameters include: Alkalinity (as $CaCO_3$), Ammonia (as Nitrogen), Chloride, Divalent Iron, Hardness (as $CaCO_3$), Nitrate (as Nitrogen), Phosphorous, Sulfate, Total Organic Carbon, Turbidity, and Dissolved Methane.
NA = Not applicable.
● = Sample was analyzed for this parameter.
Blank cell indicates that this analysis was not performed for this sample.

TABLE 4-8 (PAGE 1 OF 16)

SUMMARY OF POSITIVE SOIL ANALYTICAL RESULTS FOR ZONE 1 LOWER SUBASE; NSB-NLON; GROTON, CONNECTICUT

SAMPLE NUMBER:	13MW1(12-14)	13MW18-0911	13MW2(10-12)	13MW3(12-14)	13MW4(6-8)	13MW5(10-12)
DEPTH (feet):	12 - 14'	9 - 11'	10 - 12'	12 - 14'	6 - 8'	10 - 12'
INVESTIGATION:	PH1	PH2-1	PH1	PH1	PH1	PH1
SAMPLE DATE:	11/05/90	01/26/94	11/05/90	11/07/90	11/07/90	11/08/90
LOCATION:	13MW1	13MW18	13MW2	13MW3	13MW4	13MW5
VALIDATED:	VALIDATED	VALIDATED	VALIDATED	VALIDATED	VALIDATED	VALIDATED
SAMPLE TYPE:	GRAB	GRAB	GRAB	GRAB	GRAB	GRAB
STATUS:						
FIELD DUPLICATE OF:						
VOLATILES (µg/kg)						
ACETONE	11 U		1100 U	54 U	12 U	14 U
CARBON DISULFIDE	6 U		560 U	27 U	5 U	6 U
METHYLENE CHLORIDE	6 U		560 U	27 U	5 U	6 U
XYLENES, TOTAL	6 U		560 U	27 U	5 U	6 U
METALS (mg/kg)						
ALUMINUM	5470		4480	4310	6490	6980
ANTIMONY	5.6 UJ		5.6 UJ	5.4 UJ	5.5 UJ	5.8 UJ
ARSENIC	0.59		1.3	4.3	1.9	2
BARIUM	34.3		31.5	32	37.1	40.5
BERYLLIUM	0.23 U		0.25	0.21 U	0.4	0.28
CADMIUM	1.2 J		0.8 J	0.81 J	1 J	1.1 J
CALCIUM	593 J		1070 J	647 J	1870 J	900 J
CHROMIUM	15.4		7.7	7.5	13.8	12.5
COBALT	3.5		3.4	3.1	5.5	5.5
COPPER	9.1 J		10.3 J	8.2 J	59.6	18.1 J
IRON	8200		6420	7610	9030	10400
LEAD	4.2 J	2.6	22.8 J	3 J	383 J	17.6 J
MAGNESIUM	2590		1830	2170	3020	2890
MANGANESE	118		125	95.9	148	173
MERCURY	0.11 U		0.11 U	0.1 U	0.48 J	0.12 U
NICKEL	4.8		4.4	4.4	12	10.3
POTASSIUM	2830 J		1500 J	1870 J	1950 J	2190 J

TABLE 4-8 (PAGE 2 OF 16)

SUMMARY OF POSITIVE SOIL ANALYTICAL RESULTS FOR ZONE 1 LOWER SUBASE; NSB-NLON; GROTON, CONNECTICUT

SAMPLE NUMBER:	13MW1(12-14)	13MW18-0911	13MW2(10-12)	13MW3(12-14)	13MW4(6-8)	13MW5(10-12)
DEPTH (feet):	12 - 14'	9 - 11'	10 - 12'	12 - 14'	6 - 8'	10 - 12'
INVESTIGATION:	PH1	PH2-1	PH1	PH1	PH1	PH1
SAMPLE DATE:	11/05/90	01/26/94	11/05/90	11/07/90	11/07/90	11/08/90
LOCATION:	13MW1	13MW18	13MW2	13MW3	13MW4	13MW5
VALIDATED:	VALIDATED	VALIDATED	VALIDATED	VALIDATED	VALIDATED	VALIDATED
SAMPLE TYPE:	GRAB	GRAB	GRAB	GRAB	GRAB	GRAB
STATUS:						
FIELD DUPLICATE OF:						
METALS (mg/kg)						
SILVER	1.6 U		1.6 U	1.5 U	2.2 J	1.6 U
SODIUM	140 J		74 J	117 J	365 J	114 J
VANADIUM	12		10.6	11.1	27.1	16.9
ZINC	37.4		24.6	20.7	70.4	29.1
TOTAL PETROLEUM HYDROCARBONS (mg/kg)						
TPH	1200	51600 J	14000	11000	450	7000

TABLE 4-8 (PAGE 3 OF 16)

SUMMARY OF POSITIVE SOIL ANALYTICAL RESULTS FOR ZONE 1 LOWER SUBASE; NSB-NLON; GROTON, CONNECTICUT

SAMPLE NUMBER:	13MW7(8-10)	13MW8(8-10)	13MW9(6-8)	13TB13-0305	13TB13-0911	13TB15-0305
DEPTH (feet):	8 - 10'	8 - 10'	6 - 8'	3 - 5'	9 - 11'	3 - 5'
INVESTIGATION:	PH1	PH1	PH1	PH2-1	PH2-1	PH2-1
SAMPLE DATE:	11/07/90	11/07/90	11/07/90	01/26/94	01/26/94	01/25/94
LOCATION:	13MW7	13MW8	13MW9	13TB13	13TB13	13TB15
VALIDATED:	VALIDATED	VALIDATED	VALIDATED	VALIDATED	VALIDATED	VALIDATED
SAMPLE TYPE:	GRAB	GRAB	GRAB	GRAB	GRAB	GRAB
STATUS:						
FIELD DUPLICATE OF:						
VOLATILES (µg/kg)						
ACETONE	11 U	11 U	11 U			
CARBON DISULFIDE	5 J	6 U	6 U			
METHYLENE CHLORIDE	6 U	6 U	6 U			
XYLENES, TOTAL	6 U	6 U	6 U			
METALS (mg/kg)						
ALUMINUM	3250	3490	3370			
ANTIMONY	6 UJ	6 UJ	5.9 UJ			
ARSENIC	0.75	0.53	0.47 U			
BARIUM	14.7	20.6	21.3			
BERYLLIUM	0.24 U	0.24 U	0.24 U			
CADMIUM	0.57 J	1.4 J	0.7 J			
CALCIUM	539 J	870 J	681 J			
CHROMIUM	4.6	7.1	7.4			
COBALT	1.8	3.3	2.9			
COPPER	7.7 J	10.7 J	14 J			
IRON	3770	6280	5380			
LEAD	3.8 J	15.3 J	23.3 J	26.7	3.6	112
MAGNESIUM	1310	1600	1550			
MANGANESE	56.1	85.2	139			
MERCURY	0.12 J	0.12 U	0.1 U			
NICKEL	2.4	4.8	4.3			
POTASSIUM	1170 J	1590 J	1520 J			

TABLE 4-8 (PAGE 4 OF 16)
SUMMARY OF POSITIVE SOIL ANALYTICAL RESULTS FOR ZONE 1
LOWER SUBASE; NSB-NLON; GROTON, CONNECTICUT

SAMPLE NUMBER:	13MW7(8-10)	13MW8(8-10)	13MW9(6-8)	13TB13-0305	13TB13-0911	13TB15-0305
DEPTH (feet):	8 - 10'	8 - 10'	6 - 8'	3 - 5'	9 - 11'	3 - 5'
INVESTIGATION:	PH1	PH1	PH1	PH2-1	PH2-1	PH2-1
SAMPLE DATE:	11/07/90	11/07/90	11/07/90	01/26/94	01/26/94	01/25/94
LOCATION:	13MW7	13MW8	13MW9	13TB13	13TB13	13TB15
VALIDATED:	VALIDATED	VALIDATED	VALIDATED	VALIDATED	VALIDATED	VALIDATED
SAMPLE TYPE:	GRAB	GRAB	GRAB	GRAB	GRAB	GRAB
STATUS:						
FIELD DUPLICATE OF:						
METALS (mg/kg)						
SILVER	1.7 U	1.7 U	1.7 U			
SODIUM	184 J	444 J	821 J			
VANADIUM	5.7	13.6	14.9			
ZINC	20.3	28.5	32.7			
TOTAL PETROLEUM HYDROCARBONS (mg/kg)						
TPH	830	4900	70 U	263 J	686 J	213 J

TABLE 4-8 (PAGE 5 OF 16)

SUMMARY OF POSITIVE SOIL ANALYTICAL RESULTS FOR ZONE 1 LOWER SUBASE; NSB-NLON; GROTON, CONNECTICUT

SAMPLE NUMBER:	13TB15-0709	13TB16-0204	13TB16-0810	13TB17-0406	13TB17-0608	FPTB25L-06
DEPTH (feet):	7 - 9'	2 - 4'	8 - 10'	4 - 6'	6 - 8'	6 - 6'
INVESTIGATION:	PH2-1	PH2-1	PH2-1	PH2-1	PH2-1	TFI96
SAMPLE DATE:	01/25/94	01/24/94	01/24/94	01/25/94	01/25/94	11/19/95
LOCATION:	13TB15	13TB16	13TB16	13TB17	13TB17	GS-25L
VALIDATED:	VALIDATED	VALIDATED	VALIDATED	VALIDATED	VALIDATED	VALIDATED
SAMPLE TYPE:	GRAB	GRAB	GRAB	GRAB	GRAB	GRAB
STATUS:						
FIELD DUPLICATE OF:						
METALS (mg/kg)						
LEAD	6.4	24.2	87	62.5	3.4	
TOTAL PETROLEUM HYDROCARBONS (mg/kg)						
TPH	788 J	23.8 J	610 J	546 J	45 J	6670

TABLE 4-8 (PAGE 6 OF 16)

SUMMARY OF POSITIVE SOIL ANALYTICAL RESULTS FOR ZONE 1 LOWER SUBASE; NSB-NLON; GROTON, CONNECTICUT

SAMPLE NUMBER:	FPTB26L-05	FPTB28L-04	FPTB29L-07	DUP04-100795	FPTB30L-07	FPTB31L-07
DEPTH (feet):	5.8 - 6.8'	4 - 4'	7 - 7'	7 - 7'	7 - 8'	7 - 8'
INVESTIGATION:	TFI96	TFI96	TFI96	TFI96	TFI96	TFI96
SAMPLE DATE:	10/07/95	11/19/95	10/07/95	10/07/95	10/07/95	10/07/95
LOCATION:	GS-26L	GS-28L	GS-29L	GS-29L	GS-30L	GS-31L
VALIDATED:	VALIDATED	VALIDATED	VALIDATED	VALIDATED	VALIDATED	VALIDATED
SAMPLE TYPE:	GRAB	GRAB	GRAB	GRAB	GRAB	GRAB
STATUS:						
FIELD DUPLICATE OF:				FPTB29L-07		
TOTAL PETROLEUM HYDROCARBONS (mg/kg)						
TPH	147	223	8470	14900	27.3	240

TABLE 4-8 (PAGE 7 OF 16)

SUMMARY OF POSITIVE SOIL ANALYTICAL RESULTS FOR ZONE 1 LOWER SUBASE; NSB-NLON; GROTON, CONNECTICUT

SAMPLE NUMBER:	FPTB32L-11	Pipe Chase	LS1SB0010101	LS1SB0010201	LS1SB0020101	LS1SB0020201
DEPTH (feet):	11 - 12'	2 - 2'	1.5 - 3.5'	5 - 6'	2 - 3.5'	7 - 7.5'
INVESTIGATION:	TFI96	SCRBLDG89	1997RI	1997RI	1997RI	1997RI
SAMPLE DATE:	10/07/95	06/03/94	09/26/97	09/26/97	09/26/97	09/26/97
LOCATION:	GS-32L	PIPECHASE	TB1-1RI	TB1-1RI	TB2-1RI	TB2-1RI
VALIDATED:	VALIDATED		VALIDATED	VALIDATED	VALIDATED	VALIDATED
SAMPLE TYPE:	GRAB	GRAB	GRAB	GRAB	GRAB	GRAB
STATUS:						
FIELD DUPLICATE OF:						
VOLATILES (µg/kg)						
ACETONE		54 B				
CARBON DISULFIDE		11 U				
METHYLENE CHLORIDE		15 B				
XYLENES, TOTAL		1.29				
SEMIVOLATILES (µg/kg)						
2,4-DIMETHYLPHENOL		350 U	330 U	400 UJ	37 J	360 UR
2-METHYLNAPHTHALENE		350 U	330 U	70 J	870	1500 J
ACENAPHTHENE		24 J	330 U	400 UJ	3800	4300 J
ACENAPHTHYLENE		350 U	330 U	400 UJ	950	210 J
ANTHRACENE		30 J	330 U	200 J	12000	11000
BENZO(A)ANTHRACENE		140 J	48 J	310 J	21000	16000
BENZO(A)PYRENE		130 J	45 J	300 J	17000	13000 J
BENZO(B)FLUORANTHENE		130 J	37 J	400 UJ	17000	12000 J
BENZO(G,H,I)PERYLENE		88 J	48 J	240 J	9000	7600 J
BENZO(K)FLUORANTHENE		110 J	50 J	190 J	360 U	11000 J
BIS(2-ETHYLHEXYL)PHTHALATE		97 J	360 U	400 U	360 U	360 U
BUTYLBENZYL PHTHALATE		350 U	330 UJ	400 UJ	360 UJ	360 UJ
CARBAZOLE		29 J	330 U	400 UJ	4300	5200 J
CHRYSENE		140 J	59 J	430 J	19000	16000
DI-N-BUTYL PHTHALATE		350 U	330 U	400 UJ	360 U	360 UJ
DIBENZO(A,H)ANTHRACENE		350 U	330 U	87 J	5200	2700 J
DIBENZOFURAN		350 U	330 U	400 UJ	4000	4700 J

TABLE 4-8 (PAGE 8 OF 16)

SUMMARY OF POSITIVE SOIL ANALYTICAL RESULTS FOR ZONE 1 LOWER SUBASE; NSB-NLON; GROTON, CONNECTICUT

SAMPLE NUMBER:	FPTB32L-11	Pipe Chase	LS1SB0010101	LS1SB0010201	LS1SB0020101	LS1SB0020201
DEPTH (feet):	11 - 12'	2 - 2'	1.5 - 3.5'	5 - 6'	2 - 3.5'	7 - 7.5'
INVESTIGATION:	TFI96	SCRBLDG89	1997RI	1997RI	1997RI	1997RI
SAMPLE DATE:	10/07/95	06/03/94	09/26/97	09/26/97	09/26/97	09/26/97
LOCATION:	GS-32L	PIPECHASE	TB1-1RI	TB1-1RI	TB2-1RI	TB2-1RI
VALIDATED:	VALIDATED		VALIDATED	VALIDATED	VALIDATED	VALIDATED
SAMPLE TYPE:	GRAB	GRAB	GRAB	GRAB	GRAB	GRAB
STATUS:						
FIELD DUPLICATE OF:						
SEMIVOLATILES (µg/kg)						
FLUORANTHENE		310 J	74 J	1300 J	44000	37000
FLUORENE		350 U	330 U	400 UJ	4800	5200 J
INDENO(1,2,3-CD)PYRENE		81 J	38 J	290 J	12000	9500 J
NAPHTHALENE		350 U	330 U	66 J	1300	1700 J
PHENANTHRENE		190 J	30 J	780 J	41000	42000
PHENOL		350 U	330 U	400 U	29 J	360 UR
PYRENE		230 J	68 J	770 J	45000	41000
METALS (mg/kg)						
ALUMINUM		5710	5750		4670	
ANTIMONY		0.64	0.41 U		0.42 U	
ARSENIC		1.4 U	2.0		12.3	
BARIUM		20.5	36.8		45.7	
BERYLLIUM		0.2	0.22 U		0.18 U	
CADMIUM		0.34	0.04 U		0.04 U	
CALCIUM		838	846		1810	
CHROMIUM		4.9	11.7		10.5	
COBALT		1.7 U	3.1		3.0	
COPPER		8	64.5		18.1	
IRON		6810	7830		11600	
LEAD		7.7	34.3		98.8	
MAGNESIUM		1420	2240		1850	
MANGANESE		122	133		118	

TABLE 4-8 (PAGE 9 OF 16)

SUMMARY OF POSITIVE SOIL ANALYTICAL RESULTS FOR ZONE 1 LOWER SUBASE; NSB-NLON; GROTON, CONNECTICUT

SAMPLE NUMBER:	FPTB32L-11	Pipe Chase	LS1SB0010101	LS1SB0010201	LS1SB0020101	LS1SB0020201
DEPTH (feet):	11 - 12'	2 - 2'	1.5 - 3.5'	5 - 6'	2 - 3.5'	7 - 7.5'
INVESTIGATION:	TFI96	SCRBLDG89	1997RI	1997RI	1997RI	1997RI
SAMPLE DATE:	10/07/95	06/03/94	09/26/97	09/26/97	09/26/97	09/26/97
LOCATION:	GS-32L	PIPECHASE	TB1-1RI	TB1-1RI	TB2-1RI	TB2-1RI
VALIDATED:	VALIDATED		VALIDATED	VALIDATED	VALIDATED	VALIDATED
SAMPLE TYPE:	GRAB	GRAB	GRAB	GRAB	GRAB	GRAB
STATUS:						
FIELD DUPLICATE OF:						
METALS (mg/kg)						
MERCURY		0.11 U	0.01 UJ		83.4 J	
NICKEL		3.4	8.1		7.0	
POTASSIUM		1280	1490		1350	
SILVER		0.54	0.18 U		0.18 U	
SODIUM		422	99.3		119	
VANADIUM		8.9	14.0		15.3	
ZINC		18.3	54.8		35.8	
TOTAL PETROLEUM HYDROCARBONS (mg/kg)						
TPH	26800	10.8 U	78 J		760 J	

TABLE 4-8 (PAGE 10 OF 16)

SUMMARY OF POSITIVE SOIL ANALYTICAL RESULTS FOR ZONE 1 LOWER SUBASE; NSB-NLON; GROTON, CONNECTICUT

SAMPLE NUMBER:	LS1SB0030101	LS1SB0030201	LS1SB0040101	LS1SB0040301	LS1SB0050101	LS1SB0050301
DEPTH (feet):	2 - 4'	5 - 8'	2 - 4'	9 - 10.5'	2 - 4'	10 - 12'
INVESTIGATION:	1997RI	1997RI	1997RI	1997RI	1997RI	1997RI
SAMPLE DATE:	09/24/97	09/24/97	09/25/97	09/25/97	09/24/97	09/24/97
LOCATION:	TB3-1RI	TB3-1RI	TB4-1RI	TB4-1RI	TB5-1RI	TB5-1RI
VALIDATED:	VALIDATED	VALIDATED	VALIDATED	VALIDATED	VALIDATED	VALIDATED
SAMPLE TYPE:	GRAB	GRAB	GRAB	GRAB	GRAB	GRAB
STATUS:						
FIELD DUPLICATE OF:						
SEMIVOLATILES (µg/kg)						
2,4-DIMETHYLPHENOL	360 U	460 U	360 U	330 U	360 U	330 U
2-METHYLNAPHTHALENE	110 J	720	82 J	50 J	360 U	330 U
ACENAPHTHENE	36 J	88 J	76 J	72 J	360 U	330 U
ACENAPHTHYLENE	360 U	90 J	950	310 J	21 J	330 U
ANTHRACENE	41 J	47 J	780	340	360 U	330 U
BENZO(A)ANTHRACENE	63 J	81 J	4300	2500	140 J	330 U
BENZO(A)PYRENE	75 J	79 J	6900	2100	170 J	330 U
BENZO(B)FLUORANTHENE	61 J	60 J	7400	2200	170 J	330 U
BENZO(G,H,I)PERYLENE	220 J	180 J	6800	2100 J	150 J	330 U
BENZO(K)FLUORANTHENE	95 J	35 J	5100	330 UJ	170 J	330 U
BIS(2-ETHYLHEXYL)PHTHALATE	360 U	460 U	360 U	330 U	360 U	1100
BUTYLBENZYL PHTHALATE	360 U	460 UJ	360 U	22 J	360 U	330 U
CARBAZOLE	360 U	460 U	130 J	64 J	360 U	330 U
CHRYSENE	95 J	120 J	4800	2400	180 J	330 U
DI-N-BUTYL PHTHALATE	360 U	460 U	360 U	330 U	360 U	330 U
DIBENZO(A,H)ANTHRACENE	360 U	51 J	360 U	1500 J	40 J	330 U
DIBENZOFURAN	360 U	47 J	50 J	41 J	360 U	330 U
FLUORANTHENE	110 J	71 J	4300	2600	220 J	330 U
FLUORENE	61 J	130 J	200 J	110 J	360 U	330 U
INDENO(1,2,3-CD)PYRENE	55 J	70 J	6000	1900 J	170 J	330 U
NAPHTHALENE	19 J	130 J	130 J	35 J	360 U	330 U
PHENANTHRENE	280 J	290 J	840	850	57 J	330 U

TABLE 4-8 (PAGE 11 OF 16)

SUMMARY OF POSITIVE SOIL ANALYTICAL RESULTS FOR ZONE 1 LOWER SUBASE; NSB-NLON; GROTON, CONNECTICUT

SAMPLE NUMBER:	LS1SB0030101	LS1SB0030201	LS1SB0040101	LS1SB0040301	LS1SB0050101	LS1SB0050301
DEPTH (feet):	2 - 4'	5 - 8'	2 - 4'	9 - 10.5'	2 - 4'	10 - 12'
INVESTIGATION:	1997RI	1997RI	1997RI	1997RI	1997RI	1997RI
SAMPLE DATE:	09/24/97	09/24/97	09/25/97	09/25/97	09/24/97	09/24/97
LOCATION:	TB3-1RI	TB3-1RI	TB4-1RI	TB4-1RI	TB5-1RI	TB5-1RI
VALIDATED:	VALIDATED	VALIDATED	VALIDATED	VALIDATED	VALIDATED	VALIDATED
SAMPLE TYPE:	GRAB	GRAB	GRAB	GRAB	GRAB	GRAB
STATUS:						
FIELD DUPLICATE OF:						
SEMIVOLATILES (µg/kg)						
PHENOL	360 U	460 U	360 U	330 U	360 U	330 U
PYRENE	240 J	450 J	7500	2300	250 J	330 U

TABLE 4-8 (PAGE 12 OF 16)

SUMMARY OF POSITIVE SOIL ANALYTICAL RESULTS FOR ZONE 1 LOWER SUBASE; NSB-NLON; GROTON, CONNECTICUT

SAMPLE NUMBER:	LS1SB0060101	LS1SB0060301	LS1SB0070101	LS1SB0070401	SBFD008	LS1SB0080101
DEPTH (feet):	2 - 4'	9 - 10'	2 - 4'	13 - 14'	13 - 14'	2 - 4'
INVESTIGATION:	1997RI	1997RI	1997RI	1997RI	1997RI	1997RI
SAMPLE DATE:	09/24/97	09/24/97	09/26/97	09/26/97	09/26/97	09/26/97
LOCATION:	TB6-1RI	TB6-1RI	TB7-1RI	TB7-1RI	TB7-1RI	TB8-1RI
VALIDATED:	VALIDATED	VALIDATED	VALIDATED	VALIDATED	VALIDATED	VALIDATED
SAMPLE TYPE:	GRAB	GRAB	GRAB	GRAB	GRAB	GRAB
STATUS:						
FIELD DUPLICATE OF:					LS1SB0070401	
SEMIVOLATILES (µg/kg)						
2,4-DIMETHYLPHENOL	330 UR	330 U	360 U	360 U	360 U	360 U
2-METHYLNAPHTHALENE	32 J	330 U	360 U	360 U	360 U	360 U
ACENAPHTHENE	330 U	330 U	360 U	360 U	360 U	360 U
ACENAPHTHYLENE	330 U	330 U	360 U	360 U	360 U	360 U
ANTHRACENE	330 U	330 U	360 U	360 U	360 U	360 U
BENZO(A)ANTHRACENE	110 J	330 U	23 J	360 U	360 U	20 J
BENZO(A)PYRENE	140 J	330 U	23 J	360 U	360 U	18 J
BENZO(B)FLUORANTHENE	83 J	330 U	31 J	360 U	360 U	360 U
BENZO(G,H,I)PERYLENE	96 J	330 U	20 J	360 U	360 U	360 U
BENZO(K)FLUORANTHENE	150 J	330 U	360 U	360 U	360 U	360 U
BIS(2-ETHYLHEXYL)PHTHALATE	330 U	330 U	360 U	360 U	360 U	360 U
BUTYLBENZYL PHTHALATE	330 U	330 U	360 U	360 U	360 U	360 U
CARBAZOLE	330 U	330 U	360 U	360 U	360 U	360 U
CHRYSENE	160 J	330 U	33 J	360 U	360 U	28 J
DI-N-BUTYL PHTHALATE	330 U	330 U	360 U	360 U	360 U	130 J
DIBENZO(A,H)ANTHRACENE	330 U	330 U	360 U	360 U	360 U	360 U
DIBENZOFURAN	330 U	330 U	360 U	360 U	360 U	360 U
FLUORANTHENE	110 J	330 U	29 J	360 U	360 U	23 J
FLUORENE	330 U	330 U	360 U	360 U	360 U	360 U
INDENO(1,2,3-CD)PYRENE	81 J	330 U	25 J	360 U	360 U	360 U
NAPHTHALENE	26 J	330 U	360 U	360 U	360 U	360 U
PHENANTHRENE	90 J	330 U	20 J	360 U	360 U	360 U

TABLE 4-8 (PAGE 13 OF 16)

SUMMARY OF POSITIVE SOIL ANALYTICAL RESULTS FOR ZONE 1 LOWER SUBASE; NSB-NLON; GROTON, CONNECTICUT

SAMPLE NUMBER:	LS1SB0060101	LS1SB0060301	LS1SB0070101	LS1SB0070401	SBFD008	LS1SB0080101
DEPTH (feet):	2 - 4'	9 - 10'	2 - 4'	13 - 14'	13 - 14'	2 - 4'
INVESTIGATION:	1997RI	1997RI	1997RI	1997RI	1997RI	1997RI
SAMPLE DATE:	09/24/97	09/24/97	09/26/97	09/26/97	09/26/97	09/26/97
LOCATION:	TB6-1RI	TB6-1RI	TB7-1RI	TB7-1RI	TB7-1RI	TB8-1RI
VALIDATED:	VALIDATED	VALIDATED	VALIDATED	VALIDATED	VALIDATED	VALIDATED
SAMPLE TYPE:	GRAB	GRAB	GRAB	GRAB	GRAB	GRAB
STATUS:						
FIELD DUPLICATE OF:					LS1SB0070401	
SEMIVOLATILES (µg/kg)						
PHENOL	330 UR	330 U	360 U	360 U	360 U	360 U
PYRENE	170 J	330 U	31 J	360 U	360 U	24 J
METALS (mg/kg)						
ALUMINUM	5630					
ANTIMONY	0.39 UJ					
ARSENIC	1.3					
BARIUM	42.9					
BERYLLIUM	0.20 J					
CADMIUM	0.03 U					
CALCIUM	19900 J					
CHROMIUM	13.7					
COBALT	3.1					
COPPER	13.0					
IRON	8650					
LEAD	58.5					
MAGNESIUM	2850 J					
MANGANESE	228					
MERCURY	0.01 UJ					
NICKEL	7.8 J					
POTASSIUM	1580					
SILVER	0.17 U					
SODIUM	211					

TABLE 4-8 (PAGE 14 OF 16)

SUMMARY OF POSITIVE SOIL ANALYTICAL RESULTS FOR ZONE 1 LOWER SUBASE; NSB-NLON; GROTON, CONNECTICUT

SAMPLE NUMBER:	LS1SB0060101	LS1SB0060301	LS1SB0070101	LS1SB0070401	SBFD008	LS1SB0080101
DEPTH (feet):	2 - 4'	9 - 10'	2 - 4'	13 - 14'	13 - 14'	2 - 4'
INVESTIGATION:	1997RI	1997RI	1997RI	1997RI	1997RI	1997RI
SAMPLE DATE:	09/24/97	09/24/97	09/26/97	09/26/97	09/26/97	09/26/97
LOCATION:	TB6-1RI	TB6-1RI	TB7-1RI	TB7-1RI	TB7-1RI	TB8-1RI
VALIDATED:	VALIDATED	VALIDATED	VALIDATED	VALIDATED	VALIDATED	VALIDATED
SAMPLE TYPE:	GRAB	GRAB	GRAB	GRAB	GRAB	GRAB
STATUS:						
FIELD DUPLICATE OF:					LS1SB0070401	
METALS (mg/kg)						
VANADIUM	14.3					
ZINC	28.3					
TOTAL PETROLEUM HYDROCARBONS (mg/kg)						
TPH	2300		39	75		25 U

TABLE 4-8 (PAGE 15 OF 16)

SUMMARY OF POSITIVE SOIL ANALYTICAL RESULTS FOR ZONE 1 LOWER SUBASE; NSB-NLON; GROTON, CONNECTICUT

SAMPLE NUMBER:	LS1SB0080301	LS1SB0090101	LS1SB0090201	TANK_GRAVE_N	Tank Grave-S	
DEPTH (feet):	10 - 11'	2 - 4'	5.5 - 6.5'	7 - 7'	7 - 7'	
INVESTIGATION:	1997RI	1997RI	1997RI	SCRBLDG89	SCRBLDG89	
SAMPLE DATE:	09/26/97	09/26/97	09/26/97	06/03/94	06/03/94	/ /
LOCATION:	TB8-1RI	TB9-1RI	TB9-1RI	Tank Grave-N	Tank Grave-S	
VALIDATED:	VALIDATED	VALIDATED	VALIDATED			
SAMPLE TYPE:	GRAB	GRAB	GRAB	GRAB	GRAB	
STATUS:						
FIELD DUPLICATE OF:						
VOLATILES (µg/kg)						
XYLENES, TOTAL				0.657 J	1.07 U	
SEMIVOLATILES (µg/kg)						
2,4-DIMETHYLPHENOL	360 U	430 U	360 U			
2-METHYLNAPHTHALENE	360 U	430 U	360 U			
ACENAPHTHENE	360 U	430 U	360 U			
ACENAPHTHYLENE	360 U	430 U	18 J			
ANTHRACENE	360 U	430 U	33 J			
BENZO(A)ANTHRACENE	360 UJ	84 J	200 J			
BENZO(A)PYRENE	360 UJ	100 J	230 J			
BENZO(B)FLUORANTHENE	360 UJ	140 J	170 J			
BENZO(G,H,I)PERYLENE	360 UJ	110 J	200 J			
BENZO(K)FLUORANTHENE	360 UJ	96 J	260 J			
BIS(2-ETHYLHEXYL)PHTHALATE	360 U	430 U	360 U			
BUTYLBENZYL PHTHALATE	360 UJ	430 UJ	360 U			
CARBAZOLE	360 U	430 U	360 U			
CHRYSENE	19 J	110 J	310 J			
DI-N-BUTYL PHTHALATE	680	430 U	360 U			
DIBENZO(A,H)ANTHRACENE	360 UJ	52 J	81 J			
DIBENZOFURAN	40 J	430 U	360 U			
FLUORANTHENE	360 U	100 J	300 J			
FLUORENE	87 J	430 U	360 U			
INDENO(1,2,3-CD)PYRENE	360 UJ	87 J	170 J			

TABLE 4-8 (PAGE 16 OF 16)
SUMMARY OF POSITIVE SOIL ANALYTICAL RESULTS FOR ZONE 1
LOWER SUBASE; NSB-NLON; GROTON, CONNECTICUT

SAMPLE NUMBER:	LS1SB0080301	LS1SB0090101	LS1SB0090201	TANK_GRAVE_N	Tank Grave-S	
DEPTH (feet):	10 - 11'	2 - 4'	5.5 - 6.5'	7 - 7'	7 - 7'	
INVESTIGATION:	1997RI	1997RI	1997RI	SCRBLDG89	SCRBLDG89	
SAMPLE DATE:	09/26/97	09/26/97	09/26/97	06/03/94	06/03/94	/ /
LOCATION:	TB8-1RI	TB9-1RI	TB9-1RI	Tank Grave-N	Tank Grave-S	
VALIDATED:	VALIDATED	VALIDATED	VALIDATED			
SAMPLE TYPE:	GRAB	GRAB	GRAB	GRAB	GRAB	
STATUS:						
FIELD DUPLICATE OF:						
SEMIVOLATILES (µg/kg)						
NAPHTHALENE	360 U	430 U	360 U			
PHENANTHRENE	81 J	36 J	140 J			
PHENOL	360 U	430 U	360 U			
PYRENE	27 J	240 J	710			
TOTAL PETROLEUM HYDROCARBONS (mg/kg)						
TPH	3400	26		10.9 U	23.5	

TABLE 4-9 (PAGE 1 OF 3)

SUMMARY OF POSITIVE TCLP ANALYTICAL RESULTS FOR ZONE 1 LOWER SUBASE; NSB-NLON; GROTON, CONNECTICUT

SAMPLE NUMBER:	13MW1(12-14)	13MW18-0911	13MW2(10-12)	13MW3(12-14)	13MW4(6-8)	13MW5(10-12)
DEPTH (feet):	12 - 14'	9 - 11'	10 - 12'	12 - 14'	6 - 8'	10 - 12'
INVESTIGATION:	PH1	PH2-1	PH1	PH1	PH1	PH1
SAMPLE DATE:	11/05/90	01/26/94	11/05/90	11/07/90	11/07/90	11/08/90
LOCATION:	13MW1	13MW18	13MW2	13MW3	13MW4	13MW5
VALIDATED:	VALIDATED	VALIDATED	VALIDATED	VALIDATED	VALIDATED	VALIDATED
SAMPLE TYPE:	GRAB	GRAB	GRAB	GRAB	GRAB	GRAB
STATUS:						
FIELD DUPLICATE OF:						
TCLP METALS (mg/L)*						
ARSENIC (5.0/0.5)	0.5 U	0.026 U	0.5 U	0.5 U	0.5 U	0.5 U
BARIUM (100.0/10.0)	0.14	0.0899	0.22	0.092	0.196	0.33
CADMIUM (1.0/0.05)	0.002 U	0.002 U	0.002 U	0.002 U	0.002 U	0.002 U
CHROMIUM (5.0/0.5)	0.016 J	0.003 UJ	0.0084 J	0.005 UJ	0.0052 J	0.0085 J
LEAD (5.0/0.15)	0.1 U	0.02 U	0.15	0.1 U	1.7	0.1 U
SELENIUM (1.0/0.5)	0.2 U	0.024 U	0.2 U	0.2 U	0.2 U	0.2 U
SILVER (5.0/0.36)	0.007 UJ	0.002 U	0.045 J	0.007 UJ	0.007 UJ	0.007 UJ

*Federal Toxicity Characteristic Regulatory Level (58 FR 46049)/Connecticut Remediation Standard Pollutant Mobility Criteria for GB Waters

TABLE 4-9 (PAGE 2 OF 3)

SUMMARY OF POSITIVE TCLP ANALYTICAL RESULTS FOR ZONE 1 LOWER SUBASE; NSB-NLON; GROTON, CONNECTICUT

SAMPLE NUMBER:	13MW7(8-10)	13MW8(8-10)	13MW9(6-8)	13TB13-0305	13TB13-0911	13TB15-0305
DEPTH (feet):	8 - 10'	8 - 10'	6 - 8'	3 - 5'	9 - 11'	3 - 5'
INVESTIGATION:	PH1	PH1	PH1	PH2-1	PH2-1	PH2-1
SAMPLE DATE:	11/07/90	11/07/90	11/07/90	01/26/94	01/26/94	01/25/94
LOCATION:	13MW7	13MW8	13MW9	13TB13	13TB13	13TB15
VALIDATED:	VALIDATED	VALIDATED	VALIDATED	VALIDATED	VALIDATED	VALIDATED
SAMPLE TYPE:	GRAB	GRAB	GRAB	GRAB	GRAB	GRAB
STATUS:						
FIELD DUPLICATE OF:						
TCLP METALS (mg/L)*						
ARSENIC (5.0/0.5)	0.5 U	0.5 U	0.5 U	0.026 U	0.026 U	0.026 U
BARIUM (100.0/10.0)	0.087	0.13	0.098	0.254	0.081	0.106
CADMIUM (1.0/0.05)	0.002 U	0.0029	0.002 U	0.002 U	0.002 U	0.002 U
CHROMIUM (5.0/0.5)	0.0077 J	0.007 J	0.0061 J	0.0093 J	0.0037 J	0.005 J
LEAD (5.0/0.15)	0.1 U	0.2	0.1 U	0.0512	0.02 U	0.02 U
SELENIUM (1.0/0.5)	0.2 U	0.2 U	0.2 U	0.0269 J	0.024 U	0.024 U
SILVER (5.0/0.36)	0.007 UJ	0.007 UJ	0.007 UJ	0.002 U	0.002 U	0.002 U

*Federal Toxicity Characteristic Regulatory Level (58 FR 46049)/Connecticut Remediation Standard Pollutant Mobility Criteria for GB Waters

TABLE 4-9 (PAGE 3 OF 3)
SUMMARY OF POSITIVE TCLP ANALYTICAL RESULTS FOR ZONE 1 LOWER SUBASE; NSB-NLON; GROTON, CONNECTICUT

SAMPLE NUMBER:	13TB15-0709	13TB16-0204	13TB16-0810	13TB17-0406	13TB17-0608	Pipe Chase
DEPTH (feet):	7 - 9'	2 - 4'	8 - 10'	4 - 6'	6 - 8'	2'
INVESTIGATION:	PH2-1	PH2-1	PH2-1	PH2-1	PH2-1	SCR95
SAMPLE DATE:	01/25/94	01/24/94	01/24/94	01/25/94	01/25/94	06/03/94
LOCATION:	13TB15	13TB16	13TB16	13TB17	13TB17	PIPE CHASE
VALIDATED:	VALIDATED	VALIDATED	VALIDATED	VALIDATED	VALIDATED	
SAMPLE TYPE:	GRAB	GRAB	GRAB	GRAB	GRAB	GRAB
STATUS:						
FIELD DUPLICATE OF:						
TCLP METALS (mg/L)*						
ARSENIC (5.0/0.5)	0.026 U	0.026 U	0.0362	0.026 U	0.026 U	0.045 U
BARIUM (100.0/10.0)	0.0453	0.235	0.243	0.284	0.0508	0.137 U
CADMIUM (1.0/0.05)	0.002 U	0.002 U	0.002 U	0.0025 J	0.002 U	0.003 U
CHROMIUM (5.0/0.5)	0.003 UJ	0.003 UJ	0.0047 J	0.0073 J	0.0054 J	0.004 U
LEAD (5.0/0.15)	0.02 U	0.02	0.38	0.194	0.02 U	0.016 U
SELENIUM (1.0/0.5)	0.0269 J	0.025 J	0.0644	0.024 U	0.0335 J	0.032 U
SILVER (5.0/0.36)	0.002 U	0.002 U	0.002 U	0.002 U	0.002 U	0.0021 U

*Federal Toxicity Characteristic Regulatory Level (58 FR 46049)/Connecticut Remediation Standard Pollutant Mobility Criteria for GB Waters

TABLE 4-10

SUMMARY OF SOIL ANALYTICAL RESULTS - ZONE 1
LOWER SUBASE
NSB-NLON, GROTON, CONNECTICUT
PAGE 1 OF 3

Analyte	SHALLOW SOILS (<5 FEET)[1]			DEEP SOILS (>5 FEET)[2]		
	Frequency of Detection	Concentration Range	Location of Maximum Detection	Frequency of Detection	Concentration Range	Location of Maximum Detection
VOLATILE ORGANICS (ug/kg)						
Acetone	1/1	54	PIPECHASE	0/8	ND	ND
Carbon disulfide	0/1	ND	ND	1/8	5	13MW7
Methylene chloride	1/1	15	PIPECHASE	0/8	ND	ND
Xylenes, total	1/1	1.29	PIPECHASE	1/10	0.657	Tank Grave_N
SEMIVOLATILE ORGANICS (ug/kg)						
2,4-Dimethylphenol	1/9	37	TB2-1RI	0/9	ND	ND
2-Methylnaphthalene	4/10	32 - 870	TB2-1RI	4/10	50 - 1500	TB2-1RI
Acenaphthene	4/10	24 - 3800	TB2-1RI	3/10	72 - 4300	TB2-1RI
Acenaphthylene	3/10	21 - 950	TB4-1RI/TB4-1RI	4/10	18 - 310	TB4-1RI
Anthracene	4/10	30 - 12000	TB2-1RI	5/10	33 - 11000	TB2-1RI
Benzo(a)anthracene	10/10	20 - 21000	TB2-1RI	5/10	81 - 16000	TB2-1RI
Benzo(a)pyrene	10/10	18 - 17000	TB2-1RI	5/10	79 - 13000	TB2-1RI
Benzo(b)fluoranthene	9/10	31 - 17000	TB2-1RI	4/10	60 - 12000	TB2-1RI
Benzo(g,h,i)perylene	9/10	20 - 9000	TB2-1RI	5/10	180 - 7600	TB2-1RI
Benzo(k)fluoranthene	7/10	50 - 5100	TB4-1RI	4/10	35 - 11000	TB2-1RI
Bis(2-Ethylhexyl)phthalate	1/10	97	PIPECHASE	1/10	1100	TB5-1RI
Butylbenzyl phthalate	0/10	ND	ND	1/10	22	TB4-1RI
Carbazole	3/10	29 - 4300	TB2-1RI	2/10	64 - 5200	TB2-1RI
Chrysene	10/10	28 - 19000	TB2-1RI	6/10	19 - 16000	TB2-1RI
Di-N-butyl phthalate	1/10	130	TB8-1RI	1/10	680	TB8-1RI
Dibenzo(a,h)anthracene	3/10	40 - 5200	TB2-1RI	5/10	51 - 2700	TB2-1RI
Dibenzofuran	2/10	50 - 4000	TB2-1RI	4/10	40 - 4700	TB2-1RI
Fluoranthene	10/10	23 - 44000	TB2-1RI	5/10	71 - 37000	TB2-1RI
Fluorene	3/10	61 - 4800	TB2-1RI	4/10	87 - 5200	TB2-1RI
Indeno(1,2,3-Cd)pyrene	9/10	25 - 12000	TB2-1RI	5/10	70 - 9500	TB2-1RI

TABLE 4-10

SUMMARY OF SOIL ANALYTICAL RESULTS - ZONE 1
LOWER SUBASE
NSB-NLON, GROTON, CONNECTICUT
PAGE 2 OF 3

Analyte	SHALLOW SOILS (<5 FEET)[1]			DEEP SOILS (>5 FEET)[2]		
	Frequency of Detection	Concentration Range	Location of Maximum Detection	Frequency of Detection	Concentration Range	Location of Maximum Detection
Naphthalene	4/10	19 - 1300	TB2-1RI	4/10	35 - 1700	TB2-1RI
Phenanthrene	9/10	20 - 41000	TB2-1RI	6/10	81 - 42000	TB2-1RI
Phenol	1/9	29	TB2-1RI	0/9	ND	ND
Pyrene	10/10	24 - 45000	TB2-1RI	6/10	27 - 41000	TB2-1RI
INORGANICS (mg/kg)						
Aluminum	4/4	4670 - 5750	TB1-1RI	8/8	3250 - 6980	13MW5
Antimony	1/4	0.64	PIPECHASE	0/8	ND	ND
Arsenic	3/4	1.3 - 12.3	TB2-1RI	7/8	0.53 - 4.3	13MW3
Barium	4/4	20.5 - 45.7	TB2-1RI	8/8	14.7 - 40.5	13MW5
Beryllium	2/4	0.2	PIPECHASE/TB6-1RI	3/8	0.25 - 0.4	13MW4
Cadmium	1/4	0.34	PIPECHASE	8/8	0.57 - 1.4	13MW8
Calcium	4/4	838 - 19900	TB6-1RI	8/8	539 - 1870	13MW4
Chromium	4/4	4.9 - 13.7	TB6-1RI	8/8	4.6 - 15.4	13MW1
Cobalt	3/4	3 - 3.1	TB6-1RI/TB1-1RI	8/8	1.8 - 5.5	13MW4/13MW5
Copper	4/4	8 - 64.5	TB1-1RI	8/8	7.7 - 59.6	13MW4
Iron	4/4	6810 - 11600	TB2-1RI	8/8	3770 - 10400	13MW5
Lead	8/8	7.7 - 112	13TB15	13/13	2.6 - 383	13MW4
Magnesium	4/4	1420 - 2850	TB6-1RI	8/8	1310 - 3020	13MW4
Manganese	4/4	118 - 228	TB6-1RI	8/8	56.1 - 173	13MW5
Mercury	1/4	83.4	TB2-1RI	2/8	0.12 - 0.48	13MW4
Nickel	4/4	3.4 - 8.1	TB1-1RI	8/8	2.4 - 12	13MW4
Potassium	4/4	1280 - 1580	TB6-1RI	8/8	1170 - 2830	13MW1
Silver	1/4	0.54	PIPECHASE	1/8	2.2	13MW4
Sodium	4/4	99.3 - 422	PIPECHASE	8/8	74 - 821	13MW9
Vanadium	4/4	8.9 - 15.3	TB2-1RI	8/8	5.7 - 27.1	13MW4
Zinc	4/4	18.3 - 54.8	TB1-1RI	8/8	20.3 - 70.4	13MW4

TABLE 4-10

SUMMARY OF SOIL ANALYTICAL RESULTS - ZONE 1
LOWER SUBASE
NSB-NLON, GROTON, CONNECTICUT
PAGE 3 OF 3

Analyte	SHALLOW SOILS (<5 FEET)[1]			DEEP SOILS (>5 FEET)[2]		
	Frequency of Detection	Concentration Range	Location of Maximum Detection	Frequency of Detection	Concentration Range	Location of Maximum Detection
TCLP METALS (mg/L)						
Arsenic	0/5	ND	ND	1/13	0.036	13TB16
Barium	4/5	0.106 - 0.284	13TB17	13/13	0.045 - 0.330	13MW5
Cadmium	1/5	0.0025	13TB17	1/13	0.003	13MW8
Chromium	3/5	0.005 - 0.0093	13TB13	10/13	0.004 - 0.016	13MW1
Lead	3/5	0.02 - 0.194	13TB17	4/13	0.15 - 1.70	13MW4
Mercury	0/5	ND	ND	0/13	ND	ND
Selenium	2/5	0.025 - 0.027	13TB13	3/13	0.027 - 0.064	13TB16
Silver	0/5	ND	NA	1/13	0.045	13MW2
SYNTHETIC PRECIPITATION LEACHING PROCEDURE						
Lead	0/2	ND	ND	NA	NA	ND
TOTAL PETROLEUM HYDROCARBONS (mg/kg)						
TPH	10/12	23.8 - 2300	TB6-1RI	22/24	23.5 - 51600	13MW18

1 Includes samples 13TB13-0305, 13TB15-0305, 13TB16-0204, 13TB17-0406, FPTB28L-04, LS1SB0010101, S1SB0020101, LS1SB0030101, LS1SB0040101, LS1SB0050101, LS1SB0060101, LS1SB0070101, LS1SB0080101, LS1SB0090101, Pipe Chase.

2 Includes samples 13MW1(12-14), 13MW18-0911, 13MW2(10-12), 13MW3(12-14), 13MW4(6-8), 13MW5(10-12), 13MW7(8-10), 13MW8(8-10), 13MW9(6-8), 13TB13-0911, 13TB15-0709, 13TB16-0810, 13TB17-0608, DUP04-100795 (field duplicate of FPTB29L-07), FPTB13L-07, FPTB25L-06, FPTB26L-05, FPTB30L-07, FPTB31L-07, FPTB32L-11, S1SB0010201, LS1SB0020201, LS1SB0030201, LS1SB0040301, LS1SB0050301, LS1SB0060301, LS1SB0070401, LS1SB0080301, LS1SB0090201, SBFD008 (field duplicate of LS1SB0070401), TANK_GRATE_N, Tank Grave-S.

ND - Not Detected

NA - Not Analyzed

TABLE 4-11

SUMMARY OF PHASE I SOIL FLUORESCENCE SPECTROSCOPY DATA - ZONE 1
LOWER SUBASE
NSB-NLON, GROTON, CONNECTICUT

Sample	Sample Depth (ft)	Observations
13MW1	12-14	Spectra is typical of waste lubricating oils.
13MW2	10-12	Spectra is typical of No. 2 fuel/diesel oil.
13MW3	12-14	Spectra is typical of No. 2 fuel/diesel oil.
13MW4	6-8	Spectra is unresolved. Trace concentrations of petroleum hydrocarbons make oil identification impractical.
13MW5	10-12	Spectra is typical of waste lubricating oils.
13MW7	8-10	Spectra is typical of waste lubricating oils.
13MW8	8-10	Spectra is typical of No. 2 fuel/diesel oil.
13MW9	6-8	Spectra is unresolved. Trace concentrations of petroleum hydrocarbons make oil identification impractical.

TABLE 4-12 (PAGE 1 OF 49)
SUMMARY OF POSITIVE GROUNDWATER ANALYTICAL RESULTS FOR ZONE 1
LOWER SUBASE; NSB-NLON; GROTON, CONNECTICUT

SAMPLE NUMBER:	011691-13MW1S	13GW1	13GW1	13GW1-2	13GW1-2	LS1GW13MW101
INVESTIGATION:	PH1	PH2-1	PH2-1	PH2-2	PH2-2	1997RI
SAMPLE DATE:	01/16/91	03/06/94	03/06/94	06/22/94	06/22/94	11/10/97
LOCATION:	13MW1	13MW1	13MW1	13MW1	13MW1	13MW1
VALIDATED:	VALIDATED	VALIDATED	VALIDATED	VALIDATED	VALIDATED	VALIDATED
FILTERING:	Unfiltered	Unfiltered	Filtered	Unfiltered	Filtered	Unfiltered
FIELD DUPLICATE OF:						
VOLATILES (µg/L)						
1,1-DICHLOROETHANE	5 U	10 U		10 U		
BENZENE	5 U	10 U		10 U		
CARBON DISULFIDE	5 U	10 U		10 U		
ETHYLBENZENE	5 U	10 U		10 U		
STYRENE	5 U	10 U		10 U		
TOLUENE	5 U	10 U		10 U		
XYLENES, TOTAL	5 U	10 U		10 U		
SEMIVOLATILES (µg/L)						
1,2,4-TRICHLOROBENZENE		10 U		10 U		12 U
1,3-DICHLOROBENZENE		10 U		10 U		12 U
2-METHYLNAPHTHALENE		10 U		10 U		12 U
4-METHYLPHENOL		10 U		10 U		12 U
ACENAPHTHENE		10 U		10 U		12 U
ACENAPHTHYLENE		10 U		10 U		12 U
ANTHRACENE		10 U		10 U		12 U
BENZOIC ACID		0.6 J		50 U		
BIS(2-ETHYLHEXYL)PHTHALATE		10 U		3 J		12 U
BUTYLBENZYL PHTHALATE		10 U		10 U		12 U
CARBAZOLE		10 U		10 U		12 U
DI-N-BUTYL PHTHALATE		10 U		10 U		12 UJ
DI-N-OCTYL PHTHALATE		10 U		10 U		12 UJ
DIBENZOFURAN		10 U		10 U		12 U
DIETHYL PHTHALATE		3 J		2 J		12 U
FLUORANTHENE		10 U		10 U		12 U

TABLE 4-12 (PAGE 2 OF 49)

SUMMARY OF POSITIVE GROUNDWATER ANALYTICAL RESULTS FOR ZONE 1 LOWER SUBASE; NSB-NLON; GROTON, CONNECTICUT

SAMPLE NUMBER:	011691-13MW1S	13GW1	13GW1	13GW1-2	13GW1-2	LS1GW13MW101
INVESTIGATION:	PH1	PH2-1	PH2-1	PH2-2	PH2-2	1997RI
SAMPLE DATE:	01/16/91	03/06/94	03/06/94	06/22/94	06/22/94	11/10/97
LOCATION:	13MW1	13MW1	13MW1	13MW1	13MW1	13MW1
VALIDATED:	VALIDATED	VALIDATED	VALIDATED	VALIDATED	VALIDATED	VALIDATED
FILTERING:	Unfiltered	Unfiltered	Filtered	Unfiltered	Filtered	Unfiltered
FIELD DUPLICATE OF:						
SEMIVOLATILES (µg/L)						
FLUORENE		10 U		10 U		12 U
NAPHTHALENE		10 U		10 U		12 U
PHENANTHRENE		10 U		10 U		12 U
PHENOL		10 U		10 U		12 U
PYRENE		10 U		10 U		12 U
METALS (µg/L)						
ALUMINUM	30 U	14 U	14 U	33.5	15 U	54.4 U
ANTIMONY	25 U	15 U	15 U	13 U	15.6 U	2.5 U
ARSENIC	3 U	2.7 J	2 U	2.8	1.9 J	2.5 U
BARIUM	24.1	31.6 U	34.5 U	56.2	57.6	40.4
BERYLLIUM	1 U	1 U	1 U	1 U	1 U	0.19 U
BORON	1.8 R	50 U	50 U	59.8 J	53.6 J	
CADMIUM	2 U	2 UJ	2 UJ	3 U	3 U	0.22 U
CALCIUM	17900	23900	26200	35300	36300	26500
CHROMIUM	5 U	3 U	3 U	4 U	4 U	3.1 U
COBALT	5 U	4 U	4 U	5 U	5 U	2.9 U
COPPER	5 U	2.6 J	2.3 J	5 U	5 U	1.6
IRON	5650	2970	2740	2810	2460	1160
LEAD	2 UJ	1 UJ	1 UJ	2 U	7.7 J	1.3 U
MAGNESIUM	2930	4330 J	4700 J	5630	5780	4840
MANGANESE	1090	471	457	366	369	396
MERCURY	0.2 U	0.2 U	0.2 U	0.2 U	0.2 U	0.02 U
NICKEL	27.2 J	10 U	10 U	11 U	11 U	9.0 U
POTASSIUM	3070	4300 J	4340 J	6220	6480	5690

TABLE 4-12 (PAGE 3 OF 49)
SUMMARY OF POSITIVE GROUNDWATER ANALYTICAL RESULTS FOR ZONE 1
LOWER SUBASE; NSB-NLON; GROTON, CONNECTICUT

SAMPLE NUMBER:	011691-13MW1S	13GW1	13GW1	13GW1-2	13GW1-2	LS1GW13MW101
INVESTIGATION:	PH1	PH2-1	PH2-1	PH2-2	PH2-2	1997RI
SAMPLE DATE:	01/16/91	03/06/94	03/06/94	06/22/94	06/22/94	11/10/97
LOCATION:	13MW1	13MW1	13MW1	13MW1	13MW1	13MW1
VALIDATED:	VALIDATED	VALIDATED	VALIDATED	VALIDATED	VALIDATED	VALIDATED
FILTERING:	Unfiltered	Unfiltered	Filtered	Unfiltered	Filtered	Unfiltered
FIELD DUPLICATE OF:						
METALS (µg/L)						
SELENIUM	1 U	3 UJ	3 UJ	2 UJ	2 UJ	1.9 U
SILVER	7 U	2 U	2 U	2 U	2 U	2.8 U
SODIUM	18200	27800	30100	61200	63000	40800
THALLIUM	2 U	1 UJ	1 UJ	10 U	10 U	4.8 U
VANADIUM	20 U	5 U	5 U	4 U	4 U	2.9 U
ZINC	28 J	21.2	15.7 U	18.3	18.2	9.8 U
PETROLEUM HYDROCARBONS (µg/L)						
TPH	3000 U	500 U		500 U		1000 U
WATER QUALITY PARAMETERS						
DISSOLVED OXYGEN (MG/L)						8.04
REDOX POTENTIAL (MV)						-20.4
SALINITY (PPT)						0.17
SPECIFIC CONDUCTIVITY (MS/CM)						0.354
TEMPERATURE (C)						17.11
MISCELLANEOUS PARAMETERS						
ALKALINITY AS CACO3 (MG/L)						62
AMMONIA, AS NITROGEN (MG/L)						0.20
CHLORIDE (MG/L)						58
DIVALENT IRON (MG/L)						1.2
HARDNESS AS CaCO3 (MG/L)		84		110		88
METHANE (UG/L)						64
NITRATE, AS NITROGEN (MG/L)						0.97 J
PHOSPHORUS (MG/L)						0.10 U
SULFATE (MG/L)						34

TABLE 4-12 (PAGE 4 OF 49)

SUMMARY OF POSITIVE GROUNDWATER ANALYTICAL RESULTS FOR ZONE 1 LOWER SUBASE; NSB-NLON; GROTON, CONNECTICUT

SAMPLE NUMBER:	011691-13MW1S	13GW1	13GW1	13GW1-2	13GW1-2	LS1GW13MW101
INVESTIGATION:	PH1	PH2-1	PH2-1	PH2-2	PH2-2	1997RI
SAMPLE DATE:	01/16/91	03/06/94	03/06/94	06/22/94	06/22/94	11/10/97
LOCATION:	13MW1	13MW1	13MW1	13MW1	13MW1	13MW1
VALIDATED:	VALIDATED	VALIDATED	VALIDATED	VALIDATED	VALIDATED	VALIDATED
FILTERING:	Unfiltered	Unfiltered	Filtered	Unfiltered	Filtered	Unfiltered
FIELD DUPLICATE OF:						
MISCELLANEOUS PARAMETERS						
TOTAL ORGANIC CARBON (MG/L)						22 J
TURBIDITY (NTU)						4.4
GENERAL CHEMISTRY						
PH						6.34

TABLE 4-12 (PAGE 5 OF 49)

SUMMARY OF POSITIVE GROUNDWATER ANALYTICAL RESULTS FOR ZONE 1
LOWER SUBASE; NSB-NLON; GROTON, CONNECTICUT

SAMPLE NUMBER:	DUP005	LS1GW13MW101-F	DUP005-F	13GW18	13GW18	13GW18-2
INVESTIGATION:	1997RI	1997RI	1997RI	PH2-1	PH2-1	PH2-2
SAMPLE DATE:	11/10/97	11/10/97	11/10/97	03/05/94	03/05/94	06/21/94
LOCATION:	13MW1	13MW1	13MW1	13MW18	13MW18	13MW18
VALIDATED:	VALIDATED	VALIDATED	VALIDATED	VALIDATED	VALIDATED	VALIDATED
FILTERING:	Unfiltered	Filtered	Filtered	Unfiltered	Filtered	Unfiltered
FIELD DUPLICATE OF:	LS1GW13MW101		LS1GW13MW101-F			
VOLATILES (µg/L)						
1,1-DICHLOROETHANE				10 U		10 U
BENZENE				10 U		10 U
CARBON DISULFIDE				10 U		10 U
ETHYLBENZENE				10 U		10 U
STYRENE				10 U		10 U
TOLUENE				10 U		10 U
XYLENES, TOTAL				10 U		10 U
SEMIVOLATILES (µg/L)						
1,2,4-TRICHLOROBENZENE	11 U			10 U		10 UJ
1,3-DICHLOROBENZENE	11 U			10 U		10 UJ
2-METHYLNAPHTHALENE	11 U			10 U		10 UJ
4-METHYLPHENOL	11 U			10 U		10 UJ
ACENAPHTHENE	11 U			10 U		10 UJ
ACENAPHTHYLENE	11 U			10 U		10 UJ
ANTHRACENE	11 U			10 U		10 UJ
BENZOIC ACID				50 UJ		50 UJ
BIS(2-ETHYLHEXYL)PHTHALATE	11 UJ			10 U		10 UJ
BUTYLBENZYL PHTHALATE	11 U			10 U		10 UJ
CARBAZOLE	11 U			10 UJ		10 UJ
DI-N-BUTYL PHTHALATE	11 U			10 U		10 UJ
DI-N-OCTYL PHTHALATE	11 U			10 U		10 U
DIBENZOFURAN	11 U			10 U		10 UJ
DIETHYL PHTHALATE	1 J			10 U		1 J
FLUORANTHENE	11 U			10 U		10 UJ

TABLE 4-12 (PAGE 6 OF 49)
SUMMARY OF POSITIVE GROUNDWATER ANALYTICAL RESULTS FOR ZONE 1
LOWER SUBASE; NSB-NLON; GROTON, CONNECTICUT

SAMPLE NUMBER:	DUP005	LS1GW13MW101-F	DUP005-F	13GW18	13GW18	13GW18-2
INVESTIGATION:	1997RI	1997RI	1997RI	PH2-1	PH2-1	PH2-2
SAMPLE DATE:	11/10/97	11/10/97	11/10/97	03/05/94	03/05/94	06/21/94
LOCATION:	13MW1	13MW1	13MW1	13MW18	13MW18	13MW18
VALIDATED:	VALIDATED	VALIDATED	VALIDATED	VALIDATED	VALIDATED	VALIDATED
FILTERING:	Unfiltered	Filtered	Filtered	Unfiltered	Filtered	Unfiltered
FIELD DUPLICATE OF:	LS1GW13MW101		LS1GW13MW101-F			
SEMIVOLATILES (µg/L)						
FLUORENE	11 U			10 U		10 UJ
NAPHTHALENE	11 U			10 U		10 UJ
PHENANTHRENE	11 U			10 U		10 UJ
PHENOL	11 U			10 U		10 UJ
PYRENE	11 U			10 U		10 UJ
METALS (µg/L)						
ALUMINUM	41.6 U	38.6 U	21.4 U	16.5 U	42.3 U	88.7 J
ANTIMONY	2.5 U	2.5 U	2.5 U	15 U	15 U	13 UJ
ARSENIC	2.5 U	2.5 U	2.5 U	2 UJ	2 UJ	4.4 J
BARIUM	40.2	41.2	41.5	111	95	29.2 J
BERYLLIUM	0.19 U	0.19 U	0.19 U	1 U	1 U	1 UJ
BORON				65.1 J	53.3 J	50 UJ
CADMIUM	0.22 U	0.22 U	0.22 U	2 U	2 U	3 UJ
CALCIUM	26800	27000	27500	88000	78600	23600 J
CHROMIUM	3.1 U	3.1 U	3.1 U	4.4 U	3 U	4 UJ
COBALT	3.1 J	2.9 U	2.9 U	4 U	4 U	5 UJ
COPPER	1.8 J	1.5 U	1.5 U	2 UJ	2.4 J	5 UJ
IRON	1350	1280	1360	2880	3090	7350 J
LEAD	1.3 U	1.3 U	1.3 U	2 UJ	2 U	2 UJ
MAGNESIUM	4740	4780	4870	11600	10300	3800 J
MANGANESE	363	349	370	380	359	347 J
MERCURY	0.04 U	0.01 U	0.01 U	0.2 U	0.2 U	0.2 U
NICKEL	9.0 U	9.0 U	9.0 U	18.5 J	10 U	11 UJ
POTASSIUM	6010	5760	5830	9590	8100	4050 J

TABLE 4-12 (PAGE 7 OF 49)
SUMMARY OF POSITIVE GROUNDWATER ANALYTICAL RESULTS FOR ZONE 1
LOWER SUBASE; NSB-NLON; GROTON, CONNECTICUT

SAMPLE NUMBER:	DUP005	LS1GW13MW101-F	DUP005-F	13GW18	13GW18	13GW18-2
INVESTIGATION:	1997RI	1997RI	1997RI	PH2-1	PH2-1	PH2-2
SAMPLE DATE:	11/10/97	11/10/97	11/10/97	03/05/94	03/05/94	06/21/94
LOCATION:	13MW1	13MW1	13MW1	13MW18	13MW18	13MW18
VALIDATED:	VALIDATED	VALIDATED	VALIDATED	VALIDATED	VALIDATED	VALIDATED
FILTERING:	Unfiltered	Filtered	Filtered	Unfiltered	Filtered	Unfiltered
FIELD DUPLICATE OF:	LS1GW13MW101		LS1GW13MW101-F			
METALS (µg/L)						
SELENIUM	1.9 U	2.8 U	1.9 U	3 UJ	3 U	2 UJ
SILVER	3.4 J	2.8 U	2.8 U	2 U	2 U	2 UJ
SODIUM	42800	45300	45100	223000	192000	69200 J
THALLIUM	4.8 U	4.8 U	4.8 U	1 UJ	10 UJ	10 UJ
VANADIUM	2.9 U	2.9 U	3.2 U	5 U	5 U	5.1 J
ZINC	9.3 U	10.6 U	10.2 U	13.2 U	9.3 U	7.3 J
PETROLEUM HYDROCARBONS (µg/L)						
TPH	1000 U			500 U		1100
MISCELLANEOUS PARAMETERS						
ALKALINITY AS CACO3 (MG/L)	61					
AMMONIA, AS NITROGEN (MG/L)	0.21					
CHLORIDE (MG/L)	56					
HARDNESS AS CaCO3 (MG/L)	86			278		76
METHANE (UG/L)	57					
NITRATE, AS NITROGEN (MG/L)	1.2 J					
PHOSPHORUS (MG/L)	0.39 J					
SULFATE (MG/L)	34					
TOTAL ORGANIC CARBON (MG/L)	18 J					

TABLE 4-12 (PAGE 8 OF 49)
SUMMARY OF POSITIVE GROUNDWATER ANALYTICAL RESULTS FOR ZONE 1
LOWER SUBASE; NSB-NLON; GROTON, CONNECTICUT

SAMPLE NUMBER:	13GW18-2	LS1GW13MW1801	LS1GW13MW1801-F	13GW19	13GW19	13GW19-2
INVESTIGATION:	PH2-2	1997RI	1997RI	PH2-1	PH2-1	PH2-2
SAMPLE DATE:	06/21/94	11/12/97	11/12/97	03/05/94	03/05/94	06/23/94
LOCATION:	13MW18	13MW18	13MW18	13MW19	13MW19	13MW19
VALIDATED:	VALIDATED	VALIDATED	VALIDATED	VALIDATED	VALIDATED	VALIDATED
FILTERING:	Filtered	Unfiltered	Filtered	Unfiltered	Filtered	Unfiltered
FIELD DUPLICATE OF:						
VOLATILES (µg/L)						
1,1-DICHLOROETHANE				3 J		10 U
BENZENE				10 U		10 U
CARBON DISULFIDE				1 J		10 U
ETHYLBENZENE				11		10 U
STYRENE				10 U		10 U
TOLUENE				10 U		10 U
XYLENES, TOTAL				44		10 U
SEMIVOLATILES (µg/L)						
1,2,4-TRICHLOROBENZENE		12 U		10 U		10 U
1,3-DICHLOROBENZENE		12 U		10 U		10 U
2-METHYLNAPHTHALENE		12 U		1 J		10 U
4-METHYLPHENOL		12 U		4 J		2 J
ACENAPHTHENE		12 U		10 U		10 U
ACENAPHTHYLENE		12 U		10 U		10 U
ANTHRACENE		12 U		10 U		10 U
BENZOIC ACID				50 U		50 U
BIS(2-ETHYLHEXYL)PHTHALATE		12 U		10 U		10 U
BUTYLBENZYL PHTHALATE		12 U		10 U		10 U
CARBAZOLE		12 U		10 U		10 U
DI-N-BUTYL PHTHALATE		12 U		10 U		10 U
DI-N-OCTYL PHTHALATE		12 U		10 U		10 U
DIBENZOFURAN		12 U		10 U		10 U
DIETHYL PHTHALATE		1 J		10 U		10 U
FLUORANTHENE		12 U		10 U		10 U

TABLE 4-12 (PAGE 9 OF 49)
SUMMARY OF POSITIVE GROUNDWATER ANALYTICAL RESULTS FOR ZONE 1
LOWER SUBASE; NSB-NLON; GROTON, CONNECTICUT

SAMPLE NUMBER:	13GW18-2	LS1GW13MW1801	LS1GW13MW1801-F	13GW19	13GW19	13GW19-2
INVESTIGATION:	PH2-2	1997RI	1997RI	PH2-1	PH2-1	PH2-2
SAMPLE DATE:	06/21/94	11/12/97	11/12/97	03/05/94	03/05/94	06/23/94
LOCATION:	13MW18	13MW18	13MW18	13MW19	13MW19	13MW19
VALIDATED:	VALIDATED	VALIDATED	VALIDATED	VALIDATED	VALIDATED	VALIDATED
FILTERING:	Filtered	Unfiltered	Filtered	Unfiltered	Filtered	Unfiltered
FIELD DUPLICATE OF:						
SEMIVOLATILES (µg/L)						
FLUORENE		12 U		10 U		10 U
NAPHTHALENE		12 U		1 J		10 U
PHENANTHRENE		12 U		10 U		10 U
PHENOL		12 U		10 U		10 U
PYRENE		12 U		10 U		10 U
METALS (µg/L)						
ALUMINUM	28.2 J	105 U	36.5 U	26100	18700	1360
ANTIMONY	13 U	2.5 U	2.5 U	15 U	15 U	13 U
ARSENIC	4.3	3.4 J	2.5 U	13.9 J	24.8 J	2.6
BARIUM	28.8	44.0	44.6	24.3	7.1 U	2.9 U
BERYLLIUM	1 U	0.11 U	0.11 UJ	1.3 J	1 J	1 U
BORON	50 U			172	160	99.4 J
CADMIUM	3 U	0.24 U	0.22 U	2 U	2 U	3 U
CALCIUM	25900	11900	12200	8680	5810	15500
CHROMIUM	4 U	1.5 U	0.85 J	14 U	9.3	4 U
COBALT	5 U	1.9	1.9	4 U	4 U	5 U
COPPER	5 U	4.8 U	3.6 U	68.4 J	44.2	5 U
IRON	7350	2680	2880	3060	537	311
LEAD	2 U	2.1 J	1.3 U	39.3 J	12.8	2 UJ
MAGNESIUM	3950	1770	1820	1260 U	251	5050
MANGANESE	346	107	110	73.4	10.6 U	12.5
MERCURY	0.2 U	0.04 U	0.02 U	0.97	0.31 J	0.2 U
NICKEL	11 U	6.6	5.9	14.8 J	10 U	11 U
POTASSIUM	4300	2680	2710	5260	4520	6440

TABLE 4-12 (PAGE 10 OF 49)
SUMMARY OF POSITIVE GROUNDWATER ANALYTICAL RESULTS FOR ZONE 1
LOWER SUBASE; NSB-NLON; GROTON, CONNECTICUT

SAMPLE NUMBER:	13GW18-2	LS1GW13MW1801	LS1GW13MW1801-F	13GW19	13GW19	13GW19-2
INVESTIGATION:	PH2-2	1997RI	1997RI	PH2-1	PH2-1	PH2-2
SAMPLE DATE:	06/21/94	11/12/97	11/12/97	03/05/94	03/05/94	06/23/94
LOCATION:	13MW18	13MW18	13MW18	13MW19	13MW19	13MW19
VALIDATED:	VALIDATED	VALIDATED	VALIDATED	VALIDATED	VALIDATED	VALIDATED
FILTERING:	Filtered	Unfiltered	Filtered	Unfiltered	Filtered	Unfiltered
FIELD DUPLICATE OF:						
METALS (µg/L)						
SELENIUM	2 UJ	1.9 U	1.9 U	30 UJ	3 U	2 U
SILVER	2 U	1.1 U	1.1 U	2 U	2 U	2 U
SODIUM	70500	48900	51400	307000	289000	253000
THALLIUM	10 U	4.8 U	4.8 U	1 UJ	1 UJ	10 U
VANADIUM	4.7 J	3.2	2.6	689	593	17.9
ZINC	5.4 J	57.6	60.5	121	20	6.5
PETROLEUM HYDROCARBONS (µg/L)						
TPH		1000 U		2100		500 U
MISCELLANEOUS PARAMETERS						
ALKALINITY AS CACO3 (MG/L)		64				
AMMONIA, AS NITROGEN (MG/L)		0.55				
CHLORIDE (MG/L)		52				
DIVALENT IRON (MG/L)		2.6				
HARDNESS AS CaCO3 (MG/L)		37		30		60
METHANE (UG/L)		3600				
NITRATE, AS NITROGEN (MG/L)		0.056 J				
PHOSPHORUS (MG/L)		0.92 J				
SULFATE (MG/L)		1.0 U				
TOTAL ORGANIC CARBON (MG/L)		23 J				
TURBIDITY (NTU)		8.1				

TABLE 4-12 (PAGE 11 OF 49)
SUMMARY OF POSITIVE GROUNDWATER ANALYTICAL RESULTS FOR ZONE 1
LOWER SUBASE; NSB-NLON; GROTON, CONNECTICUT

SAMPLE NUMBER:	13GW19-2	LS1GW13MW1901	LS1GW13MW1901-F	011691-13MW2S	13GW2	13GW2
INVESTIGATION:	PH2-2	1997RI	1997RI	PH1	PH2-1	PH2-1
SAMPLE DATE:	06/23/94	11/11/97	11/11/97	01/16/91	03/06/94	03/06/94
LOCATION:	13MW19	13MW19	13MW19	13MW2	13MW2	13MW2
VALIDATED:	VALIDATED	VALIDATED	VALIDATED	VALIDATED	VALIDATED	VALIDATED
FILTERING:	Filtered	Unfiltered	Filtered	Unfiltered	Unfiltered	Filtered
FIELD DUPLICATE OF:						
VOLATILES (µg/L)						
1,1-DICHLOROETHANE				5 U	10 U	
BENZENE				5 U	3 J	
CARBON DISULFIDE				5 U	10 U	
ETHYLBENZENE				8	10 U	
STYRENE				5 U	10 U	
TOLUENE				5 U	10 U	
XYLENES, TOTAL				5 U	10 U	
SEMIVOLATILES (µg/L)						
1,2,4-TRICHLOROBENZENE		11 U			10 U	
1,3-DICHLOROBENZENE		11 U			10 U	
2-METHYLNAPHTHALENE		11 U			47	
4-METHYLPHENOL		11 U			10 U	
ACENAPHTHENE		11 U			10 J	
ACENAPHTHYLENE		11 U			1 J	
ANTHRACENE		11 U			2 J	
BENZOIC ACID					50 U	
BIS(2-ETHYLHEXYL)PHTHALATE		11 U			10 U	
BUTYLBENZYL PHTHALATE		11 U			10 U	
CARBAZOLE		11 U			1 J	
DI-N-BUTYL PHTHALATE		11 U			0.6 J	
DI-N-OCTYL PHTHALATE		11 U			10 U	
DIBENZOFURAN		11 U			11	
DIETHYL PHTHALATE		11 U			10 U	
FLUORANTHENE		11 U			2 J	

TABLE 4-12 (PAGE 12 OF 49)
SUMMARY OF POSITIVE GROUNDWATER ANALYTICAL RESULTS FOR ZONE 1
LOWER SUBASE; NSB-NLON; GROTON, CONNECTICUT

SAMPLE NUMBER:	13GW19-2	LS1GW13MW1901	LS1GW13MW1901-F	011691-13MW2S	13GW2	13GW2
INVESTIGATION:	PH2-2	1997RI	1997RI	PH1	PH2-1	PH2-1
SAMPLE DATE:	06/23/94	11/11/97	11/11/97	01/16/91	03/06/94	03/06/94
LOCATION:	13MW19	13MW19	13MW19	13MW2	13MW2	13MW2
VALIDATED:	VALIDATED	VALIDATED	VALIDATED	VALIDATED	VALIDATED	VALIDATED
FILTERING:	Filtered	Unfiltered	Filtered	Unfiltered	Unfiltered	Filtered
FIELD DUPLICATE OF:						
SEMIVOLATILES (µg/L)						
FLUORENE		11 U			15	
NAPHTHALENE		11 U			28	
PHENANTHRENE		11 U			9 J	
PHENOL		11 U			10 U	
PYRENE		11 U			1 J	
METALS (µg/L)						
ALUMINUM	740	1370	1140	30 U	14 U	30.1 U
ANTIMONY	13 U	2.5 U	2.5 U	25 U	15 U	15 U
ARSENIC	2.3	4.6 J	5.2	5	4 J	3.2 J
BARIUM	1.4 U	3.5	28.4	45.7	80.5 J	77.1 J
BERYLLIUM	1 U	0.11 U	0.11 U	1 U	1 U	1 U
BORON	97 J			0.7 R	50 U	50 U
CADMIUM	3 U	0.22 U	0.22 U	2 U	2 UJ	2 UJ
CALCIUM	15500	7100	6850	30600	61900	58800
CHROMIUM	4 U	1.2 U	0.94 U	5 U	3 U	3 U
COBALT	5 U	0.80 U	0.80 U	5 U	4 U	4 U
COPPER	5 U	6.3	5.0 U	5 U	2 U	2 U
IRON	127	316	239 U	11600	8050	7520
LEAD	2 UJ	2.4 J	2.1 J	2.2 J	1 UJ	1 UJ
MAGNESIUM	4990	1880	1750	3150	6340	6080
MANGANESE	8.4	9.6	8.3	697	560	539
MERCURY	0.2 U	0.24	0.20	0.2 U	0.2 U	0.2 U
NICKEL	11 U	3.2	3.1	19.7 J	10 U	10 U
POTASSIUM	6860	8220	7730	4700	7210 J	7160 J

TABLE 4-12 (PAGE 13 OF 49)
SUMMARY OF POSITIVE GROUNDWATER ANALYTICAL RESULTS FOR ZONE 1
LOWER SUBASE; NSB-NLON; GROTON, CONNECTICUT

SAMPLE NUMBER:	13GW19-2	LS1GW13MW1901	LS1GW13MW1901-F	011691-13MW2S	13GW2	13GW2
INVESTIGATION:	PH2-2	1997RI	1997RI	PH1	PH2-1	PH2-1
SAMPLE DATE:	06/23/94	11/11/97	11/11/97	01/16/91	03/06/94	03/06/94
LOCATION:	13MW19	13MW19	13MW19	13MW2	13MW2	13MW2
VALIDATED:	VALIDATED	VALIDATED	VALIDATED	VALIDATED	VALIDATED	VALIDATED
FILTERING:	Filtered	Unfiltered	Filtered	Unfiltered	Unfiltered	Filtered
FIELD DUPLICATE OF:						
METALS (µg/L)						
SELENIUM	2 U	1.9 U	1.9 U	1 U	3 UJ	3 UJ
SILVER	2 U	1.1 U	1.1 U	7 U	2 U	2 U
SODIUM	256000	305000	278000	14800 J	58900	56700
THALLIUM	10 U	4.8 U	4.8 U	2 U	10 UJ	10 UJ
VANADIUM	15.4 J	49.7	46.0	20 U	5 U	5 U
ZINC	3 U	10.8 U	14.9 U	13.4 J	5.8 U	3.3 U
PETROLEUM HYDROCARBONS (µg/L)						
TPH		1000 U		3000 U	1100	
WATER QUALITY PARAMETERS						
DISSOLVED OXYGEN (MG/L)		1.32				
REDOX POTENTIAL (MV)		-216.3				
SALINITY (PPT)		0.67				
SPECIFIC CONDUCTIVITY (MS/CM)		1.456				
TEMPERATURE (C)		42.59				
MISCELLANEOUS PARAMETERS						
ALKALINITY AS CACO3 (MG/L)		140				
AMMONIA, AS NITROGEN (MG/L)		1.2				
CHLORIDE (MG/L)		280				
DIVALENT IRON (MG/L)		0.0				
HARDNESS AS CaCO3 (MG/L)		24			174	
METHANE (UG/L)		150				
NITRATE, AS NITROGEN (MG/L)		0.15 J				
PHOSPHORUS (MG/L)		1.4 J				
SULFATE (MG/L)		140				

TABLE 4-12 (PAGE 14 OF 49)
SUMMARY OF POSITIVE GROUNDWATER ANALYTICAL RESULTS FOR ZONE 1
LOWER SUBASE; NSB-NLON; GROTON, CONNECTICUT

SAMPLE NUMBER:	13GW19-2	LS1GW13MW1901	LS1GW13MW1901-F	011691-13MW2S	13GW2	13GW2
INVESTIGATION:	PH2-2	1997RI	1997RI	PH1	PH2-1	PH2-1
SAMPLE DATE:	06/23/94	11/11/97	11/11/97	01/16/91	03/06/94	03/06/94
LOCATION:	13MW19	13MW19	13MW19	13MW2	13MW2	13MW2
VALIDATED:	VALIDATED	VALIDATED	VALIDATED	VALIDATED	VALIDATED	VALIDATED
FILTERING:	Filtered	Unfiltered	Filtered	Unfiltered	Unfiltered	Filtered
FIELD DUPLICATE OF:						
MISCELLANEOUS PARAMETERS						
TOTAL ORGANIC CARBON (MG/L)		25 J				
TURBIDITY (NTU)		6.3				
GENERAL CHEMISTRY						
PH		9.09				

TABLE 4-12 (PAGE 15 OF 49)
SUMMARY OF POSITIVE GROUNDWATER ANALYTICAL RESULTS FOR ZONE 1
LOWER SUBASE; NSB-NLON; GROTON, CONNECTICUT

SAMPLE NUMBER:	13GW2-2	13GW2-2	LS1GW13MW201	LS1GW13MW201-F	13GW20	13GW20-D
INVESTIGATION:	PH2-2	PH2-2	1997RI	1997RI	PH2-1	PH2-1
SAMPLE DATE:	06/22/94	06/22/94	11/11/97	11/11/97	03/05/94	03/05/94
LOCATION:	13MW2	13MW2	13MW2	13MW2	13MW20	13MW20
VALIDATED:	VALIDATED	VALIDATED	VALIDATED	VALIDATED	VALIDATED	VALIDATED
FILTERING:	Unfiltered	Filtered	Unfiltered	Filtered	Unfiltered	Unfiltered
FIELD DUPLICATE OF:						13MW20
VOLATILES (µg/L)						
1,1-DICHLOROETHANE	10 U				10 U	10 U
BENZENE	3 J				10 U	10 U
CARBON DISULFIDE	10 U				10 U	10 U
ETHYLBENZENE	10 U				10 U	10 U
STYRENE	10 U				10 U	10 U
TOLUENE	10 U				10 U	10 U
XYLENES, TOTAL	10 U				10 U	10 U
SEMIVOLATILES (µg/L)						
1,2,4-TRICHLOROBENZENE	10 U		11 U		10 U	10 U
1,3-DICHLOROBENZENE	10 U		11 U		10 U	10 U
2-METHYLNAPHTHALENE	24		4 J		1 J	1 J
4-METHYLPHENOL	10 U		11 U		10 U	10 U
ACENAPHTHENE	3 J		7 J		1 J	1 J
ACENAPHTHYLENE	10 U		11 U		10 U	10 U
ANTHRACENE	1 J		2 J		10 U	10 U
BENZOIC ACID	50 U				50 UJ	50 UJ
BIS(2-ETHYLHEXYL)PHTHALATE	10 U		11 U		10 U	10 U
BUTYLBENZYL PHTHALATE	10 U		2 J		10 U	10 U
CARBAZOLE	10 U		11 U		1 J	1 J
DI-N-BUTYL PHTHALATE	10 U		11 U		10 U	10 U
DI-N-OCTYL PHTHALATE	10 U		1 J		10 U	10 U
DIBENZOFURAN	4 J		8 J		1 J	1 J
DIETHYL PHTHALATE	1 J		11 U		10 U	10 U
FLUORANTHENE	0.9 J		2 J		10 U	10 U

TABLE 4-12 (PAGE 16 OF 49)
SUMMARY OF POSITIVE GROUNDWATER ANALYTICAL RESULTS FOR ZONE 1
LOWER SUBASE; NSB-NLON; GROTON, CONNECTICUT

SAMPLE NUMBER:	13GW2-2	13GW2-2	LS1GW13MW201	LS1GW13MW201-F	13GW20	13GW20-D
INVESTIGATION:	PH2-2	PH2-2	1997RI	1997RI	PH2-1	PH2-1
SAMPLE DATE:	06/22/94	06/22/94	11/11/97	11/11/97	03/05/94	03/05/94
LOCATION:	13MW2	13MW2	13MW2	13MW2	13MW20	13MW20
VALIDATED:	VALIDATED	VALIDATED	VALIDATED	VALIDATED	VALIDATED	VALIDATED
FILTERING:	Unfiltered	Filtered	Unfiltered	Filtered	Unfiltered	Unfiltered
FIELD DUPLICATE OF:						13MW20
SEMIVOLATILES (µg/L)						
FLUORENE	6 J		12		1 J	1 J
NAPHTHALENE	13		23		1 J	1 J
PHENANTHRENE	4 J		9 J		1 J	1 J
PHENOL	10 U		11 U		10 U	10 U
PYRENE	0.7 J		2 J		10 U	10 U
METALS (µg/L)						
ALUMINUM	23.5 J	20 J	82.9 U	27.9 U	307 U	342 U
ANTIMONY	13 U	13 U	2.5 U	2.5 U	15 U	15 U
ARSENIC	1.5 J	1.2 J	2.5 U	2.5 U	2 UJ	2 UJ
BARIUM	52.6	52.4	55.1	54.6	32.2	32.3
BERYLLIUM	1 U	1 U	0.19 U	0.19 U	1 U	1 U
BORON	52.9 J	52.9 J			116	116
CADMIUM	3 U	3 U	0.22 U	0.22 U	2 U	2 U
CALCIUM	35700	36400	34700	35000	30400	30600
CHROMIUM	4 U	4 U	3.1 U	3.1 U	3 U	3 U
COBALT	5 U	5 U	2.9 U	2.9 U	4 U	4 U
COPPER	5 U	5 U	1.5 U	1.5 U	3.7 J	7 J
IRON	3190	3160	8200	8490	428	459
LEAD	2 U	2 UJ	1.3 U	1.3 U	4.3 J	5.5 J
MAGNESIUM	4090	4130	3700	3450	5800 U	5710 U
MANGANESE	167	167	198	222	316	317
MERCURY	0.2 U	0.2 U	0.07 U	0.04 U	0.2 U	0.2 U
NICKEL	11 U	11 U	9.0 U	9.0 U	10 U	10 U
POTASSIUM	6460	6870	6200	6180	7090	6790

TABLE 4-12 (PAGE 17 OF 49)
SUMMARY OF POSITIVE GROUNDWATER ANALYTICAL RESULTS FOR ZONE 1
LOWER SUBASE; NSB-NLON; GROTON, CONNECTICUT

SAMPLE NUMBER:	13GW2-2	13GW2-2	LS1GW13MW201	LS1GW13MW201-F	13GW20	13GW20-D
INVESTIGATION:	PH2-2	PH2-2	1997RI	1997RI	PH2-1	PH2-1
SAMPLE DATE:	06/22/94	06/22/94	11/11/97	11/11/97	03/05/94	03/05/94
LOCATION:	13MW2	13MW2	13MW2	13MW2	13MW20	13MW20
VALIDATED:	VALIDATED	VALIDATED	VALIDATED	VALIDATED	VALIDATED	VALIDATED
FILTERING:	Unfiltered	Filtered	Unfiltered	Filtered	Unfiltered	Unfiltered
FIELD DUPLICATE OF:						13MW20
METALS (µg/L)						
SELENIUM	2 UJ	2 U	3.2 U	1.9 U	3 UJ	3 UJ
SILVER	2 U	2 U	2.8 U	2.8 U	2 U	2 U
SODIUM	75600	75800	38300	34600	199000	197000
THALLIUM	1 UJ	1 UJ	4.8 U	4.8 UJ	10 UJ	10 UJ
VANADIUM	4 U	4 U	2.9 U	2.9 U	5.1 J	5 U
ZINC	4 J	3.4 J	5.6 U	6.3 U	9.3 U	14.3 U
PETROLEUM HYDROCARBONS (µg/L)						
TPH	600		1000 U		500 U	500 U
WATER QUALITY PARAMETERS						
DISSOLVED OXYGEN (MG/L)			8.43			
REDOX POTENTIAL (MV)			-126.2			
SALINITY (PPT)			0.17			
SPECIFIC CONDUCTIVITY (MS/CM)			0.361			
TEMPERATURE (C)			17.76			
MISCELLANEOUS PARAMETERS						
ALKALINITY AS CACO3 (MG/L)			120			
AMMONIA, AS NITROGEN (MG/L)			0.85			
CHLORIDE (MG/L)			40			
DIVALENT IRON (MG/L)			0.4			
HARDNESS AS CaCO3 (MG/L)	112		100		104	104
METHANE (UG/L)			4100			
NITRATE, AS NITROGEN (MG/L)			0.14 J			
PHOSPHORUS (MG/L)			0.58 J			
SULFATE (MG/L)			13			

TABLE 4-12 (PAGE 18 OF 49)
SUMMARY OF POSITIVE GROUNDWATER ANALYTICAL RESULTS FOR ZONE 1
LOWER SUBASE; NSB-NLON; GROTON, CONNECTICUT

SAMPLE NUMBER:	13GW2-2	13GW2-2	LS1GW13MW201	LS1GW13MW201-F	13GW20	13GW20-D
INVESTIGATION:	PH2-2	PH2-2	1997RI	1997RI	PH2-1	PH2-1
SAMPLE DATE:	06/22/94	06/22/94	11/11/97	11/11/97	03/05/94	03/05/94
LOCATION:	13MW2	13MW2	13MW2	13MW2	13MW20	13MW20
VALIDATED:	VALIDATED	VALIDATED	VALIDATED	VALIDATED	VALIDATED	VALIDATED
FILTERING:	Unfiltered	Filtered	Unfiltered	Filtered	Unfiltered	Unfiltered
FIELD DUPLICATE OF:						13MW20
MISCELLANEOUS PARAMETERS						
TOTAL ORGANIC CARBON (MG/L)			24 J			
TURBIDITY (NTU)			3.9			
GENERAL CHEMISTRY						
PH			6.33			

TABLE 4-12 (PAGE 19 OF 49)
SUMMARY OF POSITIVE GROUNDWATER ANALYTICAL RESULTS FOR ZONE 1
LOWER SUBASE; NSB-NLON; GROTON, CONNECTICUT

SAMPLE NUMBER:	13GW20	13GW20-D	13GW20-2	13GW20-2	LS1GW13MW2001	LS1GW13MW2001-F
INVESTIGATION:	PH2-1	PH2-1	PH2-2	PH2-2	1997RI	1997RI
SAMPLE DATE:	03/05/94	03/05/94	06/22/94	06/22/94	11/11/97	11/11/97
LOCATION:	13MW20	13MW20	13MW20	13MW20	13MW20	13MW20
VALIDATED:	VALIDATED	VALIDATED	VALIDATED	VALIDATED	VALIDATED	VALIDATED
FILTERING:	Filtered	Filtered	Unfiltered	Filtered	Unfiltered	Filtered
FIELD DUPLICATE OF:		13MW20-DISS				
VOLATILES (µg/L)						
1,1-DICHLOROETHANE			10 U			
BENZENE			10 U			
CARBON DISULFIDE			10 U			
ETHYLBENZENE			10 U			
STYRENE			10 U			
TOLUENE			10 U			
XYLENES, TOTAL			10 U			
SEMIVOLATILES (µg/L)						
1,2,4-TRICHLOROBENZENE			10 U		11 U	
1,3-DICHLOROBENZENE			10 U		11 U	
2-METHYLNAPHTHALENE			1 J		11 U	
4-METHYLPHENOL			10 U		2 J	
ACENAPHTHENE			3 J		0.9 J	
ACENAPHTHYLENE			10 U		11 U	
ANTHRACENE			10 U		11 U	
BENZOIC ACID			50 U			
BIS(2-ETHYLHEXYL)PHTHALATE			0.9 J		11 U	
BUTYLBENZYL PHTHALATE			10 U		11 U	
CARBAZOLE			1 J		0.6 J	
DI-N-BUTYL PHTHALATE			10 U		11 U	
DI-N-OCTYL PHTHALATE			10 U		11 U	
DIBENZOFURAN			4 J		1 J	
DIETHYL PHTHALATE			10 U		0.8 J	
FLUORANTHENE			0.7 J		11 U	

TABLE 4-12 (PAGE 20 OF 49)
SUMMARY OF POSITIVE GROUNDWATER ANALYTICAL RESULTS FOR ZONE 1
LOWER SUBASE; NSB-NLON; GROTON, CONNECTICUT

SAMPLE NUMBER:	13GW20	13GW20-D	13GW20-2	13GW20-2	LS1GW13MW2001	LS1GW13MW2001-F
INVESTIGATION:	PH2-1	PH2-1	PH2-2	PH2-2	1997RI	1997RI
SAMPLE DATE:	03/05/94	03/05/94	06/22/94	06/22/94	11/11/97	11/11/97
LOCATION:	13MW20	13MW20	13MW20	13MW20	13MW20	13MW20
VALIDATED:	VALIDATED	VALIDATED	VALIDATED	VALIDATED	VALIDATED	VALIDATED
FILTERING:	Filtered	Filtered	Unfiltered	Filtered	Unfiltered	Filtered
FIELD DUPLICATE OF:		13MW20-DISS				
SEMIVOLATILES (µg/L)						
FLUORENE			4 J		2 J	
NAPHTHALENE			10 U		11 U	
PHENANTHRENE			10 U		2 J	
PHENOL			10 U		5 J	
PYRENE			0.5 J		11 U	
METALS (µg/L)						
ALUMINUM	83.5 U	88.7 U	159	30.5	3650	2980 J
ANTIMONY	15 U	15 U	13 U	13 U	6.6	8.0
ARSENIC	2 UJ	2 UJ	2.7	2 J	12.4	11.3
BARIUM	29.9 U	28.2 U	28.1	28.1	136	138
BERYLLIUM	1 U	1 U	1 U	1 U	0.11 U	0.11 UJ
BORON	116 J	102 J	129	131		
CADMIUM	2 U	2 U	3 U	3 U	0.27 U	0.24 U
CALCIUM	30400	30300	19900	19900	58000	61300
CHROMIUM	3 J	3.8 J	4 U	4 U	4.8	3.5
COBALT	4 U	4 U	5 U	5 U	0.80 U	0.80 U
COPPER	3.5 J	4.4	5 U	5 U	156	120
IRON	204	339	563	375	935	470
LEAD	2 U	2 U	2.6 J	2 UJ	55.7	36.3
MAGNESIUM	5710	5580	4480	4590	16000	17200
MANGANESE	298	292	385	383	99.8	88.1
MERCURY	0.2 U	0.2 U	0.2 U	0.2 U	0.24	0.18 U
NICKEL	10 U	10 U	11 U	11 U	6.0	4.7
POTASSIUM	6560	6930	6840	7430	41200	43400

TABLE 4-12 (PAGE 21 OF 49)

SUMMARY OF POSITIVE GROUNDWATER ANALYTICAL RESULTS FOR ZONE 1 LOWER SUBASE; NSB-NLON; GROTON, CONNECTICUT

SAMPLE NUMBER:	13GW20	13GW20-D	13GW20-2	13GW20-2	LS1GW13MW2001	LS1GW13MW2001-F
INVESTIGATION:	PH2-1	PH2-1	PH2-2	PH2-2	1997RI	1997RI
SAMPLE DATE:	03/05/94	03/05/94	06/22/94	06/22/94	11/11/97	11/11/97
LOCATION:	13MW20	13MW20	13MW20	13MW20	13MW20	13MW20
VALIDATED:	VALIDATED	VALIDATED	VALIDATED	VALIDATED	VALIDATED	VALIDATED
FILTERING:	Filtered	Filtered	Unfiltered	Filtered	Unfiltered	Filtered
FIELD DUPLICATE OF:		13MW20-DISS				
METALS (µg/L)						
SELENIUM	3 U	3 U	2 UJ	2 U	1.9 U	1.9 U
SILVER	3 U	2 U	2 U	2 U	1.6 J	1.2 J
SODIUM	193000	191000	176000	181000	749000 J	804000 J
THALLIUM	10 UJ	10 UJ	10 U	10 U	4.8 U	4.8 U
VANADIUM	5 U	5 U	4 U	4 U	43.9	46.1
ZINC	4.7 U	5 U	7.9	3 U	60.6	27.7
PETROLEUM HYDROCARBONS (µg/L)						
TPH			600		1000 U	
WATER QUALITY PARAMETERS						
DISSOLVED OXYGEN (MG/L)					1.89	
REDOX POTENTIAL (MV)					-271.7	
SALINITY (PPT)					2.65	
SPECIFIC CONDUCTIVITY (MS/CM)					4.966	
TEMPERATURE (C)					38.51	
MISCELLANEOUS PARAMETERS						
ALKALINITY AS CACO3 (MG/L)					190	
AMMONIA, AS NITROGEN (MG/L)					1.5	
CHLORIDE (MG/L)					1200	
DIVALENT IRON (MG/L)					0	
HARDNESS AS CaCO3 (MG/L)			64		240	
METHANE (UG/L)					440	
NITRATE, AS NITROGEN (MG/L)					0.16 J	
PHOSPHORUS (MG/L)					2.7 J	
SULFATE (MG/L)					270	

TABLE 4-12 (PAGE 22 OF 49)
SUMMARY OF POSITIVE GROUNDWATER ANALYTICAL RESULTS FOR ZONE 1
LOWER SUBASE; NSB-NLON; GROTON, CONNECTICUT

SAMPLE NUMBER:	13GW20	13GW20-D	13GW20-2	13GW20-2	LS1GW13MW2001	LS1GW13MW2001-F
INVESTIGATION:	PH2-1	PH2-1	PH2-2	PH2-2	1997RI	1997RI
SAMPLE DATE:	03/05/94	03/05/94	06/22/94	06/22/94	11/11/97	11/11/97
LOCATION:	13MW20	13MW20	13MW20	13MW20	13MW20	13MW20
VALIDATED:	VALIDATED	VALIDATED	VALIDATED	VALIDATED	VALIDATED	VALIDATED
FILTERING:	Filtered	Filtered	Unfiltered	Filtered	Unfiltered	Filtered
FIELD DUPLICATE OF:		13MW20-DISS				
MISCELLANEOUS PARAMETERS						
TOTAL ORGANIC CARBON (MG/L)					1.6 J	
TURBIDITY (NTU)					18	
GENERAL CHEMISTRY						
PH					9.08	

TABLE 4-12 (PAGE 23 OF 49)

SUMMARY OF POSITIVE GROUNDWATER ANALYTICAL RESULTS FOR ZONE 1 LOWER SUBASE; NSB-NLON; GROTON, CONNECTICUT

SAMPLE NUMBER:	13GW21	13GW21	13GW21-2	13GW21-2	LS1GW13MW2101	LS1GW13MW2101-F
INVESTIGATION:	PH2-1	PH2-1	PH2-2	PH2-2	1997RI	1997RI
SAMPLE DATE:	03/05/94	03/05/94	06/22/94	06/22/94	11/11/97	11/11/97
LOCATION:	13MW21	13MW21	13MW21	13MW21	13MW21	13MW21
VALIDATED:	VALIDATED	VALIDATED	VALIDATED	VALIDATED	VALIDATED	VALIDATED
FILTERING:	Unfiltered	Filtered	Unfiltered	Filtered	Unfiltered	Filtered
FIELD DUPLICATE OF:						
VOLATILES (µg/L)						
1,1-DICHLOROETHANE	10 U		10 U			
BENZENE	10 U		10 U			
CARBON DISULFIDE	10 U		10 U			
ETHYLBENZENE	2 J		10 U			
STYRENE	10 U		10 U			
TOLUENE	10 U		10 U			
XYLENES, TOTAL	8 J		10 U			
SEMIVOLATILES (µg/L)						
1,2,4-TRICHLOROBENZENE	10 U		10 U		12 U	
1,3-DICHLOROBENZENE	10 U		10 U		12 U	
2-METHYLNAPHTHALENE	10 U		10 U		12 U	
4-METHYLPHENOL	1 J		10 U		12 U	
ACENAPHTHENE	10 U		10 U		12 U	
ACENAPHTHYLENE	10 U		10 U		12 U	
ANTHRACENE	10 U		10 U		12 U	
BENZOIC ACID	50 U		50 U			
BIS(2-ETHYLHEXYL)PHTHALATE	10 U		10 U		12 U	
BUTYLBENZYL PHTHALATE	10 U		10 U		12 U	
CARBAZOLE	10 UJ		10 U		12 U	
DI-N-BUTYL PHTHALATE	1 J		10 U		12 U	
DI-N-OCTYL PHTHALATE	10 U		10 U		12 U	
DIBENZOFURAN	10 U		10 U		12 U	
DIETHYL PHTHALATE	10 U		10 U		12 U	
FLUORANTHENE	10 U		10 U		12 U	

TABLE 4-12 (PAGE 24 OF 49)
SUMMARY OF POSITIVE GROUNDWATER ANALYTICAL RESULTS FOR ZONE 1
LOWER SUBASE; NSB-NLON; GROTON, CONNECTICUT

SAMPLE NUMBER:	13GW21	13GW21	13GW21-2	13GW21-2	LS1GW13MW2101	LS1GW13MW2101-F
INVESTIGATION:	PH2-1	PH2-1	PH2-2	PH2-2	1997RI	1997RI
SAMPLE DATE:	03/05/94	03/05/94	06/22/94	06/22/94	11/11/97	11/11/97
LOCATION:	13MW21	13MW21	13MW21	13MW21	13MW21	13MW21
VALIDATED:	VALIDATED	VALIDATED	VALIDATED	VALIDATED	VALIDATED	VALIDATED
FILTERING:	Unfiltered	Filtered	Unfiltered	Filtered	Unfiltered	Filtered
FIELD DUPLICATE OF:						
SEMIVOLATILES (µg/L)						
FLUORENE	10 U		10 U		12 U	
NAPHTHALENE	10 U		10 U		12 U	
PHENANTHRENE	10 U		10 U		12 U	
PHENOL	10 U		10 U		12 U	
PYRENE	10 U		10 U		12 U	
METALS (µg/L)						
ALUMINUM	9550 J	7160	219	63.4	14100	13400
ANTIMONY	15 U	15 U	13 U	13 U	2.5 U	2.6 J
ARSENIC	16.8 J	12.8 J	1.8 J	2	9.1	8.6
BARIUM	9.6	5 U	4 U	3.3 U	9.6	9.4
BERYLLIUM	1 U	1 U	1 U	1 U	0.11 U	0.11 U
BORON	110	105 J	61.1	56.1 J		
CADMIUM	2 U	2 U	3 U	3 U	0.22 U	0.22 U
CALCIUM	6510	5730	39900	38400	6380	6380
CHROMIUM	3.3 U	3.3 J	4 U	4 U	4.0	3.6 U
COBALT	4 U	4 U	5 U	5 U	0.80 U	1.4 J
COPPER	53.3 J	20.6	5 U	5 U	16.9	15.6
IRON	771	299	43.1	24.8 U	1460	1150
LEAD	36.1	13.5	2 J	2 UJ	27.4	21.9
MAGNESIUM	399 U	195	4820	4790	226 U	161 U
MANGANESE	21.5	8.3 U	10.7	10.4	24.1	17.7
MERCURY	0.43	0.35 J	0.2 U	0.2 U	0.12 U	0.11 U
NICKEL	10.4 J	10 U	11 U	11 U	7.3	7.1
POTASSIUM	4360	4120	4700	4920	2790	2940

TABLE 4-12 (PAGE 25 OF 49)
SUMMARY OF POSITIVE GROUNDWATER ANALYTICAL RESULTS FOR ZONE 1
LOWER SUBASE; NSB-NLON; GROTON, CONNECTICUT

SAMPLE NUMBER:	13GW21	13GW21	13GW21-2	13GW21-2	LS1GW13MW2101	LS1GW13MW2101-F
INVESTIGATION:	PH2-1	PH2-1	PH2-2	PH2-2	1997RI	1997RI
SAMPLE DATE:	03/05/94	03/05/94	06/22/94	06/22/94	11/11/97	11/11/97
LOCATION:	13MW21	13MW21	13MW21	13MW21	13MW21	13MW21
VALIDATED:	VALIDATED	VALIDATED	VALIDATED	VALIDATED	VALIDATED	VALIDATED
FILTERING:	Unfiltered	Filtered	Unfiltered	Filtered	Unfiltered	Filtered
FIELD DUPLICATE OF:						
METALS (µg/L)						
SELENIUM	30 UJ	3 UJ	2 U	2 U	1.9 U	1.9 U
SILVER	2 U	2.5 U	2 U	2 U	1.1 U	1.1 U
SODIUM	266000	262000	88900	88200	368000	348000
THALLIUM	1 UJ	1 UJ	1 UJ	10 U	4.8 U	4.8 U
VANADIUM	210	205	19.2	20.3	48.3	47.5
ZINC	26.5 U	8.7 U	3 U	3 U	14.3 U	18.3 U
PETROLEUM HYDROCARBONS (µg/L)						
TPH	700		500 U		1100 U	
WATER QUALITY PARAMETERS						
DISSOLVED OXYGEN (MG/L)					0.74	
REDOX POTENTIAL (MV)					-323.4 R	
SALINITY (PPT)					1.03	
SPECIFIC CONDUCTIVITY (MS/CM)					2.151	
TEMPERATURE (C)					64.63	
MISCELLANEOUS PARAMETERS						
ALKALINITY AS CACO3 (MG/L)					370	
AMMONIA, AS NITROGEN (MG/L)					0.41	
CHLORIDE (MG/L)					170	
DIVALENT IRON (MG/L)					0	
HARDNESS AS CaCO3 (MG/L)	20		112		16	
METHANE (UG/L)					5.4 U	
NITRATE, AS NITROGEN (MG/L)					0.14 J	
PHOSPHORUS (MG/L)					3.8 J	
SULFATE (MG/L)					240	

TABLE 4-12 (PAGE 26 OF 49)
SUMMARY OF POSITIVE GROUNDWATER ANALYTICAL RESULTS FOR ZONE 1
LOWER SUBASE; NSB-NLON; GROTON, CONNECTICUT

SAMPLE NUMBER:	13GW21	13GW21	13GW21-2	13GW21-2	LS1GW13MW2101	LS1GW13MW2101-F
INVESTIGATION:	PH2-1	PH2-1	PH2-2	PH2-2	1997RI	1997RI
SAMPLE DATE:	03/05/94	03/05/94	06/22/94	06/22/94	11/11/97	11/11/97
LOCATION:	13MW21	13MW21	13MW21	13MW21	13MW21	13MW21
VALIDATED:	VALIDATED	VALIDATED	VALIDATED	VALIDATED	VALIDATED	VALIDATED
FILTERING:	Unfiltered	Filtered	Unfiltered	Filtered	Unfiltered	Filtered
FIELD DUPLICATE OF:						
MISCELLANEOUS PARAMETERS						
TOTAL ORGANIC CARBON (MG/L)					40 J	
TURBIDITY (NTU)					19	
GENERAL CHEMISTRY						
PH					10.25	

TABLE 4-12 (PAGE 27 OF 49)
SUMMARY OF POSITIVE GROUNDWATER ANALYTICAL RESULTS FOR ZONE 1
LOWER SUBASE; NSB-NLON; GROTON, CONNECTICUT

SAMPLE NUMBER:	011691-13MW3S	13GW3	13GW3	13GW3-2	13GW3-2	LS1GW13MW301
INVESTIGATION:	PH1	PH2-1	PH2-1	PH2-2	PH2-2	1997RI
SAMPLE DATE:	01/16/91	03/06/94	03/06/94	06/22/94	06/22/94	11/10/97
LOCATION:	13MW3	13MW3	13MW3	13MW3	13MW3	13MW3
VALIDATED:	VALIDATED	VALIDATED	VALIDATED	VALIDATED	VALIDATED	VALIDATED
FILTERING:	Unfiltered	Unfiltered	Filtered	Unfiltered	Filtered	Unfiltered
FIELD DUPLICATE OF:						
VOLATILES (µg/L)						
1,1-DICHLOROETHANE	5 U	10 U		10 U		
BENZENE	5 U	10 U		10 U		
CARBON DISULFIDE	5 U	10 U		10 U		
ETHYLBENZENE	5 U	10 U		10 U		
STYRENE	5 U	10 U		10 U		
TOLUENE	5 U	10 U		10 U		
XYLENES, TOTAL	5 U	10 U		10 U		
SEMIVOLATILES (µg/L)						
1,2,4-TRICHLOROBENZENE		10 U		10 UJ		11 U
1,3-DICHLOROBENZENE		10 U		0.5 J		11 U
2-METHYLNAPHTHALENE		10 U		10 UJ		11 U
4-METHYLPHENOL		10 U		6 J		11 U
ACENAPHTHENE		10 U		10 UJ		11 U
ACENAPHTHYLENE		10 U		10 UJ		11 U
ANTHRACENE		10 U		10 UJ		11 U
BENZOIC ACID		50 U		50 U		
BIS(2-ETHYLHEXYL)PHTHALATE		10 U		0.8 J		11 U
BUTYLBENZYL PHTHALATE		10 U		10 UJ		11 U
CARBAZOLE		10 U		10 UJ		11 U
DI-N-BUTYL PHTHALATE		10 U		10 UJ		11 UJ
DI-N-OCTYL PHTHALATE		10 U		10 UJ		11 UJ
DIBENZOFURAN		10 U		10 UJ		11 U
DIETHYL PHTHALATE		10 U		0.6 J		11 U
FLUORANTHENE		10 U		10 UJ		11 U

TABLE 4-12 (PAGE 28 OF 49)
SUMMARY OF POSITIVE GROUNDWATER ANALYTICAL RESULTS FOR ZONE 1
LOWER SUBASE; NSB-NLON; GROTON, CONNECTICUT

SAMPLE NUMBER:	011691-13MW3S	13GW3	13GW3	13GW3-2	13GW3-2	LS1GW13MW301
INVESTIGATION:	PH1	PH2-1	PH2-1	PH2-2	PH2-2	1997RI
SAMPLE DATE:	01/16/91	03/06/94	03/06/94	06/22/94	06/22/94	11/10/97
LOCATION:	13MW3	13MW3	13MW3	13MW3	13MW3	13MW3
VALIDATED:	VALIDATED	VALIDATED	VALIDATED	VALIDATED	VALIDATED	VALIDATED
FILTERING:	Unfiltered	Unfiltered	Filtered	Unfiltered	Filtered	Unfiltered
FIELD DUPLICATE OF:						
SEMIVOLATILES (µg/L)						
FLUORENE		10 U		10 UJ		11 U
NAPHTHALENE		10 U		10 UJ		11 U
PHENANTHRENE		10 U		10 UJ		11 U
PHENOL		10 U		28 J		11 U
PYRENE		10 U		10 UJ		11 U
METALS (µg/L)						
ALUMINUM	31	47.1 U	14.7 U	76.1	15 U	60.2 U
ANTIMONY	25 U	15 U	15 U	13 U	13 U	2.5 U
ARSENIC	3.7	2 U	2 U	1.6 J	1.8 J	2.5 U
BARIUM	24.3	57.6 J	55.2 J	47.5	43.6	58.8
BERYLLIUM	1 U	1 U	1 U	1 U	1 U	0.19 U
BORON	4.1 R	61.5	61.9	52 J	50 J	
CADMIUM	2 U	2 UJ	2 UJ	3 U	3 U	0.22 U
CALCIUM	27800	39200	37800	37500	36100	36900
CHROMIUM	5 U	3 U	3 U	4 U	4 U	3.1 U
COBALT	8.2	4 U	4 U	5 U	5 U	2.9 U
COPPER	5 U	2 U	2 U	5 U	5 U	1.5 U
IRON	5860	729	662	1140	1110	1280
LEAD	2 UJ	1 UJ	1 UJ	2 U	2 U	1.3 U
MAGNESIUM	4770	5490	5290	5040	4780	5430
MANGANESE	472	169	173	169	141	247
MERCURY	0.2 U	0.2 U	0.2 U	0.2 U	0.2 U	0.01 U
NICKEL	23.2 J	10 U	10 U	11 U	11 U	9.0 U
POTASSIUM	4810	6390 J	6350 J	6570	6270	7210

TABLE 4-12 (PAGE 29 OF 49)
SUMMARY OF POSITIVE GROUNDWATER ANALYTICAL RESULTS FOR ZONE 1
LOWER SUBASE; NSB-NLON; GROTON, CONNECTICUT

SAMPLE NUMBER:	011691-13MW3S	13GW3	13GW3	13GW3-2	13GW3-2	LS1GW13MW301
INVESTIGATION:	PH1	PH2-1	PH2-1	PH2-2	PH2-2	1997RI
SAMPLE DATE:	01/16/91	03/06/94	03/06/94	06/22/94	06/22/94	11/10/97
LOCATION:	13MW3	13MW3	13MW3	13MW3	13MW3	13MW3
VALIDATED:	VALIDATED	VALIDATED	VALIDATED	VALIDATED	VALIDATED	VALIDATED
FILTERING:	Unfiltered	Unfiltered	Filtered	Unfiltered	Filtered	Unfiltered
FIELD DUPLICATE OF:						
METALS (µg/L)						
SELENIUM	1 U	3 UJ	3 UJ	2 UJ	2 U	1.9 U
SILVER	7 U	2 U	2 U	2 U	2 U	2.8 U
SODIUM	39200	49800	48300	44500	41200	63100
THALLIUM	2 U	1 UJ	1 UJ	10 U	10 U	5.4 J
VANADIUM	20 U	5 U	5 U	4 U	4 U	2.9 U
ZINC	18.3 J	10.2 U	4 U	6.1	3.7 J	10.6 U
PETROLEUM HYDROCARBONS (µg/L)						
TPH	3000 U	1500		1300		1000 U
WATER QUALITY PARAMETERS						
DISSOLVED OXYGEN (MG/L)						12.08
REDOX POTENTIAL (MV)						-82.3
SALINITY (PPT)						0.25
SPECIFIC CONDUCTIVITY (MS/CM)						0.524
TEMPERATURE (C)						18.99
MISCELLANEOUS PARAMETERS						
ALKALINITY AS CACO3 (MG/L)						83
AMMONIA, AS NITROGEN (MG/L)						0.34
CHLORIDE (MG/L)						120
DIVALENT IRON (MG/L)						1.1
HARDNESS AS CaCO3 (MG/L)		118		108		120
METHANE (UG/L)						57
NITRATE, AS NITROGEN (MG/L)						0.11 J
PHOSPHORUS (MG/L)						0.11 J
SULFATE (MG/L)						26

TABLE 4-12 (PAGE 30 OF 49)
SUMMARY OF POSITIVE GROUNDWATER ANALYTICAL RESULTS FOR ZONE 1
LOWER SUBASE; NSB-NLON; GROTON, CONNECTICUT

SAMPLE NUMBER:	011691-13MW3S	13GW3	13GW3	13GW3-2	13GW3-2	LS1GW13MW301
INVESTIGATION:	PH1	PH2-1	PH2-1	PH2-2	PH2-2	1997RI
SAMPLE DATE:	01/16/91	03/06/94	03/06/94	06/22/94	06/22/94	11/10/97
LOCATION:	13MW3	13MW3	13MW3	13MW3	13MW3	13MW3
VALIDATED:	VALIDATED	VALIDATED	VALIDATED	VALIDATED	VALIDATED	VALIDATED
FILTERING:	Unfiltered	Unfiltered	Filtered	Unfiltered	Filtered	Unfiltered
FIELD DUPLICATE OF:						
MISCELLANEOUS PARAMETERS						
TOTAL ORGANIC CARBON (MG/L)						4.7 J
TURBIDITY (NTU)						4.78
GENERAL CHEMISTRY						
PH						6.52

TABLE 4-12 (PAGE 31 OF 49)

SUMMARY OF POSITIVE GROUNDWATER ANALYTICAL RESULTS FOR ZONE 1
LOWER SUBASE; NSB-NLON; GROTON, CONNECTICUT

SAMPLE NUMBER:	LS1GW13MW301-F	011791-13MW4S	011791-13MW5S	011591-13MW7S	011591-13MW27S	021191-13MW8
INVESTIGATION:	1997RI	PH1	PH1	PH1	PH1	PH1
SAMPLE DATE:	11/10/97	01/17/91	01/17/91	01/15/91	01/15/91	02/11/91
LOCATION:	13MW3	13MW4	13MW5	13MW7	13MW7	13MW8
VALIDATED:	VALIDATED	VALIDATED	VALIDATED	VALIDATED	VALIDATED	VALIDATED
FILTERING:	Filtered	Unfiltered	Unfiltered	Unfiltered	Unfiltered	Unfiltered
FIELD DUPLICATE OF:					011591-13MW7S	
VOLATILES (µg/L)						
1,1-DICHLOROETHANE		5 U	5 U	5 U	5 U	5 U
BENZENE		5 U	5 U	5 U	5 U	5 U
CARBON DISULFIDE		5 U	5 U	5 U	1 J	5 U
ETHYLBENZENE		5 U	5 U	5 U	5 U	5 U
STYRENE		5 U	5 U	5 U	5 U	2 J
TOLUENE		5 U	5 U	5 U	5 U	5 U
XYLENES, TOTAL		5 U	5 U	5 U	5 U	5 U
METALS (µg/L)						
ALUMINUM	25.2 U	10600	178	625	638	89.3
ANTIMONY	2.5 U	25 U	25 U	25 U	25 U	10 U
ARSENIC	2.5 U	8.5	3 U	3 U	3 U	3 U
BARIUM	60.0	15 U	210	15 U	15 U	15 U
BERYLLIUM	0.19 U	1 U	1 U	1 U	1 U	1 U
BORON		18 R	1.8 R	4.3 R	4.3 R	6.79 R
CADMIUM	0.22 U	2 U	2 U	2 U	2 U	6.7 J
CALCIUM	37900	4820	53300	5330	5300	14900
CHROMIUM	3.1 U	5.9 J	5.1 J	8.7 J	11.6 J	5 UJ
COBALT	2.9 U	5 U	5 U	5 U	5 U	5 UJ
COPPER	6.3	15.6	5 U	10.4	9.5	9.2 J
IRON	1140	984	3260	697	593	1230
LEAD	1.3 U	9.4 J	2 UJ	2 J	2.8 J	15.3
MAGNESIUM	5600	129	17200	3260	3250	10700
MANGANESE	252	10.2	344	58.3	58.1	433
MERCURY	0.03 U	0.2 U	0.2 U	0.2 U	0.2 U	0.2 U

TABLE 4-12 (PAGE 32 OF 49)

SUMMARY OF POSITIVE GROUNDWATER ANALYTICAL RESULTS FOR ZONE 1
LOWER SUBASE; NSB-NLON; GROTON, CONNECTICUT

SAMPLE NUMBER:	LS1GW13MW301-F	011791-13MW4S	011791-13MW5S	011591-13MW7S	011591-13MW27S	021191-13MW8
INVESTIGATION:	1997RI	PH1	PH1	PH1	PH1	PH1
SAMPLE DATE:	11/10/97	01/17/91	01/17/91	01/15/91	01/15/91	02/11/91
LOCATION:	13MW3	13MW4	13MW5	13MW7	13MW7	13MW8
VALIDATED:	VALIDATED	VALIDATED	VALIDATED	VALIDATED	VALIDATED	VALIDATED
FILTERING:	Filtered	Unfiltered	Unfiltered	Unfiltered	Unfiltered	Unfiltered
FIELD DUPLICATE OF:					011591-13MW7S	
METALS (µg/L)						
NICKEL	9.0 U	23.5 J	22 J	19.6 J	17.8 J	7 UJ
POTASSIUM	7320	2090	12700	5130	5170	8720 J
SELENIUM	1.9 U	1 U	1 U	1 U	1 U	1
SILVER	2.8 U	7 U	7 U	7 U	7 U	7.4 J
SODIUM	65700	354000	177000	260000	258000	192000
THALLIUM	4.8 U	2 U	2 U	2 U	2 U	2 U
VANADIUM	2.9 U	22.6	20 U	20 U	20 U	20 U
ZINC	9.5 U	26.5 J	12.9 J	11.7 J	15.2 J	14.8
PETROLEUM HYDROCARBONS (µg/L)						
TPH		3000 U	3000 U	3000 U	3000 U	3000 U

TABLE 4-12 (PAGE 33 OF 49)

SUMMARY OF POSITIVE GROUNDWATER ANALYTICAL RESULTS FOR ZONE 1
LOWER SUBASE; NSB-NLON; GROTON, CONNECTICUT

SAMPLE NUMBER:	13GW8	13GW8	13GW8-2	13GW8-2-F	LS1GW13MW801	LS1GW13MW801-F
INVESTIGATION:	PH2-1	PH2-1	PH2-2	PH2-2	1997RI	1997RI
SAMPLE DATE:	03/06/94	03/06/94	06/22/94	06/22/94	11/13/97	11/13/97
LOCATION:	13MW8	13MW8	13MW8	13MW8	13MW8	13MW8
VALIDATED:	VALIDATED	VALIDATED	VALIDATED	VALIDATED	VALIDATED	VALIDATED
FILTERING:	Unfiltered	Filtered	Unfiltered	Filtered	Unfiltered	Filtered
FIELD DUPLICATE OF:						
VOLATILES (µg/L)						
1,1-DICHLOROETHANE	10 U		10 U			
BENZENE	10 U		10 U			
CARBON DISULFIDE	10 U		10 U			
ETHYLBENZENE	10 U		10 U			
STYRENE	10 U		10 U			
TOLUENE	10 U		10 U			
XYLENES, TOTAL	10 U		10 U			
SEMIVOLATILES (µg/L)						
1,2,4-TRICHLOROBENZENE	10 U		10 U		11 U	
1,3-DICHLOROBENZENE	10 U		10 U		11 U	
2-METHYLNAPHTHALENE	10 U		10 U		11 U	
4-METHYLPHENOL	10 U		10 U		11 U	
ACENAPHTHENE	2 J		2 J		1 J	
ACENAPHTHYLENE	10 U		10 U		11 U	
ANTHRACENE	10 U		10 U		11 U	
BENZOIC ACID	50 U		50 U			
BIS(2-ETHYLHEXYL)PHTHALATE	10 U		10 U		11 U	
BUTYLBENZYL PHTHALATE	10 U		10 U		11 U	
CARBAZOLE	10 U		10 U		11 U	
DI-N-BUTYL PHTHALATE	10 U		10 U		11 U	
DI-N-OCTYL PHTHALATE	10 U		10 U		11 U	
DIBENZOFURAN	10 U		10 U		11 U	
DIETHYL PHTHALATE	10 U		10 U		0.6 J	
FLUORANTHENE	1 J		10 U		1 J	

TABLE 4-12 (PAGE 34 OF 49)
SUMMARY OF POSITIVE GROUNDWATER ANALYTICAL RESULTS FOR ZONE 1
LOWER SUBASE; NSB-NLON; GROTON, CONNECTICUT

SAMPLE NUMBER:	13GW8	13GW8	13GW8-2	13GW8-2-F	LS1GW13MW801	LS1GW13MW801-F
INVESTIGATION:	PH2-1	PH2-1	PH2-2	PH2-2	1997RI	1997RI
SAMPLE DATE:	03/06/94	03/06/94	06/22/94	06/22/94	11/13/97	11/13/97
LOCATION:	13MW8	13MW8	13MW8	13MW8	13MW8	13MW8
VALIDATED:	VALIDATED	VALIDATED	VALIDATED	VALIDATED	VALIDATED	VALIDATED
FILTERING:	Unfiltered	Filtered	Unfiltered	Filtered	Unfiltered	Filtered
FIELD DUPLICATE OF:						
SEMIVOLATILES (µg/L)						
FLUORENE	10 U		10 U		11 U	
NAPHTHALENE	10 U		10 U		11 U	
PHENANTHRENE	10 U		10 U		11 U	
PHENOL	10 U		10 U		11 U	
PYRENE	0.6 J		10 U		0.6 J	
METALS (µg/L)						
ALUMINUM	14 U	25.2 U	46.5 U	23.8 U	10.0 UJ	21.4 U
ANTIMONY	15 U	15 U	13 U	13 U	2.5 U	2.5 U
ARSENIC	2 U	2 U	3.5	2.5	2.5 U	2.5 U
BARIUM	21.4 U	5.4 U	6 U	4.1 U	3.6 U	3.4 U
BERYLLIUM	1 U	1 U	1 U	1 U	0.80 U	0.19 UJ
BORON	118	206	230	214		
CADMIUM	5 U	2 UJ	3 U	3 U	0.22 U	0.22 U
CALCIUM	11700	23400	34300	32200	37100	37300
CHROMIUM	3 U	3 U	4 U	4 U	1.4	3.1 U
COBALT	6.8	4 U	5 U	5 U	0.80 U	2.9 U
COPPER	2 U	2 U	5 U	5 U	3.1 U	1.5 UJ
IRON	82.1 J	710	1330	667	1010	1050
LEAD	2.5 J	1 UJ	2 UJ	2 UJ	1.3 U	1.3 U
MAGNESIUM	23800	28700	45300	41200	18000	21900
MANGANESE	32.7	1730	2290	1930	3540	3810
MERCURY	0.2 U	0.2 U	0.2 U	0.2 U	0.03 U	0.02 U
NICKEL	10 U	10 U	11 U	11 U	1.0 J	9.0 U
POTASSIUM	7450 J	11700 J	16100	14400	9530 J	10600

TABLE 4-12 (PAGE 35 OF 49)
SUMMARY OF POSITIVE GROUNDWATER ANALYTICAL RESULTS FOR ZONE 1
LOWER SUBASE; NSB-NLON; GROTON, CONNECTICUT

SAMPLE NUMBER:	13GW8	13GW8	13GW8-2	13GW8-2-F	LS1GW13MW801	LS1GW13MW801-F
INVESTIGATION:	PH2-1	PH2-1	PH2-2	PH2-2	1997RI	1997RI
SAMPLE DATE:	03/06/94	03/06/94	06/22/94	06/22/94	11/13/97	11/13/97
LOCATION:	13MW8	13MW8	13MW8	13MW8	13MW8	13MW8
VALIDATED:	VALIDATED	VALIDATED	VALIDATED	VALIDATED	VALIDATED	VALIDATED
FILTERING:	Unfiltered	Filtered	Unfiltered	Filtered	Unfiltered	Filtered
FIELD DUPLICATE OF:						
METALS (µg/L)						
SELENIUM	3 UJ	3 UJ	2 U	2 U	1.9 U	1.9 U
SILVER	2 U	2.5 U	2 U	2 U	1.1 U	2.8 U
SODIUM	175000	311000	395000	364000	139000 J	166000
THALLIUM	1 UJ	10 UJ	10 UJ	1 UJ	4.8 UJ	4.8 U
VANADIUM	8.3 J	5 U	4 U	4 U	0.55 U	2.9 U
ZINC	7.2 U	2 U	5.9 J	6 J	7.5 U	5.3 U
PETROLEUM HYDROCARBONS (µg/L)						
TPH	500 U		500 U		1000 U	
WATER QUALITY PARAMETERS						
DISSOLVED OXYGEN (MG/L)					46.5 R	
REDOX POTENTIAL (MV)					-182.6	
SALINITY (PPT)					0.49	
SPECIFIC CONDUCTIVITY (MS/CM)					0.99	
TEMPERATURE (C)					18.29	
MISCELLANEOUS PARAMETERS						
ALKALINITY AS CACO3 (MG/L)					99	
AMMONIA, AS NITROGEN (MG/L)					0.41	
CHLORIDE (MG/L)					250	
DIVALENT IRON (MG/L)					0	
HARDNESS AS CaCO3 (MG/L)	180		268		220	
METHANE (UG/L)					1200	
NITRATE, AS NITROGEN (MG/L)					0.05 UJ	
PHOSPHORUS (MG/L)					0.27 J	
SULFATE (MG/L)					41	

TABLE 4-12 (PAGE 36 OF 49)

SUMMARY OF POSITIVE GROUNDWATER ANALYTICAL RESULTS FOR ZONE 1 LOWER SUBASE; NSB-NLON; GROTON, CONNECTICUT

SAMPLE NUMBER:	13GW8	13GW8	13GW8-2	13GW8-2-F	LS1GW13MW801	LS1GW13MW801-F
INVESTIGATION:	PH2-1	PH2-1	PH2-2	PH2-2	1997RI	1997RI
SAMPLE DATE:	03/06/94	03/06/94	06/22/94	06/22/94	11/13/97	11/13/97
LOCATION:	13MW8	13MW8	13MW8	13MW8	13MW8	13MW8
VALIDATED:	VALIDATED	VALIDATED	VALIDATED	VALIDATED	VALIDATED	VALIDATED
FILTERING:	Unfiltered	Filtered	Unfiltered	Filtered	Unfiltered	Filtered
FIELD DUPLICATE OF:						
MISCELLANEOUS PARAMETERS						
TOTAL ORGANIC CARBON (MG/L)					4.9 J	
TURBIDITY (NTU)					0.58	
GENERAL CHEMISTRY						
PH					6.92	

TABLE 4-12 (PAGE 37 OF 49)
SUMMARY OF POSITIVE GROUNDWATER ANALYTICAL RESULTS FOR ZONE 1
LOWER SUBASE; NSB-NLON; GROTON, CONNECTICUT

SAMPLE NUMBER:	011791-13MW9S	13GW9	13GW9	13GW9-2	13GW92	LS1GW13MW901
INVESTIGATION:	PH1	PH2-1	PH2-1	PH2-2	PH2-2	1997RI
SAMPLE DATE:	01/17/91	03/06/94	03/06/94	06/25/94	06/25/94	11/12/97
LOCATION:	13MW9	13MW9	13MW9	13MW9	13MW9	13MW9
VALIDATED:	VALIDATED	VALIDATED	VALIDATED	VALIDATED	VALIDATED	VALIDATED
FILTERING:	Unfiltered	Unfiltered	Filtered	Unfiltered	Filtered	Unfiltered
FIELD DUPLICATE OF:						
VOLATILES (µg/L)						
1,1-DICHLOROETHANE	5 U	10 U		10 U		
BENZENE	5 U	10 U		10 U		
CARBON DISULFIDE	5 U	10 U		3 J		
ETHYLBENZENE	5 U	10 U		10 U		
STYRENE	5 U	10 U		10 U		
TOLUENE	5 U	10 U		10 U		
XYLENES, TOTAL	5 U	10 U		10 U		
SEMIVOLATILES (µg/L)						
1,2,4-TRICHLOROBENZENE		10 U		10 UJ		11 U
1,3-DICHLOROBENZENE		10 U		10 UJ		11 U
2-METHYLNAPHTHALENE		10 U		10 UJ		11 U
4-METHYLPHENOL		10 U		10 UJ		11 U
ACENAPHTHENE		5 J		2 J		5 J
ACENAPHTHYLENE		10 U		10 UJ		11 U
ANTHRACENE		10 U		10 UJ		11 U
BENZOIC ACID		50 U		50 U		
BIS(2-ETHYLHEXYL)PHTHALATE		10 U		10 U		11 U
BUTYLBENZYL PHTHALATE		10 U		10 UJ		11 U
CARBAZOLE		10 U		10 UJ		11 U
DI-N-BUTYL PHTHALATE		10 U		10 UJ		11 U
DI-N-OCTYL PHTHALATE		10 U		10 UJ		11 U
DIBENZOFURAN		10 U		10 UJ		11 U
DIETHYL PHTHALATE		10 U		10 UJ		0.7 J
FLUORANTHENE		10 U		10 UJ		11 U

TABLE 4-12 (PAGE 38 OF 49)
SUMMARY OF POSITIVE GROUNDWATER ANALYTICAL RESULTS FOR ZONE 1
LOWER SUBASE; NSB-NLON; GROTON, CONNECTICUT

SAMPLE NUMBER:	011791-13MW9S	13GW9	13GW9	13GW9-2	13GW92	LS1GW13MW901
INVESTIGATION:	PH1	PH2-1	PH2-1	PH2-2	PH2-2	1997RI
SAMPLE DATE:	01/17/91	03/06/94	03/06/94	06/25/94	06/25/94	11/12/97
LOCATION:	13MW9	13MW9	13MW9	13MW9	13MW9	13MW9
VALIDATED:	VALIDATED	VALIDATED	VALIDATED	VALIDATED	VALIDATED	VALIDATED
FILTERING:	Unfiltered	Unfiltered	Filtered	Unfiltered	Filtered	Unfiltered
FIELD DUPLICATE OF:						
SEMIVOLATILES (µg/L)						
FLUORENE		10 U		10 UJ		11 U
NAPHTHALENE		10 U		10 UJ		11 U
PHENANTHRENE		10 U		10 UJ		11 U
PHENOL		10 U		10 UJ		11 U
PYRENE		0.6 J		1 J		1 J
METALS (µg/L)						
ALUMINUM	30 U	14 U	14 U	10 U	10 UJ	100 U
ANTIMONY	25 U	15 U	15 U	5 U	5 U	2.5 U
ARSENIC	3 U	2.1 J	2 U	2 UJ	2 UJ	2.5 U
BARIUM	47.2	40.6 U	40.3 U	61.6 J	61 J	98.1
BERYLLIUM	1 U	1 U	1 U	1 U	1 U	0.11 U
BORON	42 R	1010 J	982 J	1430	1410 J	
CADMIUM	2 U	2 UJ	2 UJ	1.4 J	1 U	0.22 U
CALCIUM	90100	127000	124000	139000	138000	207000
CHROMIUM	5 U	3 U	3 U	1 U	1 J	2.1 U
COBALT	5 U	4 U	4 U	1 U	1 U	0.80 U
COPPER	5 U	2.7 J	3.4 J	3 U	3 U	4.6 U
IRON	414	40.5 U	47.6 U	17 U	17 U	326
LEAD	10 UJ	1 UJ	1 UJ	10 UR	10 UR	2.5 J
MAGNESIUM	263000	277000	270000	443000	449000	615000 J
MANGANESE	102	213	209	151	149	140
MERCURY	0.2 U	0.2 U	0.2 U	0.2 UJ	0.2 UJ	0.05 U
NICKEL	15.2 J	10 U	10 U	3 U	3 U	1.0 J
POTASSIUM	86200	107000 J	103000 J	138000	141000	194000

TABLE 4-12 (PAGE 39 OF 49)
SUMMARY OF POSITIVE GROUNDWATER ANALYTICAL RESULTS FOR ZONE 1
LOWER SUBASE; NSB-NLON; GROTON, CONNECTICUT

SAMPLE NUMBER:	011791-13MW9S	13GW9	13GW9	13GW9-2	13GW92	LS1GW13MW901
INVESTIGATION:	PH1	PH2-1	PH2-1	PH2-2	PH2-2	1997RI
SAMPLE DATE:	01/17/91	03/06/94	03/06/94	06/25/94	06/25/94	11/12/97
LOCATION:	13MW9	13MW9	13MW9	13MW9	13MW9	13MW9
VALIDATED:	VALIDATED	VALIDATED	VALIDATED	VALIDATED	VALIDATED	VALIDATED
FILTERING:	Unfiltered	Unfiltered	Filtered	Unfiltered	Filtered	Unfiltered
FIELD DUPLICATE OF:						
METALS (µg/L)						
SELENIUM	22	3 UJ	3 UJ	20 UJ	4 UR	1.9 U
SILVER	7 U	2 U	2.1 U	2 U	2 U	2.9
SODIUM	1550000	2720000	2430000	2980000 J	3660000 J	4950000 J
THALLIUM	20 U	10 UJ	10 UJ	20 UJ	20 UR	4.8 U
VANADIUM	20 U	5 UJ	5 UJ	1 U	1.5 J	1.1 J
ZINC	10.6 J	2 U	2 U	4.4 U	3.7 U	14.3 U
PETROLEUM HYDROCARBONS (µg/L)						
TPH	3000 U	500 U		1000 U		1000 U
WATER QUALITY PARAMETERS						
DISSOLVED OXYGEN (MG/L)						538.6 R
REDOX POTENTIAL (MV)						-375.9
SALINITY (PPT)						14.0
SPECIFIC CONDUCTIVITY (MS/CM)						23.17
TEMPERATURE (C)						17.2
MISCELLANEOUS PARAMETERS						
ALKALINITY AS CACO3 (MG/L)						190
AMMONIA, AS NITROGEN (MG/L)						1.7
CHLORIDE (MG/L)						5900
DIVALENT IRON (MG/L)						0
HARDNESS AS CaCO3 (MG/L)		1640		2170		2600
METHANE (UG/L)						1700
NITRATE, AS NITROGEN (MG/L)						0.05 U
PHOSPHORUS (MG/L)						0.87 J
SULFATE (MG/L)						1400

TABLE 4-12 (PAGE 40 OF 49)
SUMMARY OF POSITIVE GROUNDWATER ANALYTICAL RESULTS FOR ZONE 1
LOWER SUBASE; NSB-NLON; GROTON, CONNECTICUT

SAMPLE NUMBER:	011791-13MW9S	13GW9	13GW9	13GW9-2	13GW92	LS1GW13MW901
INVESTIGATION:	PH1	PH2-1	PH2-1	PH2-2	PH2-2	1997RI
SAMPLE DATE:	01/17/91	03/06/94	03/06/94	06/25/94	06/25/94	11/12/97
LOCATION:	13MW9	13MW9	13MW9	13MW9	13MW9	13MW9
VALIDATED:	VALIDATED	VALIDATED	VALIDATED	VALIDATED	VALIDATED	VALIDATED
FILTERING:	Unfiltered	Unfiltered	Filtered	Unfiltered	Filtered	Unfiltered
FIELD DUPLICATE OF:						
MISCELLANEOUS PARAMETERS						
TOTAL ORGANIC CARBON (MG/L)						6.0 J
TURBIDITY (NTU)						11.3
GENERAL CHEMISTRY						
PH						7.18

TABLE 4-12 (PAGE 41 OF 49)
SUMMARY OF POSITIVE GROUNDWATER ANALYTICAL RESULTS FOR ZONE 1
LOWER SUBASE; NSB-NLON; GROTON, CONNECTICUT

SAMPLE NUMBER:	LS1GW13MW901-F	MW-13	LS1GWFOMW1301	LS1GWFOMW1301-F	MW-14	LS1GWFOMW1401
INVESTIGATION:	1997RI	FO89	1997RI	1997RI	FO89	1997RI
SAMPLE DATE:	11/12/97	07/12/89	11/12/97	11/12/97	07/12/89	11/10/97
LOCATION:	13MW9	FOMW13	FOMW13	FOMW13	FOMW14	FOMW14
VALIDATED:	VALIDATED		VALIDATED	VALIDATED		VALIDATED
FILTERING:	Filtered	Unfiltered	Unfiltered	Filtered	Unfiltered	Unfiltered
FIELD DUPLICATE OF:						
VOLATILES (µg/L)						
BENZENE		1 U			1 U	
ETHYLBENZENE		1 U			1 U	
TOLUENE		11			1 U	
XYLENES, TOTAL		9.6			1 U	
SEMIVOLATILES (µg/L)						
1,2,4-TRICHLOROBENZENE			12 U			12 U
1,3-DICHLOROBENZENE		1 U	12 U		1 U	12 U
2-METHYLNAPHTHALENE			12 U			12 U
4-METHYLPHENOL			12 U			12 U
ACENAPHTHENE			12 U			12 U
ACENAPHTHYLENE			12 U			12 U
ANTHRACENE			12 U			12 U
BIS(2-ETHYLHEXYL)PHTHALATE			12 U			12 U
BUTYLBENZYL PHTHALATE			12 U			12 UJ
CARBAZOLE			12 U			12 U
DI-N-BUTYL PHTHALATE			12 U			12 UJ
DI-N-OCTYL PHTHALATE			12 U			12 UJ
DIBENZOFURAN			12 U			12 U
DIETHYL PHTHALATE			12 U			12 U
FLUORANTHENE			12 U			12 U
FLUORENE			12 U			12 U
NAPHTHALENE			12 U			12 U
PHENANTHRENE			12 U			12 U
PHENOL			12 U			12 U

TABLE 4-12 (PAGE 42 OF 49)

SUMMARY OF POSITIVE GROUNDWATER ANALYTICAL RESULTS FOR ZONE 1 LOWER SUBASE; NSB-NLON; GROTON, CONNECTICUT

SAMPLE NUMBER:	LS1GW13MW901-F	MW-13	LS1GWFOMW1301	LS1GWFOMW1301-F	MW-14	LS1GWFOMW1401
INVESTIGATION:	1997RI	FO89	1997RI	1997RI	FO89	1997RI
SAMPLE DATE:	11/12/97	07/12/89	11/12/97	11/12/97	07/12/89	11/10/97
LOCATION:	13MW9	FOMW13	FOMW13	FOMW13	FOMW14	FOMW14
VALIDATED:	VALIDATED		VALIDATED	VALIDATED		VALIDATED
FILTERING:	Filtered	Unfiltered	Unfiltered	Filtered	Unfiltered	Unfiltered
FIELD DUPLICATE OF:						
SEMIVOLATILES (µg/L)						
PYRENE			12 U			12 UJ
METALS (µg/L)						
ALUMINUM	10.0 UJ		10.0 UJ	10.0 UJ		3480
ANTIMONY	2.5 U		2.5 U	2.8 U		2.5 U
ARSENIC	2.5 U		2.5 U	2.5 U		6.5
BARIUM	95.7		69.2	71.1		114
BERYLLIUM	0.11 UJ		0.60 U	0.61 U		0.24 U
CADMIUM	0.22 U		0.22 U	0.22 U		0.52 U
CALCIUM	203000		130000	134000		66000
CHROMIUM	0.68 U		1.1 J	0.76 J		10.5
COBALT	0.80 U		0.80 U	0.80 U		4.2 J
COPPER	1.3 U		4.2 U	3.7 U		77.9
IRON	83.7 U		214 U	196 U		7660
LEAD	1.3 U		1.3 U	1.3 U		36.8
MAGNESIUM	609000 J		3520	3620		3720
MANGANESE	136		23.1	24.0		297
MERCURY	0.01 U		0.01 U	0.02 U		0.02 U
NICKEL	0.75 U		2.0	1.0 J		12.2 J
POTASSIUM	191000		11800 J	12700 J		8980
SELENIUM	1.9 U		2.0 U	3.0 U		4.6 U
SILVER	2.6		1.1 U	1.1 U		2.8 U
SODIUM	4860000 J		100000 J	105000 J		154000
THALLIUM	4.8 U		4.8 UJ	4.8 UJ		4.8 U
VANADIUM	1.2		6.0	5.8		11.7 U

TABLE 4-12 (PAGE 43 OF 49)
SUMMARY OF POSITIVE GROUNDWATER ANALYTICAL RESULTS FOR ZONE 1
LOWER SUBASE; NSB-NLON; GROTON, CONNECTICUT

SAMPLE NUMBER:	LS1GW13MW901-F	MW-13	LS1GWFOMW1301	LS1GWFOMW1301-F	MW-14	LS1GWFOMW1401
INVESTIGATION:	1997RI	FO89	1997RI	1997RI	FO89	1997RI
SAMPLE DATE:	11/12/97	07/12/89	11/12/97	11/12/97	07/12/89	11/10/97
LOCATION:	13MW9	FOMW13	FOMW13	FOMW13	FOMW14	FOMW14
VALIDATED:	VALIDATED		VALIDATED	VALIDATED		VALIDATED
FILTERING:	Filtered	Unfiltered	Unfiltered	Filtered	Unfiltered	Unfiltered
FIELD DUPLICATE OF:						
METALS (µg/L)						
ZINC	7.4 U		8.8 U	8.9 U		48.7
PETROLEUM HYDROCARBONS (µg/L)						
TPH			1000 U			16000 J
TPH-DIESEL-FUEL #2		97000			1100000	
WATER QUALITY PARAMETERS						
DISSOLVED OXYGEN (MG/L)			559.4 R			13.37
REDOX POTENTIAL (MV)			-136.3			-105.6
SALINITY (PPT)			0.43			0.53
SPECIFIC CONDUCTIVITY (MS/CM)			0.923			1.062
TEMPERATURE (C)			13.72			16.87
MISCELLANEOUS PARAMETERS						
ALKALINITY AS CACO3 (MG/L)			440			290
AMMONIA, AS NITROGEN (MG/L)			0.13 J			0.35
CHLORIDE (MG/L)			42			140
DIVALENT IRON (MG/L)			0			1
HARDNESS AS CaCO3 (MG/L)			310			190
METHANE (UG/L)			5.4 U			200
NITRATE, AS NITROGEN (MG/L)			1.5 J			0.47 J
PHOSPHORUS (MG/L)			0.10 U			0.98 J
SULFATE (MG/L)			39			58
TOTAL ORGANIC CARBON (MG/L)			25 J			180 J
TURBIDITY (NTU)			61.9			30.7
GENERAL CHEMISTRY						
PH			7.52			6.58

TABLE 4-12 (PAGE 44 OF 49)
SUMMARY OF POSITIVE GROUNDWATER ANALYTICAL RESULTS FOR ZONE 1
LOWER SUBASE; NSB-NLON; GROTON, CONNECTICUT

SAMPLE NUMBER:	LS1GWFOMW1401-F	MW-15	LS1GWFOMW1501	LS1GWFOMW1501-F	MW-16	LS1GWFOMW1601
INVESTIGATION:	1997RI	FO89	1997RI	1997RI	FO89	1997RI
SAMPLE DATE:	11/10/97	07/12/89	11/11/97	11/11/97	07/12/89	11/11/97
LOCATION:	FOMW14	FOMW15	FOMW15	FOMW15	FOMW16	FOMW16
VALIDATED:	VALIDATED		VALIDATED	VALIDATED		VALIDATED
FILTERING:	Filtered	Unfiltered	Unfiltered	Filtered	Unfiltered	Unfiltered
FIELD DUPLICATE OF:						
VOLATILES (µg/L)						
BENZENE		1 U			1 U	
ETHYLBENZENE		1 U			1 U	
TOLUENE		1 U			1 U	
XYLENES, TOTAL		1 U			1 U	
SEMIVOLATILES (µg/L)						
1,2,4-TRICHLOROBENZENE			11 U			12 U
1,3-DICHLOROBENZENE		1 U	11 U		1 U	12 U
2-METHYLNAPHTHALENE			11 U			12 U
4-METHYLPHENOL			11 U			12 U
ACENAPHTHENE			11 U			12 U
ACENAPHTHYLENE			11 U			12 U
ANTHRACENE			11 U			12 U
BIS(2-ETHYLHEXYL)PHTHALATE			11 U			12 U
BUTYLBENZYL PHTHALATE			11 U			12 U
CARBAZOLE			11 U			12 U
DI-N-BUTYL PHTHALATE			11 U			12 U
DI-N-OCTYL PHTHALATE			11 U			12 U
DIBENZOFURAN			11 U			12 U
DIETHYL PHTHALATE			11 U			12 U
FLUORANTHENE			11 U			12 U
FLUORENE			11 U			12 U
NAPHTHALENE			11 U			12 U
PHENANTHRENE			11 U			12 U
PHENOL			11 U			12 U

TABLE 4-12 (PAGE 45 OF 49)
SUMMARY OF POSITIVE GROUNDWATER ANALYTICAL RESULTS FOR ZONE 1
LOWER SUBASE; NSB-NLON; GROTON, CONNECTICUT

SAMPLE NUMBER:	LS1GWFOMW1401-F	MW-15	LS1GWFOMW1501	LS1GWFOMW1501-F	MW-16	LS1GWFOMW1601
INVESTIGATION:	1997RI	FO89	1997RI	1997RI	FO89	1997RI
SAMPLE DATE:	11/10/97	07/12/89	11/11/97	11/11/97	07/12/89	11/11/97
LOCATION:	FOMW14	FOMW15	FOMW15	FOMW15	FOMW16	FOMW16
VALIDATED:	VALIDATED		VALIDATED	VALIDATED		VALIDATED
FILTERING:	Filtered	Unfiltered	Unfiltered	Filtered	Unfiltered	Unfiltered
FIELD DUPLICATE OF:						
SEMIVOLATILES (µg/L)						
PYRENE			11 U			12 U
METALS (µg/L)						
ALUMINUM	84.3 U		59.6 U	10.0 U		10.0 U
ANTIMONY	2.5 U		2.5 U	2.5 U		2.5 U
ARSENIC	4.2 J		2.5 U	2.5 U		2.5 U
BARIUM	84.2		61.7	57.7		80.4
BERYLLIUM	0.19 U		0.11 U	0.11 U		0.11 U
CADMIUM	0.22 U		0.22 U	0.22 U		0.25 U
CALCIUM	66300		62600	58800		84400
CHROMIUM	3.1 U		0.68 U	0.76 U		0.72 U
COBALT	3.1		0.80 U	0.80 U		0.80 U
COPPER	14.8		2.6 U	1.8 U		15.6
IRON	2250		4670	4160		48.8 U
LEAD	2.4 J		1.3 U	1.3 U		1.3 U
MAGNESIUM	2710		6590	6170		6220
MANGANESE	221		84.7	81.9		11.5
MERCURY	0.04 U		0.02 U	0.03 U		0.02 U
NICKEL	9.8 J		1.0 J	1.1 J		2.1
POTASSIUM	8130		8420	8250		12700
SELENIUM	4.4 U		1.9 J	1.9 U		3.2 J
SILVER	2.8 U		1.1 U	1.1 U		1.1 U
SODIUM	155000		115000	106000		174000
THALLIUM	4.8 U		4.8 U	4.8 U		5.4 J
VANADIUM	3.6 U		0.72 J	0.67 J		0.55 U

TABLE 4-12 (PAGE 46 OF 49)
SUMMARY OF POSITIVE GROUNDWATER ANALYTICAL RESULTS FOR ZONE 1
LOWER SUBASE; NSB-NLON; GROTON, CONNECTICUT

SAMPLE NUMBER:	LS1GWFOMW1401-F	MW-15	LS1GWFOMW1501	LS1GWFOMW1501-F	MW-16	LS1GWFOMW1601
INVESTIGATION:	1997RI	FO89	1997RI	1997RI	FO89	1997RI
SAMPLE DATE:	11/10/97	07/12/89	11/11/97	11/11/97	07/12/89	11/11/97
LOCATION:	FOMW14	FOMW15	FOMW15	FOMW15	FOMW16	FOMW16
VALIDATED:	VALIDATED		VALIDATED	VALIDATED		VALIDATED
FILTERING:	Filtered	Unfiltered	Unfiltered	Filtered	Unfiltered	Unfiltered
FIELD DUPLICATE OF:						
METALS (µg/L)						
ZINC	9.8 U		8.6 U	5.1 U		23.4 U
PETROLEUM HYDROCARBONS (µg/L)						
TPH			1000 U			1000 U
TPH-DIESEL-FUEL #2		750000			21000	
WATER QUALITY PARAMETERS						
DISSOLVED OXYGEN (MG/L)			5.81			10.33
REDOX POTENTIAL (MV)			-106.4			-104.2
SALINITY (PPT)			0.49			0.51
SPECIFIC CONDUCTIVITY (MS/CM)			0.971			0.991
TEMPERATURE (C)			17.85			17.28
MISCELLANEOUS PARAMETERS						
ALKALINITY AS CACO3 (MG/L)			120			160
AMMONIA, AS NITROGEN (MG/L)			0.81			0.10 U
CHLORIDE (MG/L)			230			290
DIVALENT IRON (MG/L)			2.8			0
HARDNESS AS CaCO3 (MG/L)			170			220
METHANE (UG/L)			810			5.4 U
NITRATE, AS NITROGEN (MG/L)			0.39 J			1.4 J
PHOSPHORUS (MG/L)			0.14 J			0.25 J
SULFATE (MG/L)			4.8			29
TOTAL ORGANIC CARBON (MG/L)			16 J			31 J
TURBIDITY (NTU)			7.96			1.07
GENERAL CHEMISTRY						
PH			6.64			6.59

TABLE 4-12 (PAGE 47 OF 49)
SUMMARY OF POSITIVE GROUNDWATER ANALYTICAL RESULTS FOR ZONE 1
LOWER SUBASE; NSB-NLON; GROTON, CONNECTICUT

SAMPLE NUMBER:	LS1GWFOMW1601-F	011891-NESOMW4S	NESO4	NESO4	NESO4-2	NESO4-2
INVESTIGATION:	1997RI	PH1	PH2-1	PH2-1	PH2-2	PH2-2
SAMPLE DATE:	11/11/97	01/18/91	03/06/94	03/06/94	06/25/94	06/25/94
LOCATION:	FOMW16	NESO4	NESO4	NESO4	NESO4	NESO4
VALIDATED:	VALIDATED	VALIDATED	VALIDATED	VALIDATED	VALIDATED	VALIDATED
FILTERING:	Filtered	Unfiltered	Unfiltered	Filtered	Unfiltered	Filtered
FIELD DUPLICATE OF:						
VOLATILES (µg/L)						
1,1-DICHLOROETHANE		5 U	10 U		10 U	
BENZENE		5 U	10 U		10 U	
CARBON DISULFIDE		5 U	10 U		10 U	
ETHYLBENZENE		5 U	10 U		10 U	
STYRENE		5 U	10 U		10 U	
TOLUENE		5 U	10 U		10 U	
XYLENES, TOTAL		5 U	10 U		10 U	
SEMIVOLATILES (µg/L)						
1,2,4-TRICHLOROBENZENE			10 U		0.7 J	
1,3-DICHLOROBENZENE			10 U		0.5 J	
2-METHYLNAPHTHALENE			10 U		10 U	
4-METHYLPHENOL			10 U		10 U	
ACENAPHTHENE			0.6 J		10 U	
ACENAPHTHYLENE			10 U		10 U	
ANTHRACENE			10 U		10 U	
BENZOIC ACID			50 U		50 U	
BIS(2-ETHYLHEXYL)PHTHALATE			10 U		10 U	
BUTYLBENZYL PHTHALATE			10 U		10 U	
CARBAZOLE			10 U		10 U	
DI-N-BUTYL PHTHALATE			10 U		10 U	
DI-N-OCTYL PHTHALATE			10 U		10 U	
DIBENZOFURAN			10 U		10 U	
DIETHYL PHTHALATE			10 U		10 U	
FLUORANTHENE			10 U		10 U	

TABLE 4-12 (PAGE 48 OF 49)
SUMMARY OF POSITIVE GROUNDWATER ANALYTICAL RESULTS FOR ZONE 1
LOWER SUBASE; NSB-NLON; GROTON, CONNECTICUT

SAMPLE NUMBER:	LS1GWFOMW1601-F	011891-NESOMW4S	NESO4	NESO4	NESO4-2	NESO4-2
INVESTIGATION:	1997RI	PH1	PH2-1	PH2-1	PH2-2	PH2-2
SAMPLE DATE:	11/11/97	01/18/91	03/06/94	03/06/94	06/25/94	06/25/94
LOCATION:	FOMW16	NESO4	NESO4	NESO4	NESO4	NESO4
VALIDATED:	VALIDATED	VALIDATED	VALIDATED	VALIDATED	VALIDATED	VALIDATED
FILTERING:	Filtered	Unfiltered	Unfiltered	Filtered	Unfiltered	Filtered
FIELD DUPLICATE OF:						
SEMIVOLATILES (µg/L)						
FLUORENE			10 U		10 U	
NAPHTHALENE			10 U		10 U	
PHENANTHRENE			10 U		10 U	
PHENOL			10 U		10 U	
PYRENE			10 U		10 U	
METALS (µg/L)						
ALUMINUM	10.0 U	30 U	14 U	35.8 U	35.9	27.9 U
ANTIMONY	2.5 U	25 U	15 U	15 U	5 U	5.7 J
ARSENIC	2.5 U	3 U	2 U	2 U	2 U	2 U
BARIUM	80.5	15 U	15.8 U	15.7 U	14	14.1 J
BERYLLIUM	0.11 U	1 U	1 U	1 U	1 U	1 U
BORON		4.2 R	119	145	197	173 J
CADMIUM	0.22 U	2 U	20.9 J	2 UJ	7.9	1 U
CALCIUM	86300	19600	25800	24500	31500	32000
CHROMIUM	0.68 U	10.7 J	3 U	3 U	1 U	1.1 J
COBALT	0.80 U	5.4	4 U	4 U	1 U	1 U
COPPER	7.1	5 U	2 U	2 U	3 U	3.1 J
IRON	27.0 U	862	532	484	903	886
LEAD	1.3 U	2.3 J	1 UJ	1 UJ	2.5 J	2 UR
MAGNESIUM	6320	14200	17600	16800	23900	23700
MANGANESE	12.3	351	354	336	322	321
MERCURY	0.03 U	0.2 U	0.2 U	0.2 U	0.2 UJ	0.2 UJ
NICKEL	2.0	19.5 J	10 U	10 U	3 U	3 U
POTASSIUM	12400	10000	9850 J	9370 J	12200	12600

TABLE 4-12 (PAGE 49 OF 49)
SUMMARY OF POSITIVE GROUNDWATER ANALYTICAL RESULTS FOR ZONE 1
LOWER SUBASE; NSB-NLON; GROTON, CONNECTICUT

SAMPLE NUMBER:	LS1GWFOMW1601-F	011891-NESOMW4S	NESO4	NESO4	NESO4-2	NESO4-2
INVESTIGATION:	1997RI	PH1	PH2-1	PH2-1	PH2-2	PH2-2
SAMPLE DATE:	11/11/97	01/18/91	03/06/94	03/06/94	06/25/94	06/25/94
LOCATION:	FOMW16	NESO4	NESO4	NESO4	NESO4	NESO4
VALIDATED:	VALIDATED	VALIDATED	VALIDATED	VALIDATED	VALIDATED	VALIDATED
FILTERING:	Filtered	Unfiltered	Unfiltered	Filtered	Unfiltered	Filtered
FIELD DUPLICATE OF:						
METALS (µg/L)						
SELENIUM	3.1 J	1 U	3 UJ	3 UJ	2 U	2 UR
SILVER	1.1 U	7 U	2 U	2 U	2 U	2 U
SODIUM	163000	169000	191000	186000	239000 J	231000 J
THALLIUM	4.8 U	2 U	10 UJ	10 UJ	20 UJ	20 UR
VANADIUM	0.55 U	20 U	5 U	5 U	3.2	2.7
ZINC	23.9 U	12.6 J	6.2 U	3.9 U	14.2	7 U
PETROLEUM HYDROCARBONS (µg/L)						
TPH		3000 U	500 U		1000 U	
MISCELLANEOUS PARAMETERS						
HARDNESS AS CaCO3 (MG/L)			140		177	

TABLE 4-13

SUMMARY OF HISTORICAL AND LOWER SUBASE RI GROUNDWATER ANALYTICAL RESULTS - ZONE 1
LOWER SUBASE
NSB-NLON, GROTON, CONNECTICUT
PAGE 1 OF 4

Analyte	Historical Data[1]				Lower Subase RI[2]		
	Frequency of Detection	Concentration Range	Maximum Detection		Frequency of Detection	Concentration Range	Location of Maximum Detection
			Location	Investigation[3]			
VOLATILE ORGANICS (µg/L)							
1,1-Dichloroethane	1/31	3	13MW19	PH2-1	NA	NA	ND
Benzene	2/35	3	13MW2	PH2-1/PH2-2	NA	NA	ND
Carbon disulfide	4/31	1 - 3	13MW9	PH2-2	NA	NA	ND
Ethylbenzene	3/35	2 - 11	13MW19	PH2-1	NA	NA	ND
Styrene	1/31	2	13MW8	PH1	NA	NA	ND
Toluene	1/35	11	FOMW13	FO89	NA	NA	ND
Xylenes, total	3/35	8 - 44	13MW19	PH2-1	NA	NA	ND
SEMIVOLATILE ORGANICS (µg/L)							
1,2,4-Trichlorobenzene	1/21	0.7	NESO4	PH2-2	0/14	ND	ND
1,3-Dichlorobenzene	2/25	0.5	13MW3/NES04	PH2-2	0/14	ND	ND
2-Methylnaphthalene	5/21	1 - 47	13MW2	PH2-1	1/14	4	13MW2
4-Methylphenol	4/21	1 - 6	13MW3	PH2-2	1/14	2	13MW20
Acenaphthene	9/21	0.6 - 10	13MW2	PH2-1	4/14	0.9 - 7	13MW2
Acenaphthylene	1/21	1	13MW2	PH2-1	0/14	ND	ND
Anthracene	2/21	1 - 2	13MW2	PH2-1	1/14	2	13MW2
Benzoic acid	1/21	0.6	13MW1	PH2-1	0/14	ND	ND
Bis(2-Ethylhexyl)phthalate	3/21	0.8 - 3	13MW1	PH2-2	0/14	ND	ND
Butylbenzyl phthalate	0/21	ND	ND	ND	1/14	2	13MW2
Carbazole	3/21	1	13MW2/13MW20	PH2-1/PH2-2	1/14	0.6	13MW20
Di-N-butyl phthalate	2/21	0.6 - 1	13MW21	PH2-1	0/14	ND	ND
Di-N-octyl phthalate	0/21	ND	ND	ND	1/14	1	13MW2
Dibenzofuran	4/21	1 - 11	13MW2	PH2-1	2/14	1 - 8	13MW2
Diethyl phthalate	6/21	0.6 - 3	13MW1	PH2-1	5/14	0.6 - 1	13MW1/13MW18
Fluoranthene	4/21	0.7 - 2	13MW2	PH2-1	2/14	1 - 2	13MW2
Fluorene	5/21	1 - 15	13MW2	PH2-1	2/14	2 - 12	13MW2

TABLE 4-13

SUMMARY OF HISTORICAL AND LOWER SUBASE RI GROUNDWATER ANALYTICAL RESULTS - ZONE 1
LOWER SUBASE
NSB-NLON, GROTON, CONNECTICUT
PAGE 2 OF 4

Analyte	Historical Data[1]				Lower Subase RI[2]		
	Frequency of Detection	Concentration Range	Maximum Detection		Frequency of Detection	Concentration Range	Location of Maximum Detection
			Location	Investigation[3]			
Naphthalene	5/21	1 - 28	13MW2	PH2-1	1/14	23	13MW2
Phenanthrene	4/21	1 - 9	13MW2	PH2-1	2/14	2 - 9	13MW2
Phenol	1/21	28	13MW3	PH2-2	1/14	5	13MW20
Pyrene	6/21	0.5 - 1	13MW2/13MW9	PH2-1/PH2-2	3/14	0.6 - 2	13MW2
INORGANICS (μg/L)							
Aluminum	16/31	23.5 - 26100	13MW19	PH2-1	4/14	1370 - 14100	13MW21
Aluminum, filtered	7/21	20 - 18700	13MW19	PH2-1	3/14	1140 - 13400	13MW21
Antimony	0/31	ND	ND	ND	1/14	6.6	13MW20
Antimony, filtered	1/21	5.7	NESO4	PH2-2	2/14	2.6 - 8	13MW20
Arsenic	16/31	1.5 - 16.8	13MW21	PH2-1	5/14	3.4 - 12.4	13MW20
Arsenic, filtered	11/21	1.2 - 24.8	13MW19	PH2-1	4/14	4.2 - 11.3	13MW20
Barium	18/31	9.6 - 210	13MW5	PH1	13/14	3.5 - 136	13MW20
Barium, filtered	11/21	14.1 - 95	13MW18	PH2-1	12/14	9.4 - 138	13MW20
Beryllium	1/31	1.3	13MW19	PH2-1	0/14	ND	ND
Beryllium, filtered	1/21	1	13MW19	PH2-1	0/14	ND	ND
Boron	18/31	52 - 1430	13MW9	PH2-2	NA	NA	ND
Boron, filtered	18/21	50 - 1410	13MW9	PH2-2	NA	NA	ND
Cadmium	4/31	1.4 - 20.9	NESO4	PH2-1	0/14	ND	ND
Cadmium, filtered	0/21	ND	ND	ND	0/14	ND	ND
Calcium	30/31	4820 - 139000	13MW9	PH2-2	14/14	6380 - 207000	13MW9
Calcium, filtered	21/21	5730 - 138000	13MW9	PH2-2	13/14	6380 - 203000	13MW9
Chromium	5/31	5.1 - 11.6	13MW7	PH1	5/14	1.1 - 10.5	FOMW14
Chromium, filtered	6/21	1 - 9.3	13MW19	PH2-1	3/14	0.76 - 3.5	13MW20
Cobalt	3/31	5.4 - 8.2	13MW3	PH1	4/14	1.9 - 4.2	FOMW14
Cobalt, filtered	0/21	ND	ND	ND	3/14	1.4 - 3.1	FOMW14
Copper	10/31	2.6 - 68.4	13MW19	PH2-1	7/14	1.7 - 156	13MW20

TABLE 4-13

SUMMARY OF HISTORICAL AND LOWER SUBASE RI GROUNDWATER ANALYTICAL RESULTS - ZONE 1
LOWER SUBASE
NSB-NLON, GROTON, CONNECTICUT
PAGE 3 OF 4

Analyte	Historical Data[1]				Lower Subase RI[2]		
	Frequency of Detection	Concentration Range	Maximum Detection		Frequency of Detection	Concentration Range	Location of Maximum Detection
			Location	Investigation[3]			
Copper, filtered	8/21	2.3 - 44.2	13MW19	PH2-1	5/14	6.3 - 120	13MW20
Iron	30/31	43.1 - 11600	13MW2	PH1	12/14	316 - 8200	13MW2
Iron, filtered	19/21	127 - 7520	13MW2	PH2-1	9/14	470 - 8490	13MW2
Lead	14/31	2 - 39.3	13MW19	PH2-1	6/14	2.1 - 55.7	13MW20
Lead, filtered	3/21	7.7 - 13.5	13MW21	PH2-1	4/14	2.1 - 36.3	13MW20
Magnesium	27/31	129 - 443000	13MW9	PH2-2	13/14	1770 - 615000	13MW9
Magnesium, filtered	21/21	195 - 449000	13MW9	PH2-2	12/14	1750 - 609000	13MW9
Manganese	30/31	10.2 - 2290	13MW8	PH2-2	14/14	9.6 - 3540	13MW8
Manganese, filtered	20/21	8.4 - 1930	13MW8	PH2-2	13/14	8.3 - 3810	13MW8
Mercury	2/31	0.43 - 0.97	13MW19	PH2-1	2/14	0.24	13MW19/13MW20
Mercury, filtered	2/21	0.31 - 0.35	13MW21	PH2-1	1/14	0.2	13MW19
Nickel	12/31	10.4 - 27.2	13MW1	PH1	10/14	1 - 12.2	FOMW14
Nickel, filtered	0/21	ND	ND	ND	8/14	1 - 9.8	FOMW14
Potassium	30/31	2090 - 138000	13MW9	PH2-2	14/14	2680 - 194000	13MW9
Potassium, filtered	21/21	4120 - 141000	13MW9	PH2-2	13/14	2710 - 191000	13MW9
Selenium	2/31	1 - 22	13MW9	PH1	2/14	1.9 - 3.2	FOMW16
Selenium, filtered	0/18	ND	ND	ND	1/14	3.1	FOMW16
Silver	1/31	7.4	13MW8	PH1	4/14	1.6 - 3.4	13MW1
Silver, filtered	0/21	ND	ND	ND	2/14	1.2 - 2.6	13MW9
Sodium	30/31	14800 - 2980000	13MW9	PH2-2	14/14	38300 - 4950000	13MW9
Sodium, filtered	21/21	30100 - 3660000	13MW9	PH2-2	13/14	34600 - 4860000	13MW9
Thallium	0/31	ND	ND	ND	2/14	5.4	13MW3/FOMW16
Thallium, filtered	0/21	ND	ND	ND	0/14	ND	ND
Vanadium	9/31	3.2 - 689	13MW19	PH2-1	7/14	0.72 - 49.7	13MW19
Vanadium, filtered	7/21	1.5 - 593	13MW19	PH2-1	7/14	0.67 - 47.5	13MW21
Zinc	20/31	4 - 121	13MW19	PH2-1	3/14	48.7 - 60.6	13MW20

TABLE 4-13

SUMMARY OF HISTORICAL AND LOWER SUBASE RI GROUNDWATER ANALYTICAL RESULTS - ZONE 1
LOWER SUBASE
NSB-NLON, GROTON, CONNECTICUT
PAGE 4 OF 4

Analyte	Historical Data[1]				Lower Subase RI[2]		
	Frequency of Detection	Concentration Range	Maximum Detection		Frequency of Detection	Concentration Range	Location of Maximum Detection
			Location	Investigation[3]			
Zinc, filtered	6/21	3.4 - 20	13MW19	PH2-1	2/14	27.7 - 60.5	13MW18
TOTAL PETROLEUM HYDROCARBONS (μg/L)							
TPH	8/31	600 - 2100	13MW19	PH2-1	1/14	16000	FOMW14
TPH-Diesel-fuel #2	4/4	21000 - 1100000	FOMW14	FO89	NA	NA	ND

1 Includes samples 011591-13MW7S, 011591-1327S, 011591-13MW7S-D (field duplicate of 011591-13MW27S), 011691-13MW1S, 011691-13MW2S, 011691-13MW3S, 011791-13MW4S, 011791-13MW5S, 011791-13MW9S, 011891-NESOMW4S, 021191-13MW8, 13GW1, 13GW1-2, 13GW18-2, 13GW19-2, 13GW2, 13GW2-2, 13GW20-2, 13GW21-2, 13GW3, 13GW3-2, 13GW8, 13GW8-2, 13GW9, 13MW18, 13MW19, 13MW20, 13MW20-D (field duplicate of 13GW20-D), 13MW21, 13MW9-2, MW-13 (89), MW-14 (89), MW-15 (89), MW-16 (89), NES04, NES04-2.

2 Includes samples LS1GW13MW101, DUP005 (field duplicate of LS1GW13MW101), LS1GW13MW1801, LS1GW13MW1901, LS1GW13MW2001, LS1GW13MW201, LS1GW13MW2101, LS1GW13MW301, LS1GW13MW801, LS1GW13MW9, LS1GW13MW901, LS1GWFOMW13, LS1GWFOMW1301, LS1GWFOMW1401, LS1GWFOMW15, LS1GWFOMW1501, LS1GWFOMW16, LS1GWFOMW1601.

3 PH1 = Phase I RI; PH2-1 = Round 1 of Phase II RI; PH2-2 = Round 2 of Phase II RI; F089 = Hydrogeologic Investigation Underground Storage Tanks (1989).

4 NA - Not Analyzed.

5 ND - Not Detected.

TABLE 4-14

SUMMARY OF PHASE I GROUNDWATER FLUORESCENCE SPECTROSCOPY DATA - ZONE 1
LOWER SUBASE
NSB-NLON, GROTON, CONNECTICUT

Sample	Observations
13MW1S	Spectra is similar to waste oil/heavy residual fuel oil (i.e., No. 6 fuel oil) mixture.
13MW2S	Spectra is similar to waste oil/heavy residual fuel oil (i.e., No. 6 fuel oil)mixture.
13MW3S	Spectra is similar to waste oil/heavy residual fuel oil (i.e., No. 6 fuel oil) mixture.
13MW4S	Spectra is typical of No. 2 diesel oil.
13MW5S	Spectra is typical of waste lubricating oils.
13MW7S	Spectra is similar to diesel fuel/heavy residual fuel oil (i.e., No. 6 fuel oil) mixture.
13MW8S	Spectra is unresolved. Trace concentrations of petroleum hydrocarbons make oil identification by fluorescence impractical.
13MW9S	Spectra is unresolved. Trace concentrations of petroleum hydrocarbons make oil identification by fluorescence impractical.
NESOMW4S	Spectra is typical of residual fuel oil.

TABLE 4-15

SUMMARY OF NATURAL ATTENUATION AND WATER QUALITY PARAMETERS - ZONE 1
LOWER SUBASE RI
NSB-NLON, GROTON, CONNECTICUT

Analyte	Lower Subase RI[1]		
	Frequency of Detection	Concentration Range	Location of Maximum Detection
MISCELLANEOUS			
Alkalinity as CaCO3 (mg/L)	14/14	61 - 440	FOMW13
Ammonia, as nitrogen (mg/L)	13/14	0.13 - 1.7	13MW9
Chloride (mg/L)	14/14	40 - 5900	13MW9
Dissolved oxygen (mg/L)	9/9	0.74 - 13.37	FOMW14
Divalent iron (mg/L)	6/13	0.4 - 2.8	FOMW15
Hardness as CaCO3 (mg/L)	14/14	16 - 2600	13MW9
Methane (mg/L)	11/14	57 - 4100	13MW2
Nitrate, as nitrogen (mg/L)	12/14	0.056 - 1.5	FOMW13
pH	12/12	6.33 - 10.25	13MW21
Phosphorus (mg/L)	12/14	0.11 - 3.8	13MW21
Redox potential (mV)	10/10	-271.7 - -20.4	13MW1
Salinity (ppt)	12/12	0.17 - 14	13MW9
Specific conductivity (ms/cm)	12/12	0.354 - 23.17	13MW9
Sulfate (mg/L)	13/14	4.8 - 1400	13MW9
Temperature (C)	12/12	13.72 - 64.63	13MW21
Total organic carbon (mg/L)	14/14	1.6 - 180	FOMW14
Turbidity (NTU)	13/13	0.58 - 61.9	FOMW13

1 Includes samples LS1GW13MW101, DUP005 (field duplicate of LS1GW13MW101), LS1GW13MW1801, LS1GW13MW1901, LS1GW13MW2001, LS1GW13MW201, LS1GW13MW2101, LS1GW13MW301, LS1GW13MW801, LS1GW13MW901, LS1GWFOMW1301, LS1GWFOMW1401, LS1GWFOMW1501, and LS1GWFOMW1601.

TABLE 4-16

SUMMARY OF POSITIVE STORM SEWER SURFACE WATER ANALYTICAL RESULTS FOR ZONE 1 LOWER SUBASE; NSB-NLON; GROTON, CONNECTICUT

SAMPLE NUMBER:	BLD_89	BLD_89	BLD_89			
INVESTIGATION:	ST_SEWER	ST_SEWER	ST_SEWER			
SAMPLE DATE:	09/21/93	02/28/95	10/08/96	/ /	/ /	/ /
LOCATION:	BLD_89	BLD_89	BLD_89			
VALIDATED:						
FILTERING:	UNFILTERED	UNFILTERED	UNFILTERED			
FIELD DUPLICATE OF:						
METALS (µg/L)						
COPPER	570	23	100			
LEAD	310	64	90			
ZINC	620	120	500			
PETROLEUM HYDROCARBONS (µg/L)						
OIL & GREASE	4000	1500	1000 U			
MISCELLANEOUS PARAMETERS (mg/L)						
CHEMICAL OXYGEN DEMAND	64	8	56.3			
FECAL COLIFORM	40	100 U	11000			
NITRATE, AS NITROGEN	0.8	0.54	1.08			
PH	6.7	6.6	4.32			
TOTAL DISSOLVED SOLIDS	52					
TOTAL KJELDAHL NITROGEN	1.54	0.23	0.42			
TOTAL PHOSPHORUS	0.14	0.1	0.14			
TOTAL SUSPENDED SOLIDS	34	190	9			

TABLE 4-17

CHEMICALS OF CONCERN - ZONE 1
LOWER SUBASE
NSB-NLON, GROTON, CONNNECTICUT

Chemicals of Concern[1]		
Shallow Soil (0 - 5 Feet)	**All Soil (0 - 10 Feet)**	**Groundwater[2]**
Benzo(a)anthracene	Benzo(a)anthracene	Benzene
Benzo(a)pyrene	Benzo(a)pyrene	Acenaphthylene
Benzo(b)fluoranthene	Benzo(b)fluoranthene	Bis(2-ethylhexyl)phthalate
Benzo(k)fluoranthene	Benzo(k)fluoranthene	Phenanthrene
Carbazole	Carbazole	Aluminum
Chyrsene	Chyrsene	Antimony
Dibenzo(a,h)anthracene	Dibenzo(a,h)anthracene	Arsenic
Indeno(1,2,3-cd)pyrene	Indeno(1,2,3-cd)pyrene	Beryllium
Phenanthrene	Phenanthrene	Boron
Pyrene	Pyrene	Cadmium (unfiltered only)
Arsenic	Arsenic	Copper
Beryllium	Beryllium	Iron
Chromium (total)	Cadmium	Lead
Iron	Chromium (total)	Manganese
Manganese	Iron	Mercury
Mercury	Lead	Nickel
Nickel	Manganese	Selenium (unfiltered only)
TPH	Mercury	Silver
	Nickel	Sodium
	Silver	Thallium (unfiltered only)
	TPH	Vanadium
		Zinc (unfiltered only)
		TPH

1 Chemical is identified as a Chemical of Concern (COC) if the maximum detection in a single sample exceeds one or more criteria (i.e., Region III COC screening level, State Remediation Standards, Federal Soil Screening Levels, etc.).

2 Unless otherwise noted, the inorganic chemicals presented are COCs for the unfiltered and filtered groundwater sample matrix.

TABLE 4-18

EXPOSURE CONCENTRATIONS FOR DIRECT EXPOSURE CHEMICALS OF CONCERN - ZONE 1 LOWER SUBASE NSB-NLON, GROTON, CONNECTICUT

Direct Exposure Chemical of Concern	Exposure Concentration		
	Surface Soil[1] (mg/kg)	All Soil[1] (mg/kg)	Groundwater[2] (mg/L)
Volatile Organic Compounds			
Benzene	NA[3]	NA	0.003[5]
Semivolatile Organic Compounds			
Benzo(a)anthracene	2.9/21	3.0/21	NA
Benzo(a)pyrene	2.7/17	17[4]	NA
Benzo(b)fluoranthene	2.8/17	2.7/17	NA
Benzo(k)fluoranthene	NA	1.2/11	NA
Bis(2-ethylhexyl)phthalate	NA	NA	0.003[5]
Dibenzo(a,h)anthracene	0.70/5.2	0.73/5.2	NA
Indeno(1,2,3-cd)pyrene	2.1/12	2.0/12	NA
Metals			
Antimony	NA	NA	0.0061/0.0066[5]
Arsenic	5.2/12.3	2.7/12.3	0.0034/0.0092
Beryllium	0.13/0.2	0.17/0.40	0.00037/0.00062
Boron	NA	NA	0.208/1.22
Cadmium	NA	NA	0.0014/0.0099
Lead	NA	NA	0.0072/0.0368
Manganese	160/228	130/228	0.279/1.57
Mercury	27.8/83.4	12.0/83.4	NA
Selenium	NA	NA	0.0022/0.0086
Thallium	NA	NA	0.0028/0.0054
Vanadium	NA	NA	0.0263/0.252

1 UCL if single concentration is presented, otherwise average concentration is used for CTE and maximum detected concentration is used for RME unless otherwise noted. See Section 3.3.1.
2 Average concentration is used for CTE and maximum concentration is used for RME. Maximum is defined as the highest average concentration in a single well, and the average is defined as the overall average concentration of all well-specific averages.
3 NA - Not applicable. Chemical is not a chemical of concern for this medium.
4 Maximum concentration is presented since UCL is greater than maximum detected concentration.
5 Maximum concentration is presented since average concentration exceeds the maximum detected concentration.

TABLE 4-19

ESTIMATED RISKS [1] - ZONE 1
LOWER SUBASE
NSB-NLON, GROTON, CONNECTICUT

Exposure Route	Construction Worker		Full-Time Employee		Future Resident	
	RME[2]	CTE[3]	RME	CTE	RME	CTE
HAZARD INDEX						
Incidental Ingestion of Soil	0.72	0.019	0.19	0.016	0.50	0.021
Dermal Contact with Soil	0.02	0.0007	0.03	0.002	0.04	0.002
Total Risk from Soil	0.74	0.02	0.22	0.018	0.54	0.023
Dermal Contact with Groundwater	0.75	0.14	NA[4]	NA	NA	NA
Cumulative Risk:	1.49	0.16	0.22	0.018	0.54	0.023
INCREMENTAL CANCER RISK						
Incidental Ingestion of Soil	7.1E-06	7.5E-07	4.6E-05	4.8E-07	1.5E-04	7.5E-06
Dermal Contact with Soil	7.6E-06	6.8E-07	2.4E-04	7.5E-06	3.7E-04	1.5E-05
Total Risk from Soil	1.5E-05	1.4E-06	2.9E-04	8.0E-06	5.2E-04	2.3E-05
Dermal Contact with Groundwater	5.7E-08	2.5E-08	NA	NA	NA	NA
Cumulative Risk:	1.5E-05	1.5E-06	2.9E-04	8.0E-06	5.2E-04	2.3E-05

1 Chemical-specific risks presented in Appendix I.5.
2 RME - Reasonable Maximum Exposure.
3 CTE - Central Tendency Exposure.
4 NA - Not applicable; exposure route not evaluated for this receptor.

TABLE 4-20

SUMMARY OF MAJOR CONTRIBUTORS TO RISK - ZONE 1
LOWER SUBASE
NSB-NLON, GROTON, CONNECTICUT

Receptor	Chemical	Cancer Risk	Percent Contribution
Construction Worker - RME	Benzo(a)anthracene	1.1E-06	7%
	Benzo(a)pyrene	8.6E-06	59%
	Benzo(k)fluoranthene	5.6E-08	0%
	Dibenzo(a,h)anthracene	2.6E-06	18%
Construction Worker - CTE	Benzo(a)pyrene	1.3E-06	90%
Full-Time Employee - RME	Benzo(a)anthracene	2.1E-05	7%
	Benzo(a)pyrene	1.7E-04	61%
	Benzo(b)fluoranthene	1.7E-05	6%
	Dibenzo(a,h)anthracene	5.2E-05	19%
	Indeno(1,2,3-cd)pyrene	1.2E-05	4%
	Arsenic	8.6E-06	3%
Full-Time Employee - CTE	Benzo(a)pyrene	4.8E-06	2%
	Dibenzo(a,h)anthracene	1.3E-06	0%
Future Resident - RME	Benzo(a)anthracene	3.8E-05	7%
	Benzo(a)pyrene	3.1E-04	60%
	Benzo(b)fluoranthene	3.1E-05	6%
	Benzo(k)fluoranthene	2.0E-06	0.4%
	Dibenzo(a,h)anthracene	9.5E-05	18%
	Indeno(1,2,3-cd)pyrene	2.2E-05	4%
	Arsenic	2.0E-05	4%
Future Resident - CTE	Benzo(a)pyrene	2.1E-05	91%

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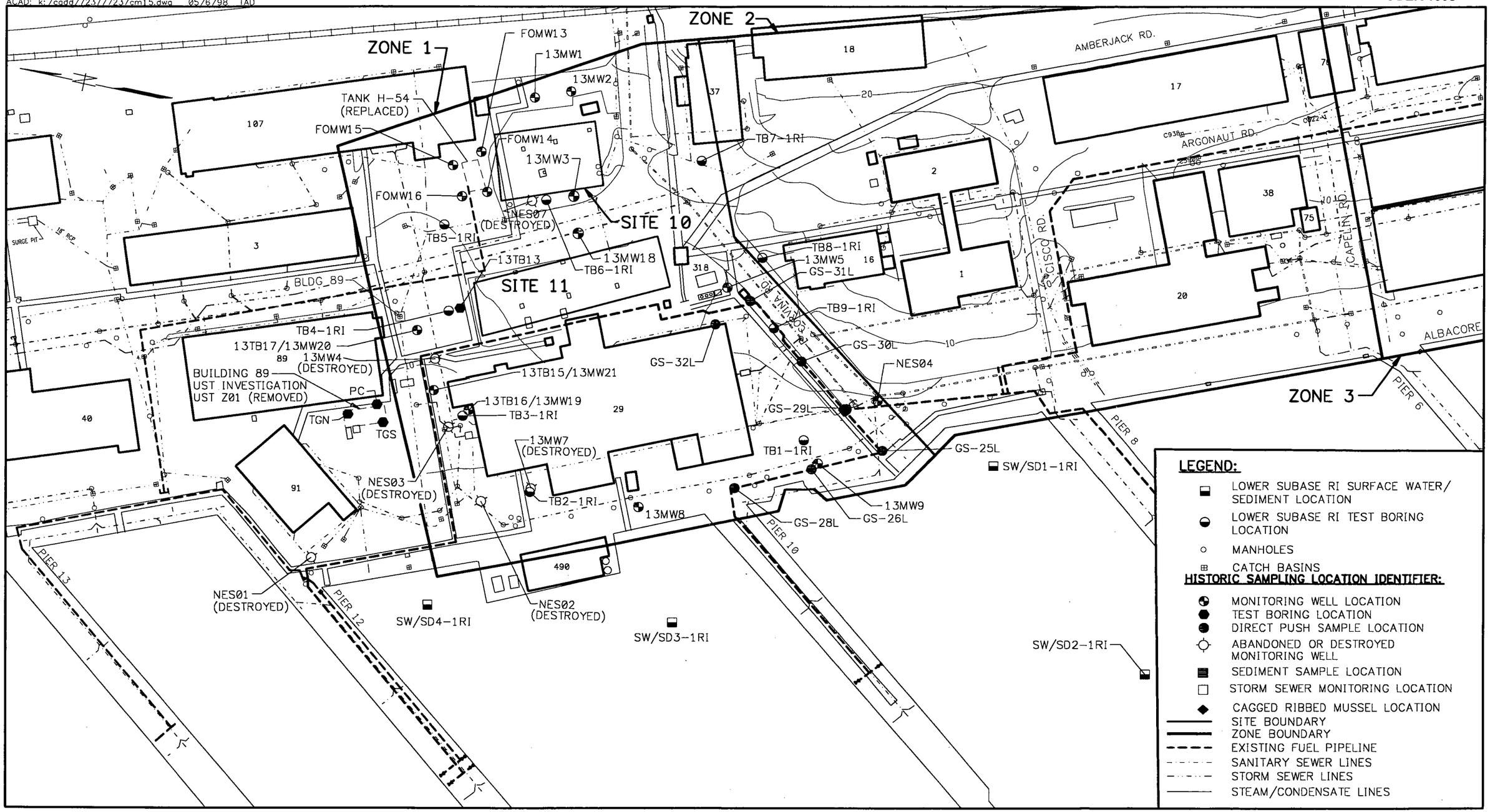

FIGURE 4-1

SAMPLE LOCATION MAP
ZONE 1
NSB-NLON, GROTON, CONNECTICUT

0 90 180
SCALE IN FEET

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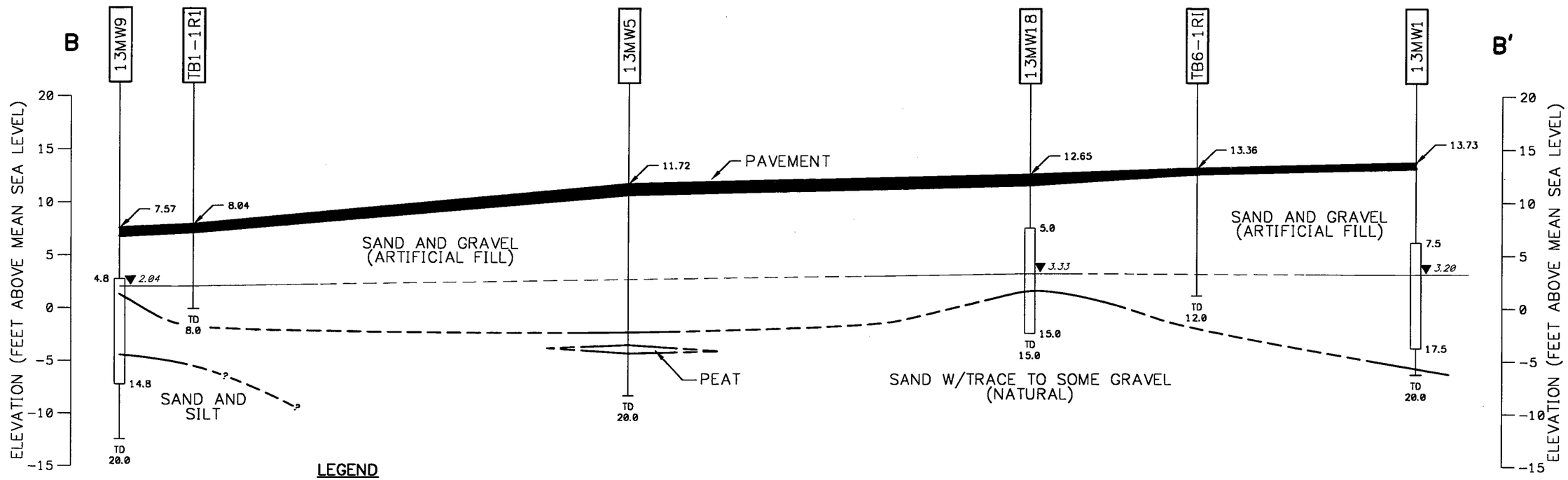
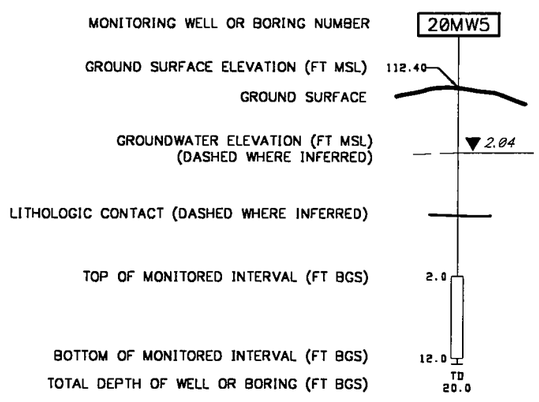
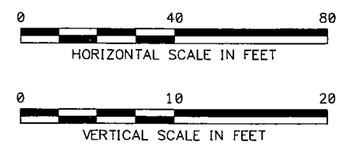


SOUTHWEST

NORTHEAST

LEGEND





NOTES

1.) ELEVATIONS BASED ON SUBASE VERTICAL DATUM (1982)

2.) POTENTIOMETRIC SURFACE FOR LOW TIDE OCTOBER 27, 1997

3.) SEE DRAWING 5 FOR CROSS SECTION LOCATION

NO.	DATE	REVISIONS	BY	CHKD	APPD	REFERENCES

DRAWN BY MF DATE 2/15/98
CHECKED BY DATE
COST/SCHED-AREA
SCALE AS NOTED

Brown & Root Environmental

GENERALIZED GEOLOGIC CROSS SECTION B – B'
ZONE 1
LOWER SUBASE RI
NSB-NLON, GROTON, CONNECTICUT

CONTRACT NO. 7237
OWNER NO. 0260
APPROVED BY Corey A. Reid DATE 10/7/98
APPROVED BY DATE
DRAWING NO. FIGURE 4-2
REV. 0

FORM CADD NO. SOUTH_BH.DGN - REV 0 - 02/11/97

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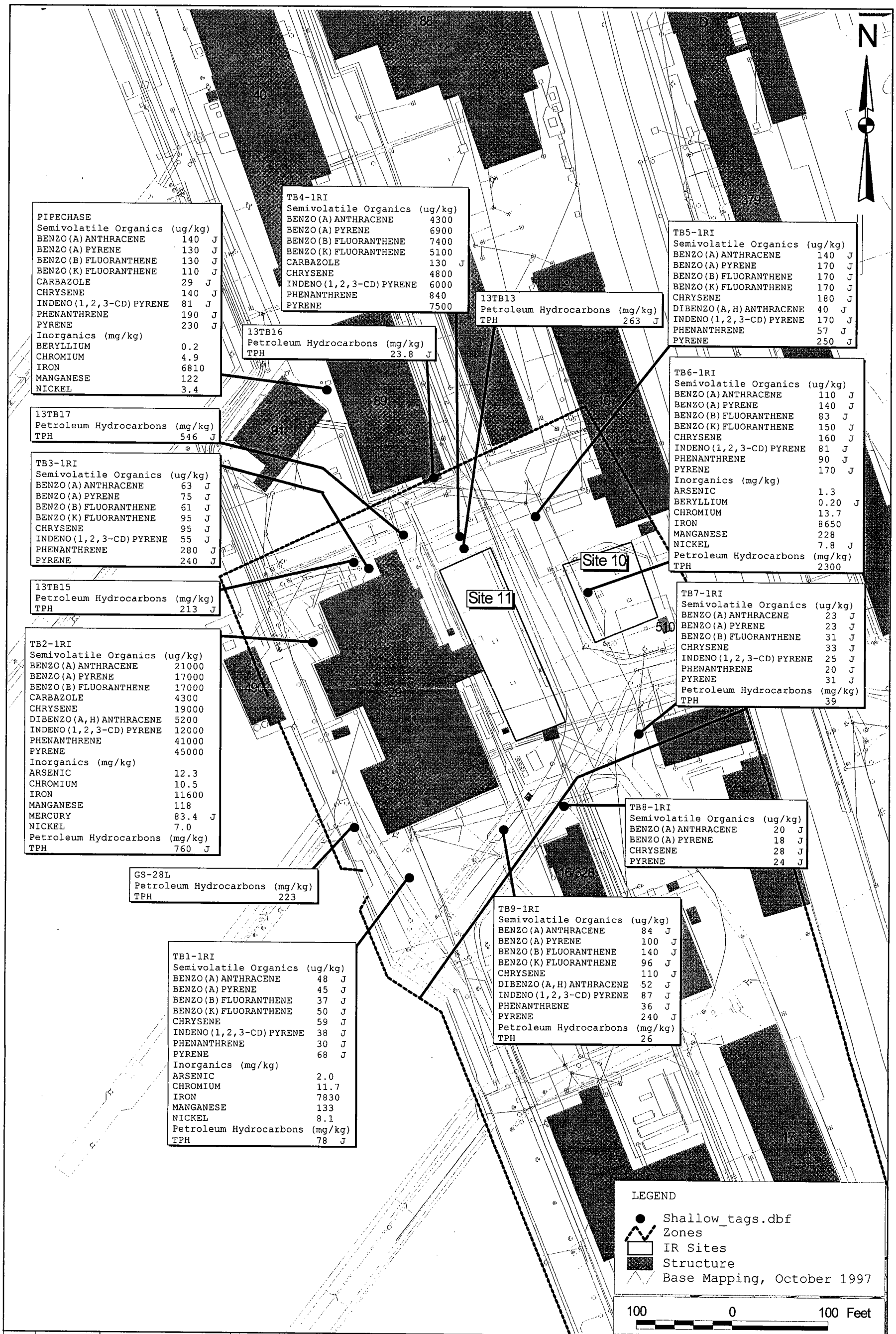

NO.	DATE	REVISIONS	DRAWN BY D. PERRY	DATE 17-FEB-98	Brown & Root Environmental	CONTRACT NO.	OWNER NO.
			CHECKED BY	DATE	ZONE 1 SHALLOW SOIL COPC POSITIVE DETECTS LOWER SUBASE RI NSB-NLON, GROTON, CONNECTICUT	APPROVED BY Cory A Rial	DATE 4/15/98
			COST/SCHED-AREA			APPROVED BY	DATE
			SCALE AS NOTED			DRAWING NO. FIGURE 4-3	REV. 0

019809/P

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CTO 0260

REVISION 1
OCTOBER 1998

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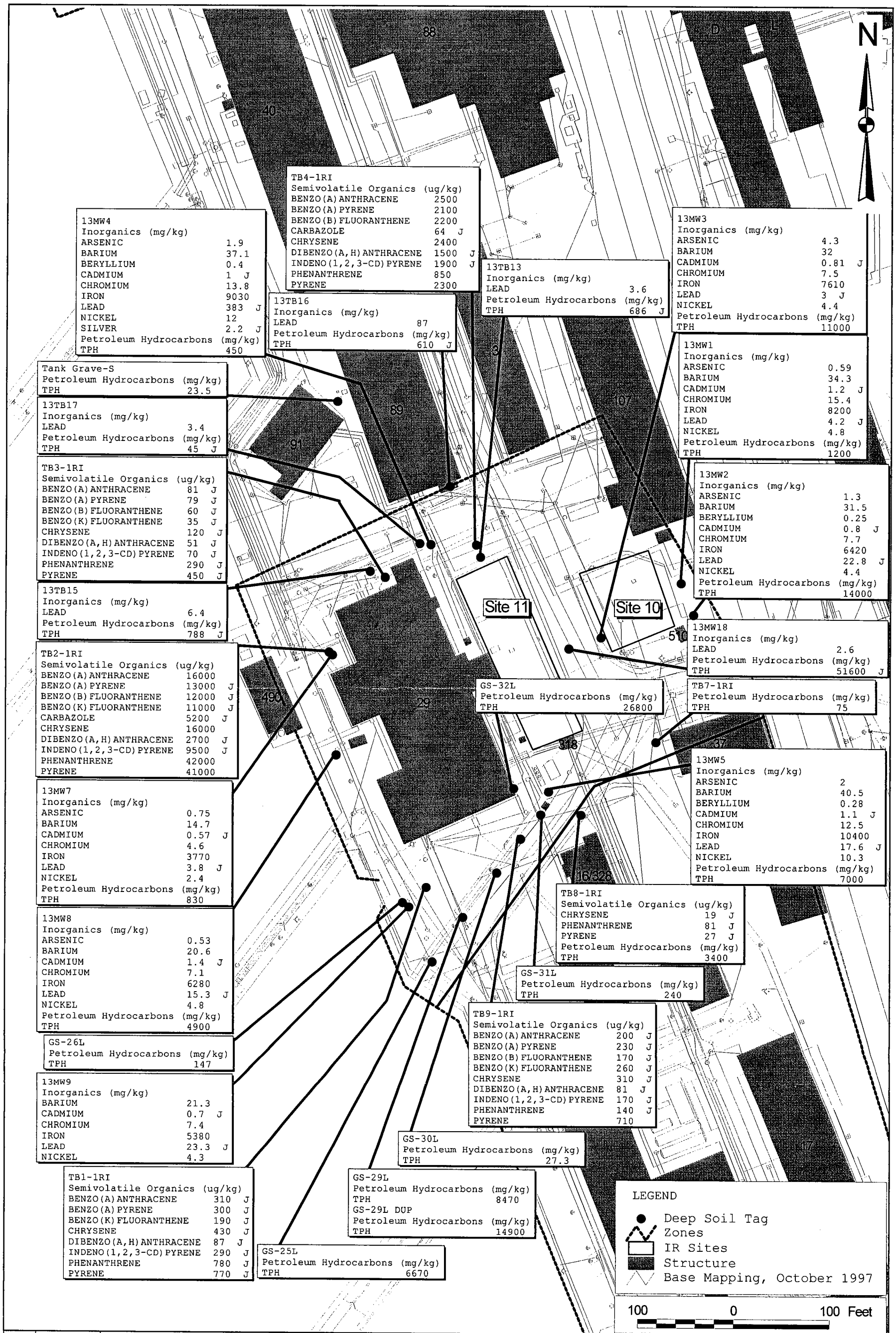

NO.	DATE	REVISIONS

DRAWN BY D. PERRY	DATE 24-FEB-98
CHECKED BY	DATE
COST/SCHED-AREA	
SCALE AS NOTED	

Brown & Root Environmental

ZONE 1 DEEP SOIL
COPC POSITIVE DETECTS
LOWER SUBASE RI
NSB-NLON, GROTON, CONNECTICUT

CONTRACT NO. | OWNER NO.

APPROVED BY Corey A Rail DATE 4/15/98

APPROVED BY DATE

DRAWING NO. FIGURE 4-4 REV. 0

019809/P

4-139

CTO 0260

REVISION 1
OCTOBER 1998

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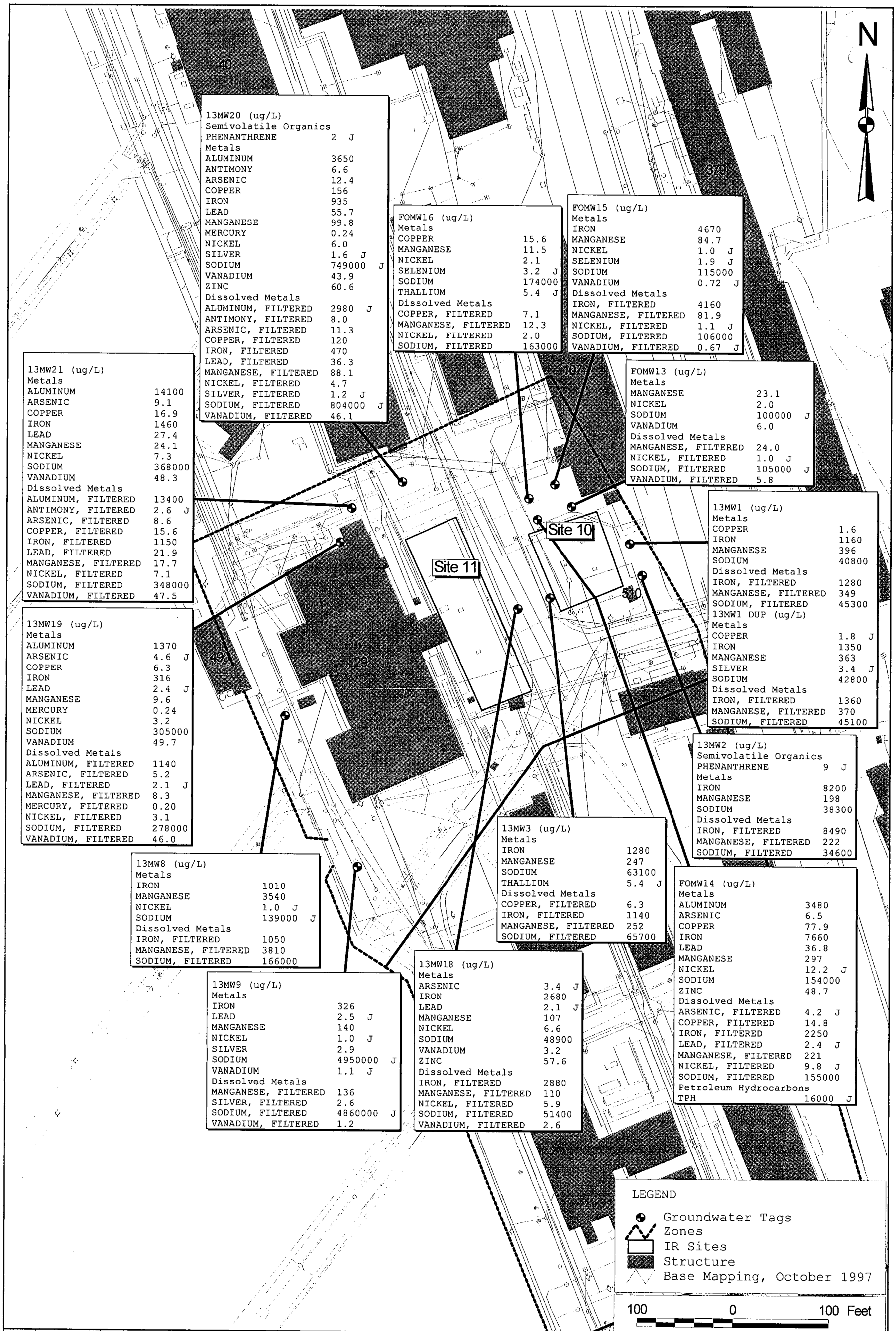

13MW20 (ug/L)

Semivolatile Organics		
PHENANTHRENE	2	J
Metals		
ALUMINUM	3650	
ANTIMONY	6.6	
ARSENIC	12.4	
COPPER	156	
IRON	935	
LEAD	55.7	
MANGANESE	99.8	
MERCURY	0.24	
NICKEL	6.0	
SILVER	1.6	J
SODIUM	749000	J
VANADIUM	43.9	
ZINC	60.6	
Dissolved Metals		
ALUMINUM, FILTERED	2980	J
ANTIMONY, FILTERED	8.0	
ARSENIC, FILTERED	11.3	
COPPER, FILTERED	120	
IRON, FILTERED	470	
LEAD, FILTERED	36.3	
MANGANESE, FILTERED	88.1	
NICKEL, FILTERED	4.7	
SILVER, FILTERED	1.2	J
SODIUM, FILTERED	804000	J
VANADIUM, FILTERED	46.1	

FOMW16 (ug/L)

Metals		
COPPER	15.6	
MANGANESE	11.5	
NICKEL	2.1	
SELENIUM	3.2	J
SODIUM	174000	
THALLIUM	5.4	J
Dissolved Metals		
COPPER, FILTERED	7.1	
MANGANESE, FILTERED	12.3	
NICKEL, FILTERED	2.0	
SODIUM, FILTERED	163000	

FOMW15 (ug/L)

Metals		
IRON	4670	
MANGANESE	84.7	
NICKEL	1.0	J
SELENIUM	1.9	J
SODIUM	115000	
VANADIUM	0.72	J
Dissolved Metals		
IRON, FILTERED	4160	
MANGANESE, FILTERED	81.9	
NICKEL, FILTERED	1.1	J
SODIUM, FILTERED	106000	
VANADIUM, FILTERED	0.67	J

13MW21 (ug/L)

Metals		
ALUMINUM	14100	
ARSENIC	9.1	
COPPER	16.9	
IRON	1460	
LEAD	27.4	
MANGANESE	24.1	
NICKEL	7.3	
SODIUM	368000	
VANADIUM	48.3	
Dissolved Metals		
ALUMINUM, FILTERED	13400	
ANTIMONY, FILTERED	2.6	J
ARSENIC, FILTERED	8.6	
COPPER, FILTERED	15.6	
IRON, FILTERED	1150	
LEAD, FILTERED	21.9	
MANGANESE, FILTERED	17.7	
NICKEL, FILTERED	7.1	
SODIUM, FILTERED	348000	
VANADIUM, FILTERED	47.5	

FOMW13 (ug/L)

Metals		
MANGANESE	23.1	
NICKEL	2.0	
SODIUM	100000	J
VANADIUM	6.0	
Dissolved Metals		
MANGANESE, FILTERED	24.0	
NICKEL, FILTERED	1.0	J
SODIUM, FILTERED	105000	J
VANADIUM, FILTERED	5.8	

13MW1 (ug/L)

Metals		
COPPER	1.6	
IRON	1160	
MANGANESE	396	
SODIUM	40800	
Dissolved Metals		
IRON, FILTERED	1280	
MANGANESE, FILTERED	349	
SODIUM, FILTERED	45300	

13MW1 DUP (ug/L)

Metals		
COPPER	1.8	J
IRON	1350	
MANGANESE	363	
SILVER	3.4	J
SODIUM	42800	
Dissolved Metals		
IRON, FILTERED	1360	
MANGANESE, FILTERED	370	
SODIUM, FILTERED	45100	

13MW19 (ug/L)

Metals		
ALUMINUM	1370	
ARSENIC	4.6	J
COPPER	6.3	
IRON	316	
LEAD	2.4	J
MANGANESE	9.6	
MERCURY	0.24	
NICKEL	3.2	
SODIUM	305000	
VANADIUM	49.7	
Dissolved Metals		
ALUMINUM, FILTERED	1140	
ARSENIC, FILTERED	5.2	
LEAD, FILTERED	2.1	J
MANGANESE, FILTERED	8.3	
MERCURY, FILTERED	0.20	
NICKEL, FILTERED	3.1	
SODIUM, FILTERED	278000	
VANADIUM, FILTERED	46.0	

13MW2 (ug/L)

Semivolatile Organics		
PHENANTHRENE	9	J
Metals		
IRON	8200	
MANGANESE	198	
SODIUM	38300	
Dissolved Metals		
IRON, FILTERED	8490	
MANGANESE, FILTERED	222	
SODIUM, FILTERED	34600	

13MW3 (ug/L)

Metals		
IRON	1280	
MANGANESE	247	
SODIUM	63100	
THALLIUM	5.4	J
Dissolved Metals		
COPPER, FILTERED	6.3	
IRON, FILTERED	1140	
MANGANESE, FILTERED	252	
SODIUM, FILTERED	65700	

13MW8 (ug/L)

Metals		
IRON	1010	
MANGANESE	3540	
NICKEL	1.0	J
SODIUM	139000	J
Dissolved Metals		
IRON, FILTERED	1050	
MANGANESE, FILTERED	3810	
SODIUM, FILTERED	166000	

FOMW14 (ug/L)

Metals		
ALUMINUM	3480	
ARSENIC	6.5	
COPPER	77.9	
IRON	7660	
LEAD	36.8	
MANGANESE	297	
NICKEL	12.2	J
SODIUM	154000	
ZINC	48.7	
Dissolved Metals		
ARSENIC, FILTERED	4.2	J
COPPER, FILTERED	14.8	
IRON, FILTERED	2250	
LEAD, FILTERED	2.4	J
MANGANESE, FILTERED	221	
NICKEL, FILTERED	9.8	J
SODIUM, FILTERED	155000	
Petroleum Hydrocarbons		
TPH	16000	J

13MW9 (ug/L)

Metals		
IRON	326	
LEAD	2.5	J
MANGANESE	140	
NICKEL	1.0	J
SILVER	2.9	
SODIUM	4950000	J
VANADIUM	1.1	J
Dissolved Metals		
MANGANESE, FILTERED	136	
SILVER, FILTERED	2.6	
SODIUM, FILTERED	4860000	J
VANADIUM, FILTERED	1.2	

13MW18 (ug/L)

Metals		
ARSENIC	3.4	J
IRON	2680	
LEAD	2.1	J
MANGANESE	107	
NICKEL	6.6	
SODIUM	48900	
VANADIUM	3.2	
ZINC	57.6	
Dissolved Metals		
IRON, FILTERED	2880	
MANGANESE, FILTERED	110	
NICKEL, FILTERED	5.9	
SODIUM, FILTERED	51400	
VANADIUM, FILTERED	2.6	

NO.	DATE	REVISIONS

DRAWN BY S. TABLER DATE 25-FEB-98
CHECKED BY DATE
COST/SCHED-AREA
SCALE AS NOTED

Brown & Root Environmental

ZONE 1 GROUNDWATER
COPC POSITIVE DETECTS
LOWER SUBASE RI
NSB-NLON, GROTON, CONNECTICUT

CONTRACT NO. OWNER NO.
APPROVED BY Corey A. Rail DATE 4/15/98
APPROVED BY DATE
DRAWING NO. FIGURE 4-5 REV. 0

019809/P

4-141

CTO 0260

REVISION 1
OCTOBER 1998

5.0 ZONE 2

5.1 SITE DESCRIPTION

Zone 2 extends from the southern boundary of Zone 1 along Corvina Road to Capelin Road just north of Building 31. The Providence and Worcester Railroad borders the eastern edge of Zone 2, and the Thames River lies to the west of it. With the exception of fuel oil distribution lines and steam, condensate, and electrical ducts, no sites have been identified within Zone 2. Figure 5-1 illustrates the zone boundaries, fuel oil distribution lines, steam and condensate lines, and sewer lines within Zone 2. Photographs of Zone 2 are provided in Appendix G.

5.1.1 Fuel Oil Distribution Lines and Utility Ducts

Fuel oil distribution lines and utility ducts and trenches run through Zone 2. A description of the fuel oil distribution system is provided in Section 1.4.1.3 and a description of the utility (steam, condensate, and electrical) ducts and trenches is provided in Section 1.4.1.4. The locations of the fuel distribution lines and the utility ducts are shown in Figure 5-1. In 1996, pressure testing was performed on the lines and valves in the fuel distribution system with Zone 2 to detect leaks. The results of this testing program are presented in Section 5.2.3.

5.1.2 Storm Sewers

As can be seen on Figure 5-1, two storm sewers discharge to the Thames River within Zone 2. Invert elevations for the storm sewer outfalls to the Thames River were not readily available; however, invert elevations for two catch basins upgradient of the outfalls were available. The invert elevations for the two catch basins were 1.43 feet msl (Catch Basin No. 520 on the south side of Building 20) and 5.55 feet msl (Catch Basin 554 on the north side of Building 20). These elevations were taken from the Navy drawing, *Utility Map, Storm Drainage* (Drawing Number 1142295, Sheet 2 of 19, July 27, 1967). The elevation of the Thames River fluctuates daily and seasonally, but the elevation of the river typically ranges between approximately 0.00 feet msl to 4.00 feet msl. Therefore, the storm sewer system will be submerged to varying degrees depending on the time of day and time of year. A typical cross-section for Zones 1 through 4, showing the storm sewer system and the variation in the tides, is provided on Figure 1-4 in Section 1.0.

5.2 SITE INVESTIGATIONS

Zone 2 was included in the following investigations:

- Oil Contamination of Groundwater at Subase New London (NESO, 1979)
- Phase I Remedial Investigation (Atlantic, 1992)
- Leak Testing Investigation for Fuel Oil Distribution System (Heitkamp, 1996)
- Existing Data Summary Report for Lower Subase Remedial Investigation (B&R Environmental, 1997a)
- Phase II Remedial Investigation (B&R Environmental, 1997b)
- Site Investigation Report for Tank Farm Investigation (B&R Environmental, 1997c)

No sampling or analysis of the stormwater discharging from Zone 2 is conducted under the Navy's NPDES permit. Therefore, no information is available for discussion.

5.2.1 Oil Contamination of Groundwater at Subase

In 1979, NESO conducted a study to identify the source and extent of oil found in soils along the Thames River at three sites at the Lower Subase. As part of the investigation, NESO drilled a total of 12 soil borings and installed piezometers in each boring. Soil samples collected from each boring were analyzed for oil content. Groundwater samples were collected from each piezometer to check for the presence of oil and, where oil was present, to measure product thickness.

Three borings/piezometers were installed during this study within Zone 2 (NESO5, NESO6, and NESO8). Sample locations are shown in Figure 5-1. Oil and grease content in soil ranged from 400 mg/kg to 14,100 mg/kg. Oil content in groundwater ranged from less than 10 mg/L to 150 mg/L.

5.2.2 Phase I Remedial Investigation

An investigation of 11 sites was completed at NSB-NLON by Atlantic Environmental Services from 1990 through 1992. One site, identified as the Lower Subase - Site 13, included the area represented by Zones 1 through 4.

The Lower Subase Phase I field investigation consisted of a utility manhole inspection and waterfront bulkhead inspection for evidence of contamination sources. Also included were a soil gas survey, test boring completion, monitoring well installation, and soil and groundwater sampling.

During the utility manhole inspection, manhole covers were removed and inspected for visual evidence of oil. Four areas of significant petroleum accumulation were observed during the manhole inspection. One of these areas, north of Building 16, was located within Zone 2. Thick black oil was noted on the western side of the manhole where conduits enter. Possible sources for the accumulation were noted as previous

product releases from underground fuel lines or storage tank leaks. The report indicated that there was no evidence of an ongoing release; the petroleum contamination appeared to be related to previous releases.

Inspection of the waterfront bulkhead was conducted by boat at low tide. During the waterfront inspection, no oil seeps or sheens or evidence of such were observed anywhere along the waterfront at the Lower Subase.

A shallow soil gas survey (at depths of 12 to 18 inches) was also conducted within Zones 1 through 4. The results for Zone 2 indicated high VOCs on the southwestern side of Building 18. However, this was likely a result of surface contamination. This area was further characterized by the subsurface investigation. Four soil borings, converted to monitoring wells (13MW6, 13MW10, 13MW11, and 13MW17), were installed within Zone 2 and are shown in Figure 5-1. Monitoring well 13MW6 was installed at the location where VOC contamination was detected during the soil gas survey. Soil and groundwater samples collected from the monitoring wells were analyzed for VOCs, inorganics, TPH, and fluorescence. In addition, an existing installed well (NESO6) was also sampled during the Phase I RI.

Based on TPH and fluorescence results, the area identified in the soil gas survey does not extend to the subsurface soil or to groundwater. The results do not indicate significant concentrations of TPH in the soil (TPH concentrations less than 200 mg/kg) or groundwater. Heavy residual fuel oil was identified in three of the monitoring wells; however, TPH was not detected in groundwater collected from any of the wells sampled within Zone 2.

5.2.3 Leak Testing Investigation for Fuel Oil Distribution System

In April and May 1996, Heitkamp performed pressure testing on the lines and valves in the fuel distribution system within Zone 2 to detect leaks. All sections of line and various valves tested in the portion of the distribution system within Zone 2 passed the leak testing procedures.

5.2.4 Site Investigation Report for Tank Farm Investigation

B&R Environmental conducted an investigation in 1995 of the UST farm along Crystal Lake Road. The primary objectives of the investigation were to define the extent of soil and groundwater contamination from the UST farm, evaluate the impact of the UST farm on the stormwater discharge, and recommend remedial alternatives, if needed. As part of the tank farm investigation, underground pipelines from the fuel loading dock (Pier 1), throughout a portion of the Lower Subase (Zones 1 through 4), and the gate valve (Building 322) to tanks within the tank farm were investigated. Soil samples were collected along

the new and old diesel underground pipeline at approximately 100-foot intervals. The samples were analyzed for TPH. The No. 6 fuel oil lines were not included as part of the investigation because they were installed within concrete-lined trenches, which would prevent or minimize any potential soil and groundwater impact from leaks. Seven samples were collected within Zone 2 (GS-14L through GS-18L, GS-22L, and GS-24L). Except the sample located north of Pier 8 (GS-22L), TPH concentrations were low (less than 100 mg/kg). Elevated TPH concentrations were detected north of Pier 8 (8210 mg/kg). Contamination was suspected to be associated with previous USTs located east of Building 29 (Zone 1).

The report recommended that additional integrity inspections be performed to determine the locations of previous line leaks on both active and inactive product lines throughout the Lower Subase. In addition, a records review was recommended to identify previous leaks based on the results of line inspections and tightness tests.

5.2.5 Phase II Remedial Investigation

B&R Environmental conducted a Phase II RI of 13 sites at NSB-NLON. The Lower Subase was included in this investigation. Soil boring installation and soil and groundwater sampling at Zone 2 were conducted as part of the investigation. Three soil samples were collected from three borings (13TB8, 13TB9, and 13TB11) and analyzed for lead, TPH, and TCLP metals. Groundwater samples were collected from five existing monitoring wells (13MW6, 13MW10, 13MW11, 13MW17, and NESO6). The groundwater samples were analyzed for VOCs, SVOCs, metals (total and dissolved), and TPH.

Analytical results for lead in the TCLP sample collected at 13MW11 in Zone 2 exceeded Federal TCLP regulatory levels. Lead was also the only chemical in Zone 2 found to exceed Connecticut GB pollutant mobility criteria.

The Phase II RI recommended that further characterization of the Lower Subase be performed during a separate RI. This characterization effort should emphasize evaluation of the nature and extent of lead, TPH, and SVOCs in soil. Continued groundwater sampling and analyses were also recommended, to monitor contamination levels. In addition, a focused data collection effort was recommended that would provide information relevant to an FS to evaluate potential remedial options for the site.

5.2.6 Existing Data Summary Investigation for Lower Subase

The Existing Data Summary Report for the Lower Subase RI was developed as part of the first tier of data collection to accumulate data from several studies, including the Phase II RI, and to identify potential data gaps that would then be filled in during the Lower Subase RI.

With respect to Zone 2, the Existing Data Summary Report recommended that further characterization to evaluate the nature and extent of contamination of TPH and SVOC concentrations in the soil be completed and the mobility of lead in deep soil be determined through sampling and analysis using the SPLP method. The report also recommended that further characterization activities at Zone 2 be coordinated with sediment sampling of the Thames River in the vicinity of Zone 2 to aid in the identification of source areas and contaminants of concern.

With respect to the fuel oil distribution lines, utility ducts, and storm sewers located in Zone 2, the report recommends that fuel line leak detection systems be evaluated to ensure against leakage, past and present fuel line leaks be identified and repaired, and utility ducts and trenches and storm sewers be inspected and repaired if necessary and any contaminated material found be removed.

5.2.7 Lower Subase Remedial Investigation

Seven test borings (TB1-2RI through TB7-2RI) were installed to the water table in Zone 2 using DPT. Boring locations are illustrated in Figure 5-1. Boring log sheets are provided in Appendix A. Two soil samples were collected from each boring from shallow (0 to 5 feet) and deep (greater than 5 feet) depths. SVOC analysis was performed on both shallow and deep samples at each test boring location. Shallow soil samples were analyzed for the presence of TPH at locations TB1-2RI, TB2-2RI, and TB3-2RI. TAL metals analysis was performed on deep soil samples from locations TB4-2RI, TB5-2RI, and TB6-2RI. SPLP lead analyses were performed on samples collected from TB5-2RI and TB6-2RI. Soil sample log sheets are included in Appendix B.1.

Groundwater samples were collected from five existing monitoring wells in Zone 2: 13MW6, 13MW10, 13MW11, 13MW17, and NES06. Groundwater samples were collected using low-flow purging and sampling techniques, as described in Section 2.3.2. Samples were analyzed for TPH, TCL SVOCs, filtered and unfiltered TAL metals and natural attenuation parameters. Groundwater sample log sheets and purge data sheets are provided in Appendix B.2.

Two sediment samples (SD1-2RI through SD4-2RI) were collected from locations in the Thames River along Zone 2. Sediment sampling locations are illustrated on Figure 5-1. Surface water quality measurements were taken from each sediment sampling location at the surface and the bottom of the water column. Sediment samples were analyzed for TCL SVOCs, TAL metals, TOC, grain size, AVS/SEM/, pH, and ammonia. Surface water quality parameters included temperature, salinity, turbidity,

pH, specific conductance, and dissolved oxygen. Sediment sample log sheets with surface water measurements are provided in Appendix B.3.

5.3 PHYSICAL CHARACTERISTICS

General physical characteristics of the Lower Subase are discussed in Sections 1.3 and 1.4. Site-specific physical characteristics for Zone 2 are discussed in the subsections following.

5.3.1 Topography and Surface Features

The ground surface of Zone 2 slopes gently to the Thames River, from an elevation of 20 to 25 feet along its eastern side to 8 feet along the waterfront. Approximately 90 to 95 percent of Zone 2 is paved or covered with buildings. The Providence and Worcester Railroad runs along the eastern border of the zone and the Thames River forms the western border.

5.3.2 Surface Water Features

Zone 2 is located along the Thames River. No other significant surface water features are located within or adjacent to Zone 2, with the exception of local storm sewers. Catch basins and storm sewers in Zone 2 are shown in Figure 5-1. From the drawing, it can be seen that three storm sewers within Zone 2 outlet to the Thames River. The storm sewers include the two along Cisco Road and the one along Capelin Road.

5.3.3 Soil Characteristics, Geology, and Hydrogeology

The soils of Zone 2 are mapped as Urban Land (USDA, 1983), and the surficial geology is mapped as artificial fill (USGS, 1960). A north-south cross-section of Zone 2 is illustrated in Drawing 7, and a west-east cross-section of Zone 2 is illustrated in Figure 5-2. Based on borings, Zone 2 is underlain by 5 to 18 feet of sand and gravel fill overlying fine to medium-grained sand or sand and silt. The fill thickens from approximately 16 feet below grade at well 13MW6 in the east to 20 feet below grade at 13MW10 along the river. The sand and sand and silt units are interpreted as natural stratified drift deposits. The bottom of the sand and silt unit was not encountered during boring installations, and its depth is unknown. Borings in Zone 2 were not advanced to bedrock, and the bedrock depth in Zone 2 is unknown. However, the USGS bedrock map (USGS, 1967) identifies the Mamacoke Formation underlying Zone 2, and the Phase II RI report (B&R Environmental, 1997b) estimates the bedrock to be more than 60 feet below msl (70 feet bgs).

The unconfined water table in Zone 2 lies within the sand and gravel fill and the sand unit underlying it. Depth to the water table ranges from approximately 4 to 5 feet bgs along the river to 18 feet bgs at 13MW6. Groundwater flow is generally west toward the Thames River at low tide (Drawing 3) and reverses along the river during high tide (Drawing 1). Groundwater in the eastern half of Zone 2 continues to flow west during high tide, but groundwater in the western half reverses and flows east, forming a groundwater low in the area of Building 1. Tidal influence is restricted to monitoring wells along the Thames River (NESO4, 13MW11, and 13MW17).

Based on slug tests conducted by Atlantic (1992) in Zone 2, the hydraulic conductivity of the sand and gravel fill ranges from 59 to 94 feet per day, with a geometric mean of 74 feet per day. The average hydraulic gradient across Zone 2 from 13MW6 to 13MW17 is 0.00318, based on water-level data obtained during low tide on October 27, 1997. The hydraulic gradient from 13MW6 to NESO6 is gradual (0.00003) but steepens from NESO6 to the river (0.06).

The volumetric rate of groundwater discharge through the sand and gravel fill material in Zone 2 to the Thames River was calculated to be 1,398 cubic feet per day, using Darcy's Law $Q = - KA(dh/dl)$, where Q = the volumetric discharge, K = the average hydraulic conductivity, A = the cross-sectional area (i.e., the saturated fill thickness by the width of the fill material along the Thames River), and dh/dl = the hydraulic gradient. An average saturated fill thickness of 12 feet and a width of 495 feet of fill along the Thames River in Zone 2 were assumed.

Generic contaminant loading rates for groundwater discharge into the Thames River from Zone 2 were generated using an estimated groundwater discharge rate (Q, discounting tidal effects) of 1,398 cubic feet/day; a 0.75 factor applied to this flux rate to account for the lack of groundwater discharge during periods of high tide (assumed to be about 6 hours/day over two tidal cycles); hypothetical solute concentrations (C) of 10, 100, and 1,000 μg/L; and, the following mass flux equation: Mass flux = Q x 0.75 x C. The corresponding daily discharge rates from Zone 2 into the Thames River are 0.00049, 0.0049, and 0.049 lbs/day for solute concentrations of 10, 100, and 1,000 μg/L, respectively. Actual discharge rates for individual dissolved constituents can be approximated by using these generic discharge rates and the average concentration of the constituent. For example, a compound present at an average concentration of 25 μg/L in groundwater would have a loading rate 2.5 times the generic rate calculated for a solute present at the 10 μg/L concentration. This loading estimate does not factor in retardation and degradation of solutes, which may be substantial in some cases and would reduce the loading rate.

5.4 NATURE AND EXTENT OF CONTAMINATION

This section is a discussion of the nature and extent of contamination of Zone 2 at the Lower Subase. Figure 1-2 displays all zones, including Zone 2, studied as part of the Lower Subase RI. Figure 5-1 provides more detail, including sampling locations, for Zone 2. As discussed in Section 5.2, soil and groundwater sampling were conducted at Zone 2 during the Phase I and Phase II RIs and the Lower Subase RI, as well as during the tank farm investigation. Tables 5-1 through 5-4 summarize the sampling and analytical programs for each investigation. Appendix H contains the complete database for Zone 2.

5.4.1 Soil

Positive analytical results for all soil samples collected from Zone 2 are presented in Table 5-5. Positive TCLP and SPLP results for Zone 2 soil samples are presented in Tables 5-6 and 5-7, respectively. A summary of the positive results for Zone 2 shallow (0 to 4 feet bgs) and deep (greater than 4 feet bgs) soil samples is provided in Table 5-8. Table 5-9 provides a summary of fluorescence spectroscopy data collected for Zone 2 soil samples during the Phase I RI (Atlantic, 1992).

Background concentrations of inorganics in soil, used below for comparison purposes, were taken from the Background Concentrations of Inorganics in Soil Report (Atlantic, 1995b). A tabular summary of these background values is presented in Section 1 on Table 1-4.

Figures 5-3 and 5-4 depict, for Zone 2 shallow and deep soil samples, respectively, the locations and concentrations of parameters that were detected in excess of COC selection criteria used in the risk assessment. Drawings 8 through 11 contained in Volume III of this report delineate TPH and lead concentrations in all zones, including Zone 2, being investigated as part of the Lower Subase RI. Drawings 8 and 9 depict TPH isoconcentration contours for shallow and deep soil, respectively. Drawings 10 and 11 show lead isoconcentration contours in shallow and deep soil, respectively.

5.4.1.1 Shallow Soil

Three Zone 2 shallow soil samples were analyzed for lead, and only one of these shallow soil samples was analyzed for the full list of TAL metals. This sample was collected from well 13MW11, located just south of Building 20. Concentrations of metals in this shallow soil sample were similar although generally lower than those found in deeper soils in Zone 2. As shown in Table 5-8, 19 metals were detected in this shallow soil sample. Concentrations of cadmium, calcium, lead, mercury, nickel, sodium, and zinc exceeded NSB-NLON background levels. Lead was detected in all three shallow soil samples at

concentrations ranging from 149 mg/kg to 178 mg/kg. Drawing 10 shows the distribution of lead in shallow soil samples within Zone 2.

TCLP extraction followed by RCRA metals analysis was performed for three Zone 2 shallow soil samples. Barium, cadmium, chromium, and lead were detected in the TCLP leachates. The concentration of lead in the TCLP leachate of the shallow soil sample collected from location 13MW11 exceeded both the Federal toxicity characteristic regulatory levels and Connecticut remediation standard pollutant mobility criterion for GB areas. TCLP concentrations of the remaining metals did not exceed any of the Federal or state criteria. SPLP extraction followed by metals analysis was not performed for any of the Zone 2 shallow soil samples.

VOCs were not detected in the single Zone 2 shallow soil sample analyzed for this analytical fraction. Seven shallow soil samples were analyzed for SVOCs. PAHs, carbazole, and diethyl phthalate were the only SVOCs detected in these shallow soils. As shown in Table 5-8, diethyl phthalate, which is a common laboratory contaminant, was only detected in two shallow soil samples and at concentrations of 22 μg/kg and 24 μg/kg. Concentrations of PAHs in Zone 2 shallow soil samples ranged from 18 μg/kg to 790 μg/kg. Benzo(a)anthracene, benzo(a)pyrene, benzo(b)fluoranthene, benzo(g,h,i)perylene, benzo(k)fluoranthene, chrysene, dibenzo(a,h)anthracene, fluoranthene, indeno(1,2,3-cd)pyrene, phenanthrene, and pyrene were detected in all seven shallow soil borings; the maximum concentrations were all detected in the shallow sample collected from boring TB2-2RI. The following PAHs were detected in from one to five shallow soil sample borings: 2-methylnaphthalene, acenaphthene, acenaphthylene, anthracene, fluorene, and naphthalene. In general, high molecular weight PAHs were detected more frequently and at greater concentrations than low molecular weight PAHs in the Zone 2 shallow soil samples. These findings indicate the presence of heavy fuel oils or tar/asphalt. A fuel oil distribution line is located near boring TB2-2RI. Therefore, PAH contamination in the area of boring TB2-2RI could be the result of former or current leaks in the fuel line.

TPH was detected in eight of nine Zone 2 shallow soil samples at concentrations ranging from 26.8 mg/kg to 856 mg/kg. The maximum TPH concentration (856 mg/kg) was detected in the shallow soil sample collected from location 13TB8, located near the southwestern side of Building 17 and next to the fuel pipeline along Argonaut Road. Drawing 8, which shows isoconcentration contours of TPH, indicates that there are areas of TPH contamination in shallow soil at the southern and western edges of Zone 2.

Fluorescence spectroscopy (Table 5-9) was performed on the shallow soil sample collected from location 13MW11 during the Phase I RI. Oil identification was not possible for this sample since only trace petroleum hydrocarbon concentrations were detected.

5.4.1.2 Deep Soil

Eight deep soil samples were analyzed for lead. Seven of these samples were also analyzed for the remaining TAL metals. A majority of the maximum concentrations of metals were detected in the deep soil sample collected from test boring TB4-2RI. Concentrations of metals in deep soil samples collected from Zone 2 were similar to concentrations of metals detected throughout the Lower Subase and in the Zone 2 shallow soil samples. Table 5-8 indicates that 18 metals were detected in Zone 2 deep soil samples. Concentrations of cadmium, calcium, lead, manganese, nickel, and sodium exceeded NSB-NLON background levels (Table 1-4). Lead was detected at a concentration of 404 mg/kg in the deep soil sample collected from boring 13TB11. This boring is located near Building 31 (in Zone 3), where remediation of lead-contaminated soil has been conducted. Concentrations of lead in the remaining Zone 2 deep soil samples range from 2 mg/kg to 14.6 mg/kg. Therefore, it is likely that the lead contamination in the vicinity of 13T11 is related to historic operations at Building 31 in Zone 3. Drawing 11 shows isoconcentration contours of lead concentrations measured in Zone 2 deep soil samples.

TCLP extraction followed by analysis for RCRA metals was performed on four deep soil samples. Barium was detected in all four of the TCLP leachates, lead was detected in two of the four leachates, and chromium and silver were each detected in one TCLP leachate. Only lead, at a concentration of 3.43 mg/L in the TCLP leachate of the deep soil sample from location 13TB11, exceeded the Connecticut pollutant mobility criterion for GB classified areas. None of the TCLP metals concentrations exceeded Federal toxicity characteristic regulatory levels.

SPLP extraction followed by analysis for lead was performed on three Zone 2 deep soil samples collected during the Lower Subase RI. Lead was detected in only one of the three SPLP leachates. The SPLP lead concentration did not exceed the Federal toxicity characteristic regulatory level or the Connecticut remediation standard pollutant mobility criterion for lead. The results of the recent SPLP analyses do not confirm the results of the historical TCLP analyses, which indicated a potential migration problem.

Methylene chloride, a common laboratory contaminant, and trichloroethene were detected at low concentrations (2 μg/kg and 1 μg/kg, respectively) in one of the three deep soil samples analyzed for VOCs. Several SVOCs, primarily PAHs, were detected in the deep soil samples. Concentrations of PAHs in deep soil samples ranged from 18 μg/k to 1,300 μg/kg. Pyrene was detected most frequently (in six of eight deep soil samples). Benzo(a)anthracene, benzo(a)pyrene, benzo(b)fluoranthene, chrysene, and fluoranthene were each detected in five of eight deep soil samples, and benzo(g,h,i)perylene, benzo(k)fluoranthene, indeno(1,2,3-cd)pyrene, and phenanthrene were each detected in four of eight

deep soil samples. The maximum concentrations of all the aforementioned PAHs were detected in the deep soil sample collected from boring TB3-2RI, located along the fuel pipeline near the northwestern corner of Zone 2. Seven additional PAHs were detected in from one to three deep soil samples. In general, high molecular weight PAHs were detected at greater concentrations and at greater frequencies than low molecular weight PAHs in Zone 2 deep soil samples. As noted for Zone 2 shallow soils, this is consistent with the presence of heavy fuel oils or tar/asphalt. Deep soil samples with positive results for these PAHs were collected near the fuel oil pipeline to Pier 8. The PAH concentrations detected in the deep soil sample collected from boring TB3-2RI were generally two to four times greater than the respective PAH concentrations detected in the shallow soil sample from this location. Conversely, PAH concentrations detected in the deep soil sample from the other Zone 2 sampling locations were generally less than the PAH concentrations detected in the shallow soil samples collected from the same locations.

TPH was detected in seven of 13 Zone 2 deep soil samples at concentrations ranging from 16.3 mg/kg to 8,210 mg/kg. The maximum TPH concentration was detected in the deep soil sample collected from location GS-22L, located near several fuel pipelines at the base of Pier 8. Drawing 9, which shows isoconcentration contours of TPH in deep soil, indicates that TPH contamination is not widespread in the deep soils within Zone 2.

Fluorescence spectroscopy was performed on three of the Phase I RI deep soil samples (Table 5-9). Oil identification was not possible for deep soil samples collected from locations 13MW10 and 13MW17 since only trace petroleum hydrocarbon concentrations were detected. However, spectra for the deep soil sample collected from location 13MW6 were similar to asphalt/tar spectra.

5.4.2 Groundwater

Positive results for all Zone 2 groundwater samples are presented in Table 5-10. Table 5-11 summarizes analytical results for groundwater samples collected from Zone 2 during historical investigations (i.e., prior to the Lower Subase RI) and during the Lower Subase RI. Table 5-12 summarizes fluorescence spectroscopy data for groundwater samples collected during the Phase I RI (Atlantic, 1992). Table 5-13 provides a summary of natural attenuation and water-quality parameters for Zone 2 groundwater samples; these data will be discussed in Section 5.5.3.

Figure 5-5 shows, for data collected during the Lower Subase RI only, the locations and concentrations of parameters that were detected in excess of COC selection criteria used during the risk assessment. Drawings 12 through 14 (Volume III) show the distribution of TPH and lead contamination in groundwater for all zones, including Zone 2, using data collected during the Lower Subase RI. Drawing 12 depicts

isoconcentration contours of TPH in groundwater, and Drawings 13 and 14 show lead isoconcentration contours for unfiltered and filtered groundwater, respectively (i.e., total and dissolved lead).

5.4.2.1 Historical Data

Table 5-11 indicates that 17 metals were detected in the historical unfiltered groundwater samples collected from Zone 2. Fifteen of 17 maximum concentrations were detected in groundwater samples collected from wells 13MW10 and 13MW11. Well 13MW10 is located at the northwestern corner of Building 20. Well 13MW11 is located south of Building 20. Most metals were infrequently detected; only boron, calcium, iron, lead, magnesium, potassium, sodium, and zinc were detected in at least half of the 18 unfiltered groundwater samples.

Lead was detected at a concentration of 23.2 µg/L in the unfiltered groundwater sample collected from well 13MW11, located in the southwestern section of Zone 2 near the Thames River at Pier 6. The source of this historical contamination is likely to be Building 31, located within Zone 3, where a removal action was undertaken.

Sixteen metals were detected in Zone 2 filtered groundwater samples. In general, concentrations of metals detected in Zone 2 filtered groundwater samples were similar but slightly lower than metals concentrations detected in Zone 2 unfiltered groundwater samples. A majority of the maximum metals concentrations were once again detected in groundwater samples collected from wells 13MW10 and 13MW11.

1,1,1-Trichloroethane, carbon disulfide, chloroform, tetrachloroethene, benzoic acid, and bis(2-ethylhexyl)phthalate were the only VOCs and SVOCs detected in groundwater samples collected from Zone 2. Each of these contaminants was detected in only one Zone 2 groundwater sample, with concentrations ranging from 0.8 µg/L to 3 µg/L.

TPH was detected at a concentration of 600 µg/L in groundwater samples collected from well 13MW6 and from well 13MW11. TPH was not detected in any of the other 16 historic groundwater samples; however, TPH reporting limits for the six groundwater samples collected during the Phase I RI ranged from 2,000 µg/L to 3,000 µg/L.

Fluorescence spectroscopy was performed for the Phase I RI groundwater samples. Resulting observations are summarized in Table 5-12. Oil identification was not possible for the groundwater sample from well 13MW11 since only trace petroleum hydrocarbon concentrations were detected. No

petroleum hydrocarbons were observed in the spectra for the groundwater sample from well 13MW6. However, spectra for groundwater samples collected from wells NESO6 and 13MW10 indicated the presence of heavy residual fuel oil, and spectra for the groundwater sample collected from well 13MW17 indicated the presence of a mixture of waste oil and heavy residual fuel oil (i.e., No. 6 fuel oil).

5.4.2.2 Lower Subase RI

Table 5-11 indicates that 16 metals were detected in the five unfiltered groundwater samples collected from Zone 2 during the Lower Subase RI. Barium, calcium, magnesium, manganese, potassium, and sodium were detected in all five unfiltered groundwater samples. Lead was detected in four of five unfiltered groundwater samples; a maximum concentration of 27.7 µg/L was detected in the unfiltered groundwater sample from well 13MW10. A majority of the maximum concentrations of both total and dissolved metals were detected in the groundwater samples collected from well 13MW10. In general, the concentrations of dissolved metals in Zone 2 groundwater samples were less than the concentrations of total metals. The maximum concentration of lead detected in the recent groundwater samples collected from well 13MW11 is 2.7 µg/L. This indicates that the impact of the lead contamination from Building 31 (Zone 3) on the southwestern corner of Zone 2 may be lessening with time. The distribution of lead in the groundwater system beneath Zone 2, based on concentrations of lead detected in unfiltered and filtered groundwater samples collected during the Lower Subase RI, is depicted in Drawings 13 and 14, respectively.

Zone 2 groundwater samples collected during the Lower Subase RI were not analyzed for VOCs. Butylbenzyl phthalate, di-n-butyl phthalate, and di-n-octyl phthalate were each detected in only one of five Zone 2 groundwater samples. These SVOCs, which are all common laboratory contaminants, were detected at concentrations ranging from 0.9 µg/L to 3 µg/L.

TPH was not detected in any of the five groundwater samples collected during the Lower Subase RI. Based on the sensitivity of the method used for analysis, the reporting limits for TPH were greater than the Connecticut remediation criterion of 500 µg/L. The presence of TPH below the reporting limits could not be confirmed since TPH at concentrations less than the reporting limits would not have been reported. Based on convention, one-half the TPH reporting limit for each groundwater sample is shown on Drawing 12. The values provided on Drawing 12 (500 µg/L to 600 µg/L) for Zone 2 groundwater samples are equal to or slightly greater than the Connecticut remediation criteria of 500 µg/L.

5.4.3 Surface Water/Sediment

Surface water and sediment samples were collected from the Thames River adjacent to Zone 2. The nature and extent of contamination in Thames River surface water and sediment samples, as well as the impact of the activities and contamination at the Lower Subase (including Zone 2) on Thames River surface water and sediments, are discussed in Section 11.4.

5.5 CONTAMINANT FATE AND TRANSPORT

5.5.1 General Contaminant Fate and Transport Processes

The major area of concern for Zone 2 is impacted soil, as evidenced by detection of TPH (which is comprised of PAHs and other compounds). Zone 2 soil also contains lead and several other metals (cadmium, calcium, manganese, mercury, nickel, silver, sodium, and zinc) at elevated concentrations relative to background concentrations.

PAHs are generally considered to be fairly immobile in the environment. As noted in Section 3.3.2.4, PAHs have very low solubilities, vapor pressures, and Henry's Law constants, and high K_{oc}s and K_{ow}s. The low-molecular weight PAHs (e.g., acenaphthene, anthracene, fluorene, phenanthrene) are more mobile (higher solubilities, etc.) than the high-molecular-weight PAHs (e.g., benzo(a)pyrene, benzo(a)anthracene, chrysene, etc.). PAHs in soil are much more likely to bind to soil and be transported via mass transport mechanisms than go into solution. PAHs can be degraded via aerobic bacteria, but may be relatively persistent in the absence of microbial population or macronutrients such as phosphorous and nitrogen.

Within Zone 2, TPH, as well as the PAHs, were found in both shallow and deep soils. The presence of these compounds at higher concentrations at depth appears to be related more to leakage from the fuel pipelines in the area than from downward migration of the compounds from the surface. The highest concentrations of TPH in deep soils are located in the immediate vicinity of the fuel pipelines in the northwest corner of Zone 2. There is also a possibility that the contamination in this area is a result of contaminants migrating from Zone 1. The highest concentrations of TPH in the shallow soils were found along the quay wall and along the boundary with Zone 3.

PAHs were not detected in any of the groundwater samples at Zone 2. As noted above, PAHs have very low solubilities and generally do not enter into solution. The data confirm that PAHs have not migrated into the groundwater in Zone 2.

As noted in Section 3.3.2.9, metals are highly persistent environmental contaminants. They do not biodegrade, photolyze, hydrolyze, etc. The major fate mechanisms for metals are adsorption to the soil matrix (as compared to being part of the soil structure) and bioaccumulation.

In addition, under normal conditions, metals are not very mobile in the environment. Because metals frequently remain bound to particulate matter, the major transport mechanism for metals is bulk movement processes (erosion). However, metals can become mobile in the environment under certain conditions. The mobility of metals is influenced primarily by their physical or chemical properties in conjunction with the physical and chemical properties of the soil matrix. Factors that assist in predicting the mobility of metals are the soil/pore water pH, REDOX potential, and cation exchange capacity. The mobility of metals generally increases with decreasing soil pH and cation exchange capacity. The effect of REDOX potential varies for each metal.

Within Zone 2, metals were detected in shallow soil samples and deep soil samples at elevated levels. The presence of metals in the soil samples may be indicative of the fill material used to construct the Lower Subase. However, the presence of lead in deep soil samples and groundwater samples is more likely the result of handling of lead batteries used in submarines for underwater propulsion until the 1950's. Because of the low pH acid present in the batteries, the lead in the batteries would have been extremely mobile, and if the batteries had been spilled on the ground surface, the lead would have migrated much farther than under normal conditions.

The concentrations of lead in the shallow soil samples were generally higher than the concentrations in the deep soil samples, indicating that migration of lead has not occurred to a great extent. The highest concentration of lead in a deep soil sample was detected in the sample collected from 13TB11, which is located in the southwestern corner of Zone 2 near Building 31. Because the concentration of lead detected in the deep sample in this area was higher than the concentration of lead in the shallow soil sample in this area, it appears that the lead detected in the deep soil in this area may be related to activities that occurred historically at Building 31 (Zone 3).

Because the use of the lead acid batteries was discontinued in the 1950's, it is likely that the pH of the media in the area of Zone 2 has increased to its present level (groundwater pH between 6.22 and 6.76 and soil pH unknown). In soil with a pH of 6 to 8, lead may form insoluble organic lead complexes, or if the soil has less organic matter at the same pH, hydrous lead oxide complexes may form or lead may precipitate out with carbonate or phosphate ions. As long as the pH in the soil remains above 6, the lead present in the soil may continue to be relatively immobile and the lead concentration in the groundwater may decrease over time as it is flushed out.

Another factor that may be limiting the concentration of contaminants in the groundwater is the presence of paving over most of the site. The paving serves to limit the amount of infiltration passing through the soil. With limited infiltration, the amount of contaminants that can be leached out of the soil and transported to the groundwater is minimized.

5.5.2 Effects of Cross Contamination on Other Zones and the Thames River

TPH is an indicator of petroleum hydrocarbons contamination. PAHs are the primary components of fuel oils such as No. 2 and No. 6, which are used throughout the Lower Subase. The TPH contamination detected at the site is therefore assumed to be comprised mainly of PAHs and other SVOCs. As shown in Drawing 8, concentrations of TPH are highest in shallow soil adjacent to the quay wall throughout Zone 2 and along the boundary with Zone 3. The elevated levels of TPH in surface soil along the Zone 3 boundary may be the result of migration of petroleum hydrocarbons from Zone 3. In deep soil (Drawing 9), concentrations of TPH are highest in the northwestern corner of Zone 2 near the fuel pipeline. Some of the contamination in Zone 2 deep soil may be the result of contaminant migration from Zone 1, although the majority is most likely due to leakage from the fuel pipeline.

SVOCs (mainly PAHs) were detected in shallow and deep soil at Zone 2. VOCs and phthalates were detected infrequently in groundwater samples from Zone 2. During the latest sampling round, neither PAHs nor TPH were detected in any of the groundwater samples collected from Zone 2. PAHs were detected in Thames River sediment samples collected from locations near Zone 2. Concentrations of PAHs in soil samples were less than those detected in sediment samples. Also, concentrations of PAHs in Zone 2 sediment samples are generally higher than those detected in sediment samples collected upstream and downstream of the Lower Subase. This suggests that migration of PAHs to the Thames River may have occurred.

Inorganics have been detected in soil, groundwater, and sediment samples collected from Zone 2. Concentrations of some inorganics (cadmium, calcium, lead, manganese, mercury, nickel, sodium, and zinc) in shallow and/or deep soil exceeded background levels. Concentrations of all inorganics in sediment samples exceed background levels. This suggests that migration of inorganics in soils at Zone 2 has occurred.

As shown on Drawings 10 and 11, lead was detected at concentrations exceeding background levels in shallow and deep soils. An area of elevated lead concentrations in deep soil is observed in the vicinity of the quay wall along the border with Zone 3. This "hot spot" appears to be the result of the migration of

lead from Zone 3. Concentrations of total and dissolved lead detected in groundwater are shown on Drawings 13 and 14, respectively. The results indicate that lead does not appear to be significantly migrating in the groundwater. In addition, comparison of the total lead concentrations with the dissolved lead concentrations indicate that the lead present in the groundwater is more likely related to the amount of suspended solids in the unfiltered samples (analyzed for total lead).

As discussed in Section 5.1.2, the Zone 2 storm sewer system is submerged by groundwater to varying degrees depending on the time of day and time of year. There are two discharge points for the Zone 2 storm sewer system to the Thames River. Therefore, if the storm sewer system is deteriorated and leaks, groundwater containing dissolved phase contaminants (e.g., lead) could infiltrate into the system and be carried to the Thames River. However, this transport pathway is not considered to be as significant as bulk contaminant transport via direct discharge of groundwater to the Thames River.

There may be other off-property sources of contamination contributing to the contamination detected in Thames River sediments. The Thames River is tidally influenced, and contaminants may be migrating in the river from other upstream and downstream sources. Also, the contamination may be a result of spillage that occurred during historical refueling of submarines and tugboats at the Lower Subase.

5.5.3 Evaluation of Natural Attenuation Data

Soil and groundwater samples were collected in Zone 2 and analyzed in the field or by a fixed-base laboratory. The resulting data provide the information necessary to answer the three following questions:

- Are contaminants present in either media that could be remediated via natural attenuation or bioremediation?
- Is natural attenuation currently in progress in the groundwater?
- Are the conditions in the groundwater favorable for natural attenuation or bioremediation?

For Zone 2, TPH concentrations in soil and groundwater were contoured and the results are presented on Drawings 8, 9, and 12. Drawings 8 (shallow soil) and 9 (deep soil) show that moderate to high levels of TPH (i.e., indicative of petroleum hydrocarbons) are present in the soil of Zone 2. The maximum TPH concentrations were detected in 13TB8 (856 mg/kg, shallow soil) and GS-22L (8,210 mg/kg, deep soil). As discussed in Section 5.4, PAHs were frequently detected in the shallow and deep soil, which confirms the TPH concentrations. In addition, one chlorinated solvent, trichloroethene, was detected in the deep soil only. TPH was not detected in the groundwater of Zone 2. VOCs and SVOCs were detected infrequently (e.g., 1 of 18 and 1 of 17, respectively) in the groundwater. Therefore, petroleum

hydrocarbons seem to be generally fixed in the soil matrix and not migrating in significant amounts to the groundwater. As discussed previously, petroleum hydrocarbons in either media can be treated successfully via natural attenuation or bioremediation.

The procedure for evaluating natural attenuation data for groundwater was previously outlined in Section 3.3.4 and is followed in this section. Table 5-13 summarizes the parameters that were measured to determine if natural attenuation is occurring in the groundwater of Zone 2. Other information in the table includes parameter-specific concentration ranges and frequency of detections. Drawings showing the distribution of key parameters were also prepared to aid in the interpretation of the data. The drawings that were prepared include the following:

- Drawing 1 - High Tide Potentiometric Surface Map
- Drawing 3 - Low Tide Potentiometric Surface Map
- Drawing 15 - Dissolved Oxygen
- Drawing 16 - REDOX potential
- Drawing 17 - Divalent Iron
- Drawing 18 - Specific Conductivity

The following conclusions were reached after review and evaluation of the data presented in Table 5-13 and Drawings 1, 3, and 15 through 18.

- Limited dissolved oxygen data (3 values) were available for Zone 2. All measured concentrations were greater than 1 mg/L, but the measured concentrations varied significantly within the zone, with one measurement (12.67 mg/L at 13MW17) near the saturated concentration for groundwater. Monitoring well 13MW17 was sampled on a different day than 13MW10 and 13MW11. The high dissolved oxygen level measured in 13MW17 may be related to the faulty probe discussed in Section 4. The results are therefore ambiguous.

- REDOX potential measurements indicated that both aerobic (REDOX potential at 13MW17 of 127.4 mV > 50 mV) and anaerobic (REDOX potential of –105.1 mV < 50 mV) regions are present in Zone 2. The REDOX potential results do not correlate well with the dissolved oxygen readings. As discussed in Section 4, REDOX potential is easier to measure in the field and it is likely that the REDOX potential measurements are more representative of the actual Zone 2 groundwater conditions than are the dissolved oxygen concentrations.

- Measured concentrations of nitrate were all above 1 mg/L, which indicates that denitrification is probably not occurring.

- Divalent iron was only detected in one monitoring well (13MW11 at a concentration of 1.2 mg/L). This information suggests that limited iron reduction is occurring in the vicinity of this well.

- High sulfate concentrations (47 to 390 mg/L) were measured in the groundwater. These results indicate that sulfate reduction is probably not occurring.

- Methane was detected in only one Zone 2 well (13MW11); therefore, methanogenesis is probably occurring only near this well.

- Concentrations of alkalinity (38 to 68 mg/L) and hardness (76 to 940 mg/L) were generally normal when compared to concentrations in other zones; however, the concentrations were higher than those detected in MW1-6RI (alkalinity of 20 U mg/L and hardness of 45 mg/L).

- Groundwater temperature and pH were normal for Zone 2. The maximum temperature and pH of groundwater were detected in monitoring well 13MW11.

- Ammonia was detected in only one monitoring well (13MW11) which may indicate that denitrification is occurring in this well because ammonia is an intermediate product of denitrification. However, the nitrate concentration detected in this well does not indicate that denitrification is an active natural attenuation process; therefore, the results are ambiguous.

- Phosphorous was detected in three monitoring wells indicating that this nutrient is available in the groundwater.

- Salinity and chloride were generally high along the western side of Zone 2, with the exception of the levels detected in 13MW11. This data is confirmed by the information provided on Drawings 1 and 3, which show that under high tide conditions, the western portion of Zone 2 is tidally influenced.

The information provided above indicates that natural attenuation is probably occurring in the southwestern portion of Zone 2 (i.e., near 13MW11). The fact that TPH, VOCs, and SVOCs were either not detected or were detected very infrequently in the groundwater is most likely the result of a variety of factors (i.e., condition, type, and age of source(s), natural attenuation, mobility of contaminants, unique hydrogeologic conditions, and tidal flushing). Due to the variety of factors influencing Zone 2 and the

limited contaminant plume, it is unlikely that bioremediation or other more active remedial technologies are practical or necessary for the groundwater of this zone. It is likely that a combination of monitored natural attenuation or a tiered groundwater monitoring program and source control would be a viable remedial strategy for this zone. If monitored natural attenuation is selected as part of the remedial strategy for Zone 2, additional investigations would need to be completed to provide the preliminary data required for the remedial alternative and to monitor the progress of the alternative. Monitoring of the non-tidally influenced areas of Zone 2 would provide the best indication that natural attenuation processes are working in the groundwater.

5.6 BASELINE HUMAN HEALTH RISK ASSESSMENT

This section contains the baseline risk assessment performed for soil and groundwater exposures at Zone 2 of the Lower Subase. Section 5.6.1 contains a discussion on the selection of Chemicals of Concern (COCs), Section 5.6.2 contains information on the potential receptors considered and the routes by which they might be exposed, Section 5.6.3 contains the numerical results of the risk assessment, and Section 5.6.4 presents site-specific uncertainties associated with the risk assessment.

5.6.1 Data Evaluation

COCs were identified for Zone 2 of the Lower Subase using risk-based COC screening levels, as described in Section 3.4.3. All validated data collected during the Phase I and II RIs, the Lower Subase RI, and additional investigations, except soil data collected from depths greater than 10 feet, were used to identify COCs. Table 5-14 presents a summary of the COCs for Zone 2. Appendix I.6 contains the COC summary screening tables for the site.

A medium-specific discussion of COCs is presented in the following subsections. Within a given medium, discussions of direct exposure COCs (i.e., those chemicals detected at concentrations in excess of Federal and state direct exposure criteria) and additional COCs are provided. Additional COCs are identified based on contaminant migration tendencies, migration from soil to groundwater and from groundwater to the Thames River. It should be noted that these additional COCs are not quantitatively addressed in the human health risk assessment (i.e., numerical risk estimates are not developed) because they are not considered to be significant contributors to the direct exposure pathways identified for potential human receptors.

5.6.1.1 Soil Chemicals of Concern

The following chemicals were identified as direct exposure COCs for soil based on a comparison of maximum detected concentrations to USEPA Region III COC screening levels for residential land use and Connecticut RSRs for direct exposure (residential and industrial land use):

- PAHs [benzo(a)pyrene, and dibenzo(a,h)anthracene]
- Metals (arsenic, beryllium, iron, lead, and manganese)
- TPH

Lead and manganese were selected as COCs for the "all soils" (soil from depths of 0 to 10 feet) category only because the maximum concentrations of these inorganics in shallow soil samples were less than the risk-based screening levels. The maximum detected lead concentration of 404 mg/kg slightly exceeded the USEPA lead screening of 400 mg/kg. Therefore, lead will be retained as a COC for shallow soil at Zone 2. TPH was qualitatively identified as a COC for shallow soil because the maximum detected concentration exceeded the Connecticut RSR for residential direct exposure. Detected concentrations of TPH in subsurface soil exceeded the Connecticut RSRs for residential and industrial direct exposure.

Maximum detections in soil were also compared to generic USEPA SSLs for migration from soil to groundwater and Connecticut RSRs for pollutant mobility in a GB classified area. Maximum concentrations of the following chemicals exceeded the generic soil pollutant mobility criteria, indicating a potential for these chemicals to migrate to groundwater and potentially impact the quality of groundwater:

- VOCs (methylene chloride).
- PAHs [benzo(a)anthracene, benzo(a)pyrene, benzo(b)fluoranthene, carbazole, dibenzo(a,h)anthracene, and indeno(1,2,3-cd)pyrene].
- Metals (arsenic, cadmium, chromium, lead, and nickel).
- TPH.

Methylene chloride was selected as a COC for the "all soils" category only because methylene chloride was not detected in shallow soil.

Under the Connecticut RSR (CTDEP, 1996), concerns regarding the mobility of inorganics in soil are addressed using TCLP and SPLP data. A comparison of site-specific TCLP and SPLP data to State RSRs for pollutant mobility is provided in Tables 5-6 and 5-7. Lead concentrations in the TCLP extracts

from several subsurface soil samples exceeded the state pollutant mobility criteria. However, it should be noted that lead was not detected in the SPLP extracts associated with recent sample collection events.

Although the use of generic mobility criteria (rather than site-specific criteria) results in a conservative identification of additional COCs for soil, the mobility of TPH and a few inorganics is supported by the available groundwater data for the site. Of the chemicals previously identified as migration COCs for soil, several inorganics (arsenic, cadmium, chromium, and nickel) and TPH were detected infrequently in groundwater samples collected from the site. In most cases, the COCs were only detected in historical groundwater samples. The results of the TCLP and confirmatory SPLP analyses indicate that inorganic constituents are not mobile. However, TCLP/SPLP analyses were performed for only three soil samples collected at the site; therefore, there is still some uncertainty regarding the mobility of inorganics. A discussion of COCs for groundwater is provided in the following subsection.

5.6.1.2 Groundwater Chemicals of Concern

COCs for groundwater were selected using unfiltered and filtered data. Although groundwater at the site is not currently used or expected to be used in the future as a drinking water supply because of saline conditions, a conservative list of direct exposure COCs was developed for this medium based on a comparison of maximum detected concentrations to USEPA Region III COC screening levels for tap water, Federal and state Maximum Contaminant Levels (MCLs), and Connecticut RSRs for the protection of groundwater. Chemicals retained as direct exposure COCs include the following:

- VOCs (chloroform and tetrachloroethene).
- Metals (antimony, arsenic, boron, cadmium, lead, manganese, iron, and sodium).
- TPH.

Cadmium and lead were identified as COCs for the unfiltered sample matrix only. Reported concentrations of lead in the filtered groundwater samples were less than direct exposure criteria. Cadmium was not detected in the filtered groundwater samples. Sodium was retained as a COC because the maximum detections for this chemical in unfiltered and filtered groundwater samples were in excess of the State Notification Level. However, elevated levels of sodium in groundwater are anticipated because of nearby saltwater intrusion from the Thames River.

Because Zone 2 borders the Thames River, maximum concentrations in groundwater were also compared to the Connecticut WQS for aquatic life (chronic saltwater criteria) and for the protection of human health (water and organisms). These criteria were used to qualitatively evaluate potential surface water

concentrations should chemicals in the groundwater migrate to the Thames River. The following chemicals were detected at maximum concentrations in excess of the state WQS:

- VOCs (tetrachloroethene).
- Metals (antimony, arsenic, copper, lead, nickel, and zinc).

Antimony, lead, and nickel were identified as additional COCs for the unfiltered sample matrix only. Reported concentrations in the filtered groundwater samples were less than the Connecticut WQSs. Zinc was identified as an additional COC for the filtered sample matrix only. Reported concentrations for the unfiltered groundwater samples were less than the Connecticut WQS. The actual impact on the water quality of the Thames River is not expected to be as significant as the qualitative comparison implies since significant dilution and tidal mixing are anticipated, thereby reducing contaminant concentrations. For example the maximum detected concentrations of most of the chemicals previously identified as migration COCs (tetrachloroethene, antimony, lead, nickel, and zinc) are within one order of magnitude of the Connecticut WQSs. Appropriate alternative surface water protection criteria can be calculated by multiplying the lower of the human health or aquatic life criterion in the latest Connecticut WQSs by a site-specific dilution factor. Recently calculated site-specific dilution factors for the DRMO (Site 6) and Goss Cove Landfill (Site 8), other NSB-NLON IRP sites located along the Thames River, were 226 and 118, respectively. Consequently, these chemicals are not considered to be problematic since the maximum concentration of these chemicals would be less than the alternative SWPC. In addition, tetrachloroethene was detected in only one historical groundwater sample. A separate evaluation of the water and sediment quality of the Thames River is provided in Section 11.0.

5.6.1.3 Exposure Point Concentrations

Exposure point concentrations were developed for direct exposure COCs only using the methodologies presented in Section 3.4.1. In most cases, the average and maximum detected concentrations for soil and groundwater were used for the RME and CTE, respectively. The 95 percent UCL was used for soil if there was an adequate amount of validated data available for a given data set and if the distribution of the data set was defined. Groundwater exposure point concentrations were developed using USEPA Region I guidance (USEPA, 1994f). A summary of the exposure point concentrations used to estimate potential risks associated with direct exposure COCs for Zone 2 is provided in Table 5-15.

Because of the lack of published dose-response parameters, inorganic compounds considered as essential human nutrients (e.g., calcium, magnesium, potassium, and sodium) were not quantitatively evaluated in the baseline human health risk assessment. TPH was identified as a direct exposure COC based on a

qualitative analysis. However, exposure to this chemical could not be quantitatively evaluated because of the lack of dose-response parameters. In addition, USEPA Region I does not advocate a quantitative evaluation of exposure to iron, although it may be identified as a COC, because the only available toxicity criteria for this chemical are provisional reference doses based on daily allowable intakes rather than adverse effect levels. Exposure to this chemical is addressed in the general uncertainty section of the baseline human health risk assessment, Section 3.4.5.

5.6.2 Exposure Assessment

This section presents a summary of the persons potentially exposed to soil and groundwater at Zone 2 of the Lower Subase and describes the routes by which they might be exposed. Details on the exposure parameters used in the quantitative risk assessment were provided in Section 3.4.3.

The most likely receptors at this site include any full-time adult employees or military personnel assigned to the various buildings. These persons could be exposed to shallow soil via direct contact (incidental ingestion or dermal contact). They are assumed to be exposed 150 days/year for 6 years for the CTE and for 25 years for the RME.

A construction worker scenario was also evaluated for Zone 2. A construction project is assumed to take between 80 (CTE) and 120 (RME) days in a 1-year period. These persons could come into contact with "all soil" (soil from depths of 0 to 10 feet) via dermal contact and incidental ingestion. These receptors may also be dermally exposed to groundwater during ground-intrusive activities.

Since the site is located along the Thames River and waterfront property is typically regarded as an attractive location for residential development, future residents were evaluated as potential receptors. This exposure scenario is dependent upon Base closure, which is considered to be highly unlikely because of the critical nature of the facility with respect to support of the submarine fleet and national defense. Therefore, this scenario is primarily evaluated for informational purposes only (i.e., to aid in decision making, and risk management decisions). Future potential residents are not assumed to come in contact with groundwater at the site because saline conditions that exist near the Thames River would preclude domestic use of groundwater. Receptors are assumed to be exposed to "all soil" (soil from depths of 0 to 10 feet) via incidental ingestion and dermal contact. Soil exposures were assumed to occur 150 days/year for a total of 7 years under the CTE and 30 years for the RME.

There is no dermal absorption factor available for beryllium. As requested by EPA Region I, dermal exposure to beryllium will be evaluated using a generic absorption factor of 0.01 and the results will be discussed in the uncertainty analysis presented in Section 5.6.4.

The identified potential receptors could also be exposed to chemicals in soil via inhalation of fugitive dust and volatile emissions. This exposure pathway is evaluated in a qualitative fashion by a comparison of maximum soil concentrations to generic USEPA SSLs for the inhalation pathway, as summarized in the site-specific COC summary screening tables in Appendix I.6. Maximum detections for all soil chemicals were less than the inhalation SSLs, indicating that the inhalation pathway is not expected to be a significant exposure route. Consequently, this exposure route was eliminated from further quantitative risk evaluation.

5.6.3 Risk Characterization

A summary of the quantitative risk assessment for Zone 2 is provided in this section. Total noncarcinogenic and carcinogenic risks for each exposure route, as well as the cumulative risks for the RME and CTE scenarios, are outlined in Table 5-16 for the construction worker, full-time employee, and future resident. Sample calculations are provided in Appendix I.3. Appendix I.6 contains the chemical-specific risks for Zone 2.

5.6.3.1 Noncarcinogenic Risks

Cumulative Hazard Indices (HIs) for all receptors (the construction worker, full-time employee, and future residents) are less than unity, indicating that no averse effects are anticipated under the RME and CTE scenarios.

5.6.3.2 Carcinogenic Risks

Cumulative incremental cancer risks for Zone 2 ranged from 8.8E-8 for the construction worker (CTE) to 1.3E-5 for the future resident (RME). All cancer risk estimates were within or less than the USEPA target risk range of 1E-4 to 1E-6 although the cancer risk for the future resident under the RME scenario (1.3E-5) exceeded the CTDEP cumulative target risk level of 1E-5. Only the cancer risk estimates developed for the full-time employee (RME case only) and the hypothetical future resident (RME case only) exceed 1E-6. As summarized in Table 5-17, for the full-time employee and future resident under the RME scenario, the chemical-specific incremental cancer risks associated with benzo(a)pyrene, dibenzo(a,h)anthracene and arsenic exceed 1E-6. The exposure route of concern is incidental ingestion and dermal contact with soil. Chemical-specific incremental cancer risks do not exceed 1E-5 in any case evaluated.

5.6.3.3 Exposure to Lead

Lead was identified as a potential COC for "all soil" at Zone 2 of the Lower Subase. The maximum detected "all soil" concentration of lead (404 mg/kg) in Zone 2 slightly exceeded the OSWER soil screening level of 400 mg/kg for residential land use. The maximum detected lead concentration was below the CTDEP RSR of 500 mg/kg for residential exposure and 1,000 mg/kg for industrial exposure. Exposure of children to lead in soil at Zone 2 was addressed using the USEPA IEUBK Model, as discussed in Section 3.4.3. CTE and RME exposure concentrations for soil (presented in Table 5-15) were used, as well as several default parameters, to calculate estimated blood-lead levels for children in a residential setting. The estimated geometric mean blood-lead level for children exposed to lead in soil at Zone 2 was 3.1 µg/dL and 6 µg/dL for CTE and RME scenarios, respectively. The IEUBK model estimates that less than 1 percent (CTE) and 13 percent (RME) of children are expected to have blood-lead levels greater than 10 µg/dL. Geometric mean blood-lead levels for this receptor are less than the established level of "concern," 10 µg/dL. However, under the RME scenario, 13 percent of exposed children are anticipated to experience a blood-lead level greater than 10 µg/dL.

As discussed in Section 3.4.3, exposures to lead by nonresidential adults were evaluated by use of a slope-factor approach developed by the EPA Technical Review Workgroup Model for Lead (USEPA Region I, 1996f; and USEPA, 1996g). The estimated 95th percentile fetal blood-lead level in women exposed to lead in site soil was 6.6 µg/dL (CTE) and 7.2 µg/dL (RME) for future employees and 15.4 µg/dL (RME) for construction workers. The CTE scenario could not be evaluated for the construction worker since the exposure frequency of 80 days a year is less than the model-recommended minimal exposure frequency of 90 days a year. The values for the future employee are below the established level of "concern," 10 µg/dL, indicating that adverse effects are not anticipated for fetuses of pregnant women workers exposed to lead in surface and subsurface soil at Zone 2. The value for the RME construction worker is greater than established level of "concern" of 10 µg/dL. The estimated 95th percentile blood-lead level for women exposed to lead in site soil was 2.2 µg/dL (CTE) and 2.4 µg/dL (RME) for future employees and 5.1 µg/dL (CTE) for construction workers. These values are less than the OSHA permissible blood-lead level of 40 µg/dL for adults, indicating that adverse effects are not anticipated for adults exposed to lead in surface and subsurface soil at Zone 2.

It should also be noted that lead only exceeded the OSWER screening level of 400 mg/kg in one subsurface soil sample. All other lead soil concentrations were less than 178 mg/kg.

5.6.4 Uncertainties

A detailed discussion of uncertainties associated with the various aspects of risk assessment, in general, was provided in Section 3.4.5. Site-specific uncertainties for Zone 2 risk evaluation are presented below.

Dermal exposure to beryllium in soil could not be quantitatively evaluated in the risk assessment since there are no dermal absorption factors available for beryllium. Therefore, as requested by EPA Region I, a screening analysis was performed for dermal exposures to beryllium in soil using a generic absorption factor for inorganics of 0.01. Cancer risks could not be calculated for beryllium since the oral cancer slope factor for beryllium has been withdrawn from IRIS. Hazard indices are as follows:

	Scenario	
Receptor	**RME**	**CTE**
Construction Worker	0.009	0.0009
Full-time Employee	0.0006	0.0001
Future Resident	0.015	0.002

All cumulative hazard indices for the RME and CTE scenarios are more than an order of magnitude less the acceptable level of 1.0. Consequently, no adverse health effects are anticipated as a result of dermal exposure to beryllium in soil under the conditions evaluated in the risk assessment.

Some inorganic chemicals detected in site soil samples may be attributable to naturally occurring background levels. Background levels for metals in soil at NSB-NLON, developed by Atlantic Environmental Services, were presented in Table 1-4. All reported concentrations of aluminum, arsenic, barium, beryllium, chromium, cobalt, copper, iron, magnesium, potassium, and vanadium in the site soils were less than the established background levels.

The results of the USEPA Technical Review Workgroup Model for Lead indicate that adverse toxic effects may be experienced by future construction workers exposed to "all soil." This scenario does not take into account typical practices used to reduce exposure during construction activities (i.e., dust control measures, personal protective equipment, etc.); therefore, the calculated risks may be overestimated for this receptor.

The risks associated with soil exposure under current site conditions are overestimated to some degree. Some of the soil samples collected at the site were collected from locations beneath pavement. All soil samples (currently exposed and beneath pavement) were used to conservatively evaluate potential risks

for the site. Actual exposure under current site conditions is less than exposure that is assumed for this risk assessment.

5.7 SUMMARY AND RECOMMENDATIONS

This section presents a summary of major findings for Zone 2 of the Lower Subase. A summary of the nature and extent of contamination is provided in Section 5.7.1. Section 5.7.2 includes a summary of contaminant fate and transport information and Section 5.7.3 provides a synopsis of the baseline human health risk assessment for Zone 2. Section 5.7.4 provides recommendations regarding additional action and investigatory efforts for the soil and groundwater of Zone 2. A summary of the ecological risks for the Thames River adjacent to Zone 2 and the corresponding recommendations for the river are provided in Section 11.0.

5.7.1 Nature and Extent of Contamination

In summary, the analytical results indicate frequent detections of high molecular weight PAHs, TPH, and lead in Zone 2 shallow soil samples. The PAH and TPH data are suggestive of fuel oil contamination, perhaps from the fuel oil pipeline running through Zone 2 to Pier 8. Remediation of lead-contaminated soil was conducted at Building 31 (in Zone 3). It is likely that lead contamination in soil and groundwater in the southwestern corner of Zone 2 may be related to past lead contamination at Building 31. The infrequent detections and generally low concentrations of metals and SVOCs in groundwater samples collected from Zone 2 indicate that significant contamination of the groundwater system beneath Zone 2 has not occurred.

5.7.2 Contaminant Fate and Transport

High concentrations of petroleum hydrocarbons and SVOCs, as well as inorganic concentrations in excess of background, have been detected in the soil of Zone 2. Analytical results from the groundwater sampling activities indicate that the contamination in the soil is generally not migrating to the groundwater. Data from adjacent zones (i.e., Zone 1 and Zone 3) suggest that Zone 2 may be the recipient of cross-contamination from these zones. Zone 1 may be contributing petroleum contamination to the northern end of Zone 2, and Zone 3 may be contributing lead contamination to the southern end of Zone 2. The Thames River, which is downgradient of Zone 2, showed some potential evidence of cross-contamination with some detections of inorganics and PAHs. An evaluation of natural attenuation indicated that this process may be viable for the soil because of the presence of biodegradable contaminants (i.e., petroleum hydrocarbons and SVOCs). Key parameters indicate that natural attenuation is occurring in a limited portion of the groundwater of Zone 2; however, petroleum-related compounds were generally not detected

in the groundwater. Therefore, a tiered groundwater monitoring program versus monitored natural attenuation may be an option that could be evaluated further as part of the remedial strategy for Zone 2.

5.7.3 Baseline Human Health Risk Assessment

The baseline human health risk assessment for Zone 2 focused on three potential receptor groups: construction workers, full-time employees, and future residents. Noncarcinogenic risks for all receptor groups were less than the USEPA and CTDEP acceptable limit of one. Carcinogenic risks for all receptors were either less than or within the USEPA's acceptable target risk range of 1E-4 to 1E-6. With the exception of the future resident, all cancer risks were less than the CTDEP acceptable risk level of 1E-5. Benzo(a)pyrene, dibenzo(a,h)anthracene, and arsenic were the main contributors to the cancer risk for the full time employee and the future resident. The majority of the cumulative incremental cancer risks for the identified potential receptors were less than 1E-6. Only the cancer risk estimates developed for the full-time employee (RME case only) and the hypothetical future resident (RME case only) exceed 1E-6. Although the results of the risk assessment modeling for lead indicate that this chemical may be of concern for future construction workers, actual exposures for this receptor are not expected to be significant. Exposure to lead during construction activities is expected to be reduced via dust-control measures, personal protective equipment, etc.

Maximum detected concentrations of methylene chloride, PAHs, metals, and TPH in soil exceeded their respective generic mobility criteria which indicates the potential exists for these chemicals to migrate from soil to groundwater. Although the maximum detected concentrations of methylene chloride and PAHs exceeded the generic mobility criteria, these chemicals were not detected in groundwater samples collected at Zone 2. The mobility of some of the inorganic COCs may be supported by the groundwater data and TCLP soil data. The maximum detected concentration of arsenic and chromium exceeded the generic mobility criteria but were within background levels.

Maximum concentrations in groundwater were compared to Connecticut salt water WQSs since Zone 2 borders the Thames River. Several migration COCs in groundwater were identified as exceeding the Connecticut salt water WQSs. Use of the Connecticut salt water WQSs to determine groundwater impacts on the Thames River is very conservative since the WQSs do not account for the dilutional effects of the groundwater mixing with the river. Appropriate alternative surface water protection criteria can be calculated by multiplying the lower of the human health or aquatic life criterion in the latest Connecticut WQSs by a site-specific dilution factor. Recently calculated site-specific dilution factors for the DRMO (Stie 5) and Goss Cove Landfill (Site 8), other NSB-NLON IRP sites located along the Thames River, were 226 and 118, respectively. The maximum detected concentrations of most migration COCs

(tetrachloroethene, antimony, lead, nickel, and zinc) are within one order of magnitude of the Connecticut WQSs. Therefore, the actual impact on water quality in the Thames River is expected to be minimal because significant dilution is anticipated, thereby reducing chemical concentrations in the Thames River.

5.7.4 Recommendations

It is recommended that this zone, which includes only the fuel distribution pipeline as a potential source, proceed to a feasibility study. Because of the extensive amount of underground utilities in Zone 2 and the nature of the activities conducted at this location (i.e., national security), the feasibility study for this zone should evaluate to the extent possible alternatives that include institutional controls to limit exposure to contaminated soil and a tiered groundwater monitoring program to verify that significant contaminant migration is not occurring. Cleaning and repair of the Zone 2 storm sewer system should also be evaluated during the feasibility study. These recommendations are based on the following information:

- The nature and extent of organic and inorganic contamination in the soil and groundwater are well defined to the extent practical considering infrastructure limitations.

- The baseline human health risk assessment indicates that there are minimal risks to human receptors. There are no risks in excess of the USEPA acceptable risk range, and only the risk to the hypothetical future resident under the RME scenario slightly exceeds the CTDEP risk level. In addition, the modeling completed to evaluate the exposure to lead indicates that the exposure to lead from this site is not expected to be significant.

- Although reported concentrations of TPH in site soil samples exceeded the state RSRs for direct exposure and pollutant mobility, the chemical-specific risk assessment for those compounds assumed to be major constituents of the observed TPH contamination indicated minimal risks to potential receptors.

- The groundwater at Zone 2 is not currently or anticipated to be used in the future as a potable water source because it is brackish; therefore, there is no imminent threat to human health.

- Evidence suggests that organic contamination is generally not migrating from the site and that natural attenuation processes are at work in the southwestern portion of the Zone 2 aquifer. The data also indicates that limited inorganic contamination may be migrating from the site. Groundwater monitoring will verify that natural attenuation processes are working to minimize the migration of organic contaminants and will confirm or disprove the potential inorganic contaminant migration problem.

- A tiered groundwater monitoring program will allow for further actions to be completed if the results show significant impacts.

- The ecological risk assessment for the Thames River adjacent to Zone 2 (See Section 11.0) shows that the risks to ecological receptors in this area are relatively low.

- The Thames River provides significant dilution and mixing which minimizes the impact of any contaminant migration from Zone 2.

- The Navy conducts regular pressure testing and repairs on the fuel distribution lines; therefore, the historical source of petroleum contamination has most likely been eliminated.

- A limited evaluation of the invert elevations of the storm sewer system indicate that portions of the system are submerged by varying amounts during a given day or time of year. Because of the age of parts of the system (i.e., greater than 40 years) and the material that it was constructed with (i.e., vitrified clay), it is likely that the system is cracked and groundwater will infiltrate into the storm sewers. Therefore, the storm sewer system may act as a contaminant migration pathway.

- The zone is generally covered with pavement or buildings, which minimizes direct exposure to the contaminated soil by human receptors.

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TABLE 5-1

SUMMARY OF SAMPLING AND ANALYTICAL PROGRAM - ZONE 2
PHASE I REMEDIAL INVESTIGATION
LOWER SUBASE
NSB-NLON, GROTON, CONNECTICUT

Sample ID	Sample Depth (feet below ground)	Analysis									
		Target Compound List (TCL)			TAL Metals[1] + Cyanide		RCRA Metals[2]	Lead	TPH	Fluorescence	Misc
		Volatiles	Semivolatiles	Pesticides/PCBs	Total	Dissolved					
SOIL											
13MW10(6-8)	6-8	●			●		●		●	●	
13MW11(2-4)	2-4	●			●		●		●	●	
13MW17(8-10)	8-10	●			●		●		●	●	
13MW6(14-16)	14-16	●			●		●		●	●	
GROUNDWATER											
011591-13MW17S	NA	●			●				●	●	
011891-13MW10S	NA	●			●				●	●	
011891-13MW18S[3]	NA	●			●				●		
011891-13MW6S	NA	●			●				●	●	
012191-13MW11S	NA	●			●				●	●	
012191-NESOMW6S	NA	●			●				●	●	

1 Analysis for boron was also performed.
2 Toxicity Characteristic Leaching Procedure (TCLP) extraction followed by analysis for RCRA metals.
3 011891-13MW18S is a field duplicate of 011891-13MW10S.
NA = Not applicable.
● = Sample was analyzed for this parameter.
Blank cell indicates that this analysis was not performed for this sample.

TABLE 5-2

SUMMARY OF SAMPLING AND ANALYTICAL PROGRAM - ZONE 2
TANK FARM INVESTIGATION
LOWER SUBASE
NSB-NLON, GROTON, CONNECTICUT

Sample ID	Sample Depth (feet below ground)	Analysis									
		Target Compound List (TCL)			TAL Metals		RCRA Metals[1]	Lead	TPH	Fluorescence	Misc
		Volatiles	Semivolatiles	Pesticides/PCBs	Total	Dissolved					
SOIL											
FPTB14L-04	4-4								●		
FPTB15L-09	9-9								●		
FPTB16L-11	11-11								●		
FPTB17L-11	11-12								●		
FPTB18L-05	5-5								●		
FPTB22L-07	7-8								●		
FPTB24L-07	7-8								●		

1 Toxicity Characteristic Leaching Procedure (TCLP) extraction followed by analysis for RCRA metals.
● = Sample was analyzed for this parameter.
Blank cell indicates that this analysis was not performed for this sample.

TABLE 5-3

SUMMARY OF SAMPLING AND ANALYTICAL PROGRAM - ZONE 2
PHASE II REMEDIAL INVESTIGATION
LOWER SUBASE
NSB-NLON, GROTON, CONNECTICUT

Sample ID	Sample Depth (feet below ground)	Analysis									
		Target Compound List (TCL)			TAL Metals[1]		RCRA Metals[2]	Lead	TPH	Fluorescence	Misc[3]
		Volatiles	Semivolatiles	Pesticides/PCBs	Total	Dissolved					
SOIL											
13TB11-0406	4-6						●	●	●		
13TB8-0103	1-3						●	●	●		
13TB9-0103	1-3						●	●	●		
GROUNDWATER - ROUND 1											
13GW10	NA	●	●		●	●			●		●
13GW11	NA	●	●		●	●			●		●
13GW17	NA	●	●		●	●			●		●
13GW17D[4]	NA	●	●		●	●			●		●
13GW6	NA	●	●		●	●			●		●
NESO6	NA	●	●		●	●			●		●[5]
GROUNDWATER - ROUND 2											
13GW10-2	NA	●	●		●	●			●		●
13GW11-2	NA	●	●		●	●			●		●[5]
13GW6-2	NA	●	●		●	●			●		●
13GW17-2	NA	●	●		●	●			●		●
13GW17-D-2[6]	NA	●	●		●	●			●		●
NESO6-2	NA	●	●		●	●			●		●

1 Analysis for boron was also performed.
2 Toxicity Characteristic Leaching Procedure (TCLP) extraction followed by analysis for RCRA metals.
3 Miscellaneous parameters include: Hardness (as $CaCO_3$), except for samples 13GW11-2 and NESO6 which were also analyzed for Ammonia (as Nitrogen), Chemical Oxygen Demand, Total Organic Carbon, Total Phosphorus, and Total Suspended Solids.
4 13GW17D is a field duplicate of 13GW17.
5 Analysis for oil and grease was also performed for this sample.
6 13GW17-D-2 is a field duplicate of 13GW17-2.
NA = Not applicable.
● = Sample was analyzed for this parameter.
Blank cell indicates that this analysis was not performed for this sample.

TABLE 5-4

SUMMARY OF SAMPLING AND ANALYTICAL PROGRAM - ZONE 2
LOWER SUBASE REMEDIAL INVESTIGATION
LOWER SUBASE
NSB-NLON, GROTON, CONNECTICUT
PAGE 1 OF 2

Sample ID	Sample Depth (feet below ground)	Analysis									
		Target Compound List (TCL)			TAL Metals		SPLP Lead[1]	Lead	TPH	Fluorescence	Misc[2]
		Volatiles	Semivolatiles	Pesticides/PCBs	Total	Dissolved					
SOIL											
LS2SB0010101	3-4		●						●		
LS2SB0010201	5-7		●								
LS2SB0020101	2-4		●						●		
LS2SB0020201	5-6		●								
LS2SB0030101	2-4		●						●		
LS2SB0030201	6-8		●								
LS2SB0040101	2-4		●						●		
LS2SB0040401	14-15.5		●		●				●		
LS2SB0050101	2-4		●						●		
LS2SB0050301	8-11		●		●		●		●		
LS2SB0060101	2-4		●						●		
LS2SB0060301	8-11		●		●		●				
SBFD001[3]	8-11		●		●		●				
LS2SB0070101	2-4		●								
LS2SB0070201	6-7		●								
GROUNDWATER											
LS2GW13MW1001	NA		●		●	●			●		●
LS2GW13MW1101	NA		●		●	●			●		●
LS2GW13MW1701	NA		●		●	●			●		●
LS2GW13MW601	NA		●		●	●			●		●
LS2GWNESO601	NA		●		●	●			●		●[4,5]

1 Synthetic Precipitation Leaching Procedure (SPLP) extraction followed by analysis for lead.

2 Unless otherwise noted, miscellaneous parameters include: Alkalinity (as $CaCO_3$), Ammonia (as Nitrogen), Chloride, Dissolved Oxygen, Divalent Iron, Hardness (as CaCO3), Nitrate (as Nitrogen), pH, Phosphorous, Redox Potential, Salinity, Specific Conductivity, Sulfate, Temperature, Total Organic Carbon, Turbidity, and Dissolved Methane.

3 SBFD001 is a field duplicate of LS2SB0060301.

4 Miscellaneous parameters include: Alkalinity (as CaCO3), Ammonia (as Nitrogen), Chloride, Divalent Iron, Hardness (as CaCO3), Nitrate (as Nitrogen), Phosphorous, Sulfate, and Total Organic Carbon.

TABLE 5-4

SUMMARY OF SAMPLING AND ANALYTICAL PROGRAM - ZONE 2
LOWER SUBASE REMEDIAL INVESTIGATION
LOWER SUBASE
NSB-NLON, GROTON, CONNECTICUT
PAGE 2 OF 2

5 This sample was not analyzed for dissolved methane because of laboratory error and water quality parameters (I.e., Dissolved Oxygen, pH, Redox Potential, Salinity, Specific Conductivity, Temperature and Turbidity) were also not measured for this sample because of equipment problems.

NA = Not applicable.

● = Sample was analyzed for this parameter.

Blank cell indicates that this analysis was not performed for this sample.

TABLE 5-5 (PAGE 1 OF 9)

SUMMARY OF POSITIVE SOIL ANALYTICAL RESULTS FOR ZONE 2
LOWER SUBASE; NSB-NLON; GROTON, CONNECTICUT

SAMPLE NUMBER:	13MW10(6-8)	13MW11(2-4)	13MW17(8-10)	13MW6(14-16)	13TB11-0406	13TB8-0103
DEPTH (feet):	6 - 8'	2 - 4'	8 - 10'	14 - 16'	4 - 6'	1 - 3'
INVESTIGATION:	PH1	PH1	PH1	PH1	PH2-1	PH2-1
SAMPLE DATE:	11/08/90	11/08/90	11/12/90	11/13/90	01/24/94	01/24/94
LOCATION:	13MW10	13MW11	13MW17	13MW6	13TB11	13TB8
VALIDATED:	VALIDATED	VALIDATED	VALIDATED	VALIDATED	VALIDATED	VALIDATED
SAMPLE TYPE:	GRAB	GRAB	GRAB	GRAB	GRAB	GRAB
STATUS:						
FIELD DUPLICATE OF:						
VOLATILES (µg/kg)						
METHYLENE CHLORIDE	5 U	5 U	2 J	12 U		
TRICHLOROETHENE	5 U	5 U	1 J	12 U		
METALS (mg/kg)						
ALUMINUM	4590	7210	2670	4720		
ARSENIC	1.9	1.8	0.71 U	0.61 U		
BARIUM	24.7	30.1	15.3	39.6		
BERYLLIUM	0.22 U	0.29	0.24 U	0.2 U		
CADMIUM	0.6 J	1.3 J	0.69 J	1.2 J		
CALCIUM	1650	1540 J	604 J	645 J		
CHROMIUM	7	12.4	3.9	9.6		
COBALT	2.4	4.1	2.2 J	3.9 J		
COPPER	8.6 J	17.8 J	8.7	9.6		
IRON	5120	9560	4310	7830		
LEAD	7.6 J	178 J	5.4 J	2 J	404	149
MAGNESIUM	1850	2330	1150 J	2520		
MANGANESE	125	153	208 J	145 J		
MERCURY	0.1 U	0.11 J	0.1 UJ	0.1 UJ		
NICKEL	5.5	8.2	3.8	6.6		
POTASSIUM	1390 J	1590 J	1120	2570		
SODIUM	250 J	184 J	238	123		
VANADIUM	9.4	16.8	6	13.5		
ZINC	20.2	54.3	14 J	24.5 J		

TABLE 5-5 (PAGE 2 OF 9)

SUMMARY OF POSITIVE SOIL ANALYTICAL RESULTS FOR ZONE 2
LOWER SUBASE; NSB-NLON; GROTON, CONNECTICUT

SAMPLE NUMBER:	13MW10(6-8)	13MW11(2-4)	13MW17(8-10)	13MW6(14-16)	13TB11-0406	13TB8-0103
DEPTH (feet):	6 - 8'	2 - 4'	8 - 10'	14 - 16'	4 - 6'	1 - 3'
INVESTIGATION:	PH1	PH1	PH1	PH1	PH2-1	PH2-1
SAMPLE DATE:	11/08/90	11/08/90	11/12/90	11/13/90	01/24/94	01/24/94
LOCATION:	13MW10	13MW11	13MW17	13MW6	13TB11	13TB8
VALIDATED:	VALIDATED	VALIDATED	VALIDATED	VALIDATED	VALIDATED	VALIDATED
SAMPLE TYPE:	GRAB	GRAB	GRAB	GRAB	GRAB	GRAB
STATUS:						
FIELD DUPLICATE OF:						
TOTAL PETROLEUM HYDROCARBONS (mg/kg)						
TPH	130	150	80 U	70 U	169 J	856 J

TABLE 5-5 (PAGE 3 OF 9)

SUMMARY OF POSITIVE SOIL ANALYTICAL RESULTS FOR ZONE 2
LOWER SUBASE; NSB-NLON; GROTON, CONNECTICUT

SAMPLE NUMBER:	13TB9-0103	FPTB14L-04	FPTB15L-09	FPTB16L-11	FPTB17L-11	FPTB18L-05
DEPTH (feet):	1 - 3'	4 - 4'	9 - 9'	11 - 11'	11 - 12'	5 - 5'
INVESTIGATION:	PH2-1	TFI96	TFI96	TFI96	TFI96	TFI96
SAMPLE DATE:	01/24/94	11/18/95	11/18/95	11/17/95	10/08/95	11/17/95
LOCATION:	13TB9	GS-14L	GS-15L	GS-16L	GS-17L	GS-18L
VALIDATED:	VALIDATED	VALIDATED	VALIDATED	VALIDATED	VALIDATED	VALIDATED
SAMPLE TYPE:	GRAB	GRAB	GRAB	GRAB	GRAB	GRAB
STATUS:						
FIELD DUPLICATE OF:						
METALS (mg/kg)						
LEAD	150					
TOTAL PETROLEUM HYDROCARBONS (mg/kg)						
TPH	26.8 J	49.9	10.3 U	11.3 U	16.3	10.2 U

TABLE 5-5 (PAGE 4 OF 9)

SUMMARY OF POSITIVE SOIL ANALYTICAL RESULTS FOR ZONE 2 LOWER SUBASE; NSB-NLON; GROTON, CONNECTICUT

SAMPLE NUMBER:	FPTB22L-07	FPTB24L-07	LS2SB0010101	LS2SB0010201	LS2SB0020101	LS2SB0020201
DEPTH (feet):	7 - 8'	7 - 8'	3 - 4'	5 - 7'	2 - 4'	5 - 6'
INVESTIGATION:	TFI96	TFI96	1997RI	1997RI	1997RI	1997RI
SAMPLE DATE:	10/07/95	10/08/95	09/22/97	09/22/97	09/22/97	09/22/97
LOCATION:	GS-22L	GS-24L	TB1-2RI	TB1-2RI	TB2-2RI	TB2-2RI
VALIDATED:	VALIDATED	VALIDATED	VALIDATED	VALIDATED	VALIDATED	VALIDATED
SAMPLE TYPE:	GRAB	GRAB	GRAB	GRAB	GRAB	GRAB
STATUS:						
FIELD DUPLICATE OF:						
SEMIVOLATILES (µg/kg)						
2-METHYLNAPHTHALENE			20 J	360 U	330 U	360 U
ACENAPHTHENE			330 U	35 J	26 J	460
ACENAPHTHYLENE			37 J	360 U	18 J	360 U
ANTHRACENE			52 J	100 J	79 J	180 J
BENZO(A)ANTHRACENE			260 J	150 J	410	100 J
BENZO(A)PYRENE			250 J	110 J	390	71 J
BENZO(B)FLUORANTHENE			260 J	140 J	390	83 J
BENZO(G,H,I)PERYLENE			230 J	140 J	280 J	100 J
BENZO(K)FLUORANTHENE			170 J	74 J	300 J	43 J
CARBAZOLE			23 J	33 J	36 J	360 U
CHRYSENE			300 J	120 J	450	100 J
DI-N-BUTYL PHTHALATE			330 U	360 U	330 U	360 U
DIBENZO(A,H)ANTHRACENE			53 J	40 J	170 J	360 U
DIBENZOFURAN			330 U	26 J	330 U	320 J
DIETHYL PHTHALATE			24 J	47 J	330 U	360 U
FLUORANTHENE			470	330 J	790	590
FLUORENE			21 J	31 J	22 J	360 U
INDENO(1,2,3-CD)PYRENE			210 J	66 J	320 J	35 J
NAPHTHALENE			330 U	360 U	330 U	360 U
PHENANTHRENE			280 J	310 J	390	360 U
PHENOL			330 U	360 U	330 U	360 U
PYRENE			420	250 J	630	350 J

TABLE 5-5 (PAGE 5 OF 9)

SUMMARY OF POSITIVE SOIL ANALYTICAL RESULTS FOR ZONE 2 LOWER SUBASE; NSB-NLON; GROTON, CONNECTICUT

SAMPLE NUMBER:	FPTB22L-07	FPTB24L-07	LS2SB0010101	LS2SB0010201	LS2SB0020101	LS2SB0020201
DEPTH (feet):	7 - 8'	7 - 8'	3 - 4'	5 - 7'	2 - 4'	5 - 6'
INVESTIGATION:	TFI96	TFI96	1997RI	1997RI	1997RI	1997RI
SAMPLE DATE:	10/07/95	10/08/95	09/22/97	09/22/97	09/22/97	09/22/97
LOCATION:	GS-22L	GS-24L	TB1-2RI	TB1-2RI	TB2-2RI	TB2-2RI
VALIDATED:	VALIDATED	VALIDATED	VALIDATED	VALIDATED	VALIDATED	VALIDATED
SAMPLE TYPE:	GRAB	GRAB	GRAB	GRAB	GRAB	GRAB
STATUS:						
FIELD DUPLICATE OF:						
TOTAL PETROLEUM HYDROCARBONS (mg/kg)						
TPH	8210	89.9	330		450	

TABLE 5-5 (PAGE 6 OF 9)

SUMMARY OF POSITIVE SOIL ANALYTICAL RESULTS FOR ZONE 2
LOWER SUBASE; NSB-NLON; GROTON, CONNECTICUT

SAMPLE NUMBER:	LS2SB0030101	LS2SB0030201	LS2SB0040101	LS2SB0040401	LS2SB0050101	LS2SB0050301
DEPTH (feet):	2 - 4'	6 - 8'	2 - 4'	14 - 15.5'	2 - 4'	8 - 11'
INVESTIGATION:	1997RI	1997RI	1997RI	1997RI	1997RI	1997RI
SAMPLE DATE:	09/22/97	09/22/97	09/23/97	09/23/97	09/23/97	09/23/97
LOCATION:	TB3-2RI	TB3-2RI	TB4-2RI	TB4-2RI	TB5-2RI	TB5-2RI
VALIDATED:	VALIDATED	VALIDATED	VALIDATED	VALIDATED	VALIDATED	VALIDATED
SAMPLE TYPE:	GRAB	GRAB	GRAB	GRAB	GRAB	GRAB
STATUS:						
FIELD DUPLICATE OF:						
SEMIVOLATILES (µg/kg)						
2-METHYLNAPHTHALENE	330 U	20 J	330 U	360 U	330 U	330 U
ACENAPHTHENE	330 U	40 J	330 U	360 U	29 J	330 U
ACENAPHTHYLENE	57 J	63 J	330 U	360 U	330 U	330 U
ANTHRACENE	45 J	180 J	20 J	360 U	85 J	330 U
BENZO(A)ANTHRACENE	260 J	650	86 J	360 U	260 J	330 U
BENZO(A)PYRENE	240 J	570	87 J	360 U	260 J	330 U
BENZO(B)FLUORANTHENE	270 J	680	86 J	360 U	210 J	330 U
BENZO(G,H,I)PERYLENE	180 J	400	67 J	360 UJ	180 J	330 U
BENZO(K)FLUORANTHENE	180 J	430	90 J	360 U	230 J	330 U
CARBAZOLE	330 U	65 J	330 U	360 U	22 J	330 U
CHRYSENE	300 J	680	100 J	360 U	290 J	330 U
DI-N-BUTYL PHTHALATE	330 U	18 J	330 U	360 U	330 U	330 U
DIBENZO(A,H)ANTHRACENE	76 J	180 J	31 J	360 U	78 J	330 U
DIBENZOFURAN	330 U	42 J	330 U	360 UJ	330 U	330 U
DIETHYL PHTHALATE	330 U	360 U	330 U	360 U	330 U	18 J
FLUORANTHENE	420	1300	180 J	360 U	630	330 U
FLUORENE	330 U	64 J	330 U	360 U	330 U	330 U
INDENO(1,2,3-CD)PYRENE	180 J	400	65 J	360 UJ	170 J	330 U
NAPHTHALENE	330 U	18 J	330 U	360 U	330 U	330 U
PHENANTHRENE	82 J	750	110 J	360 U	380	330 U
PHENOL	330 U	360 U	330 U	50 J	330 U	330 U
PYRENE	390	1200	170 J	22 J	570	330 U

TABLE 5-5 (PAGE 7 OF 9)
SUMMARY OF POSITIVE SOIL ANALYTICAL RESULTS FOR ZONE 2
LOWER SUBASE; NSB-NLON; GROTON, CONNECTICUT

SAMPLE NUMBER:	LS2SB0030101	LS2SB0030201	LS2SB0040101	LS2SB0040401	LS2SB0050101	LS2SB0050301
DEPTH (feet):	2 - 4'	6 - 8'	2 - 4'	14 - 15.5'	2 - 4'	8 - 11'
INVESTIGATION:	1997RI	1997RI	1997RI	1997RI	1997RI	1997RI
SAMPLE DATE:	09/22/97	09/22/97	09/23/97	09/23/97	09/23/97	09/23/97
LOCATION:	TB3-2RI	TB3-2RI	TB4-2RI	TB4-2RI	TB5-2RI	TB5-2RI
VALIDATED:	VALIDATED	VALIDATED	VALIDATED	VALIDATED	VALIDATED	VALIDATED
SAMPLE TYPE:	GRAB	GRAB	GRAB	GRAB	GRAB	GRAB
STATUS:						
FIELD DUPLICATE OF:						
METALS (mg/kg)						
ALUMINUM				8320		3240
ARSENIC				3.0 J		1.2 J
BARIUM				41.5 U		26.3 U
BERYLLIUM				0.32 J		0.10 U
CADMIUM				0.04 U		0.04 U
CALCIUM				582 J		1030 J
CHROMIUM				13.4		7.7
COBALT				4.1		2.2
COPPER				10.8		6.6
IRON				9070		4970
LEAD				5.2		2.1
MAGNESIUM				2570 J		1680 J
MANGANESE				151		94.5
MERCURY				0.001 UJ		0.002 UJ
NICKEL				10.1		5.4
POTASSIUM				1550 J		1420 J
SODIUM				64.2 U		114
VANADIUM				17.1		8.6
ZINC				22.5 J		15.1 J
TOTAL PETROLEUM HYDROCARBONS (mg/kg)						
TPH	340		31	25 U	25 U	62

TABLE 5-5 (PAGE 8 OF 9)

SUMMARY OF POSITIVE SOIL ANALYTICAL RESULTS FOR ZONE 2 LOWER SUBASE; NSB-NLON; GROTON, CONNECTICUT

SAMPLE NUMBER:	LS2SB0060101	LS2SB0060301	SBFD001	LS2SB0070101	LS2SB0070201	
DEPTH (feet):	2 - 4'	8 - 11'	8 - 11'	2 - 4'	6 - 7'	
INVESTIGATION:	1997RI	1997RI	1997RI	1997RI	1997RI	
SAMPLE DATE:	09/22/97	09/22/97	09/22/97	09/22/97	09/22/97	/ /
LOCATION:	TB6-2RI	TB6-2RI	TB6-2RI	TB7-2RI	TB7-2RI	
VALIDATED:	VALIDATED	VALIDATED	VALIDATED	VALIDATED	VALIDATED	
SAMPLE TYPE:	GRAB	GRAB	GRAB	GRAB	GRAB	
STATUS:						
FIELD DUPLICATE OF:			LS2SB0060301			
SEMIVOLATILES (µg/kg)						
2-METHYLNAPHTHALENE	330 U	330 U	330 U	360 U	400 U	
ACENAPHTHENE	330 U	330 U	330 U	360 U	400 U	
ACENAPHTHYLENE	330 U	330 U	330 U	360 U	400 U	
ANTHRACENE	330 U	330 U	330 U	360 U	400 U	
BENZO(A)ANTHRACENE	57 J	25 J	18 J	53 J	400 U	
BENZO(A)PYRENE	74 J	22 J	19 J	60 J	400 U	
BENZO(B)FLUORANTHENE	64 J	22 J	19 J	59 J	400 U	
BENZO(G,H,I)PERYLENE	61 J	20 J	330 U	58 J	400 U	
BENZO(K)FLUORANTHENE	68 J	23 J	330 U	49 J	400 U	
CARBAZOLE	330 U	330 U	330 U	360 U	400 U	
CHRYSENE	80 J	30 J	23 J	62 J	400 U	
DI-N-BUTYL PHTHALATE	330 U	330 U	17 J	360 U	400 U	
DIBENZO(A,H)ANTHRACENE	31 J	330 U	330 U	31 J	400 U	
DIBENZOFURAN	330 U	330 U	330 U	360 U	400 U	
DIETHYL PHTHALATE	22 J	330 U	330 U	360 U	19 J	
FLUORANTHENE	100 J	44 J	34 J	94 J	400 U	
FLUORENE	330 U	330 U	330 U	360 U	400 U	
INDENO(1,2,3-CD)PYRENE	51 J	20 J	330 U	43 J	400 U	
NAPHTHALENE	330 U	330 U	330 U	20 J	400 U	
PHENANTHRENE	42 J	21 J	18 J	45 J	400 U	
PHENOL	330 U	330 U	330 U	360 U	400 U	
PYRENE	110 J	39 J	30 J	88 J	400 U	

TABLE 5-5 (PAGE 9 OF 9)
SUMMARY OF POSITIVE SOIL ANALYTICAL RESULTS FOR ZONE 2
LOWER SUBASE; NSB-NLON; GROTON, CONNECTICUT

SAMPLE NUMBER:	LS2SB0060101	LS2SB0060301	SBFD001	LS2SB0070101	LS2SB0070201	
DEPTH (feet):	2 - 4'	8 - 11'	8 - 11'	2 - 4'	6 - 7'	
INVESTIGATION:	1997RI	1997RI	1997RI	1997RI	1997RI	
SAMPLE DATE:	09/22/97	09/22/97	09/22/97	09/22/97	09/22/97	/ /
LOCATION:	TB6-2RI	TB6-2RI	TB6-2RI	TB7-2RI	TB7-2RI	
VALIDATED:	VALIDATED	VALIDATED	VALIDATED	VALIDATED	VALIDATED	
SAMPLE TYPE:	GRAB	GRAB	GRAB	GRAB	GRAB	
STATUS:						
FIELD DUPLICATE OF:			LS2SB0060301			
METALS (mg/kg)						
ALUMINUM		4000	3300			
ARSENIC		0.99 J	0.82 J			
BARIUM		32.6 U	27.4 U			
BERYLLIUM		0.12 U	0.10 U			
CADMIUM		0.04 U	0.04 U			
CALCIUM		3120 J	2520 J			
CHROMIUM		8.3	7.5			
COBALT		3.0	2.7			
COPPER		8.6	7.1			
IRON		7280	5490			
LEAD		14.6	14.0			
MAGNESIUM		2330 J	1800 J			
MANGANESE		127	97.2			
MERCURY		0.002 UJ	0.002 UJ			
NICKEL		5.6	4.8			
POTASSIUM		1610 J	1380 J			
SODIUM		209	175			
VANADIUM		13.5	9.7			
ZINC		19.2 J	16.2 J			
TOTAL PETROLEUM HYDROCARBONS (mg/kg)						
TPH	59					

TABLE 5-6 (PAGE 1 OF 2)

SUMMARY OF POSITIVE TCLP ANALYTICAL RESULTS FOR ZONE 2 LOWER SUBASE; NSB-NLON; GROTON, CONNECTICUT

SAMPLE NUMBER:	13MW10(6-8)	13MW11(2-4)	13MW17(8-10)	13MW6(14-16)	13TB11-0406	13TB8-0103
DEPTH (feet):	6 - 8'	2 - 4'	8 - 10'	14 - 16'	4 - 6'	1 - 3'
INVESTIGATION:	PH1	PH1	PH1	PH1	PH2-1	PH2-1
SAMPLE DATE:	11/08/90	11/08/90	11/12/90	11/13/90	01/24/94	01/24/94
LOCATION:	13MW10	13MW11	13MW17	13MW6	13TB11	13TB8
VALIDATED:	VALIDATED	VALIDATED	VALIDATED	VALIDATED	VALIDATED	VALIDATED
SAMPLE TYPE:	GRAB	GRAB	GRAB	GRAB	GRAB	GRAB
STATUS:						
FIELD DUPLICATE OF:						
TCLP METALS (mg/L)*						
BARIUM (100.0/10.0)	0.16	0.26	0.044	0.16	0.171	0.303
CADMIUM (1.0/0.05)	0.002 U	0.0024	0.005 U	0.005 U	0.002 U	0.002 U
CHROMIUM (5.0/0.5)	0.01 J	0.014 J	0.05 U	0.05 U	0.003 UJ	0.0032 J
LEAD (5.0/0.15)	0.2	8.6	0.3 U	0.3 U	3.43	0.11
SILVER (5.0/0.36)	0.007 UJ	0.007 UJ	0.008 J	0.007 UR	0.002 U	0.002 U

*Federal Toxicity Characteristic Regulatory Level (58 FR 46049)/Connecticut Remediation Standard Pollutant Mobility Criteria for GB Waters

TABLE 5-6 (PAGE 2 OF 2)
SUMMARY OF POSITIVE TCLP ANALYTICAL RESULTS FOR ZONE 2
LOWER SUBASE; NSB-NLON; GROTON, CONNECTICUT

SAMPLE NUMBER:	13TB9-0103					
DEPTH (feet):	1 - 3'					
INVESTIGATION:	PH2-1					
SAMPLE DATE:	01/24/94	/ /	/ /	/ /	/ /	/ /
LOCATION:	13TB9					
VALIDATED:	VALIDATED					
SAMPLE TYPE:	GRAB					
STATUS:						
FIELD DUPLICATE OF:						
TCLP METALS (mg/L)*						
BARIUM (100.0/10.0)	0.275					
CADMIUM (1.0/0.05)	0.0026 J					
CHROMIUM (5.0/0.5)	0.003 UJ					
LEAD (5.0/0.15)	0.104					
SILVER (5.0/0.36)	0.002 U					

ederal Toxicity Characteristic Regulatory Level (58 FR 46049)/Conr. cut Remediation Standard Pollutant Mobility Criteria for GB Waters

TABLE 5-7
SUMMARY OF POSITIVE SPLP ANALYTICAL RESULTS FOR ZONE 2
LOWER SUBASE; NSB-NLON; GROTON, CONNECTICUT

SAMPLE NUMBER:	LS2SB0050301	LS2SB0060301	SBFD001			
DEPTH (feet):	8 - 11'	8 - 11'	8 - 11'			
INVESTIGATION:	1997RI	1997RI	1997RI			
SAMPLE DATE:	09/23/97	09/22/97	09/22/97	/ /	/ /	/ /
LOCATION:	TB5-2RI	TB6-2RI	TB6-2RI			
VALIDATED:	VALIDATED	VALIDATED	VALIDATED			
SAMPLE TYPE:	GRAB	GRAB	GRAB			
STATUS:						
FIELD DUPLICATE OF:			LS2SB0060301			
SPLP METALS (mg/L)*						
LEAD (5.0/0.15)	0.0013 U	0.0015 J	0.0013 U			

*Federal Toxicity Characteristic Regulatory Level (58 FR 46049)/Connecticut Remediation Standard Pollutant Mobility Criteria for GB Waters

TABLE 5-8

SUMMARY OF SOIL ANALYTICAL RESULTS - ZONE 2
LOWER SUBASE
NSB-NLON, GROTON, CONNECTICUT
PAGE 1 OF 3

Analyte	SHALLOW SOILS (<4 FEET)[1]			DEEP SOILS (>4 FEET)[2]		
	Frequency of Detection	Concentration Range	Location of Maximum Detection	Frequency of Detection	Concentration Range	Location of Maximum Detection
VOLATILE ORGANICS (ug/kg)						
Methylene chloride	0/1	ND	NA	1/3	2	13MW17
Trichloroethene	0/1	ND	NA	1/3	1	13MW17
SEMIVOLATILE ORGANICS (ug/kg)						
2-Methylnaphthalene	1/7	20	TB1-2RI	1/8	20	TB3-2RI
Acenaphthene	2/7	26 - 29	TB5-2RI	3/8	35 - 460	TB2-2RI
Acenaphthylene	3/7	18 - 57	TB3-2RI	1/8	63	TB3-2RI
Anthracene	5/7	20 - 85	TB5-2RI	3/8	100 - 180	TB3-2RI/TB2-2RI
Benzo(a)anthracene	7/7	53 - 410	TB2-2RI	5/8	18 - 650	TB3-2RI
Benzo(a)pyrene	7/7	60 - 390	TB2-2RI	5/8	19 - 570	TB3-2RI
Benzo(b)fluoranthene	7/7	59 - 390	TB2-2RI	5/8	19 - 680	TB3-2RI
Benzo(g,h,i)perylene	7/7	58 - 280	TB2-2RI	4/8	20 - 400	TB3-2RI
Benzo(k)fluoranthene	7/7	49 - 300	TB2-2RI	4/8	23 - 430	TB3-2RI
Carbazole	3/7	22 - 36	TB2-2RI	2/8	33 - 65	TB3-2RI
Chrysene	7/7	62 - 450	TB2-2RI	5/8	23 - 680	TB3-2RI
Di-N-butyl phthalate	0/7	ND	ND	2/8	17 - 18	TB3-2RI
Dibenzo(a,h)anthracene	7/7	31 - 170	TB2-2RI	2/8	40 - 180	TB3-2RI
Dibenzofuran	0/7	ND	ND	3/8	26 - 320	TB2-2RI
Diethyl phthalate	2/7	22 - 24	TB1-2RI	3/8	18 - 47	TB1-2RI
Fluoranthene	7/7	94 - 790	TB2-2RI	5/8	34 - 1300	TB3-2RI
Fluorene	2/7	21 - 22	TB2-2RI	2/8	31 - 64	TB3-2RI
Indeno(1,2,3-Cd)pyrene	7/7	43 - 320	TB2-2RI	4/8	20 - 400	TB3-2RI
Naphthalene	1/7	20	TB7-2RI	1/8	18	TB3-2RI
Phenanthrene	7/7	42 - 390	TB2-2RI	4/8	18 - 750	TB3-2RI
Phenol	0/7	ND	ND	1/8	50	TB4-2RI
Pyrene	7/7	88 - 630	TB2-2RI	6/8	22 - 1200	TB3-2RI

TABLE 5-8

SUMMARY OF SOIL ANALYTICAL RESULTS - ZONE 2
LOWER SUBASE
NSB-NLON, GROTON, CONNECTICUT
PAGE 2 OF 3

Analyte	SHALLOW SOILS (<4 FEET)[1]			DEEP SOILS (>4 FEET)[2]		
	Frequency of Detection	Concentration Range	Location of Maximum Detection	Frequency of Detection	Concentration Range	Location of Maximum Detection
INORGANICS (mg/kg)						
Aluminum	1/1	7210	13MW11	7/7	2670 - 8320	TB4-2RI
Arsenic	1/1	1.8	13MW11	5/7	0.82 - 3	TB4-2RI
Barium	1/1	30.1	13MW11	3/7	15.3 - 39.6	13MW6
Beryllium	1/1	0.29	13MW11	1/7	0.32	TB4-2RI
Cadmium	1/1	1.3	13MW11	3/7	0.6 - 1.2	13MW6
Calcium	1/1	1540	13MW11	7/7	582 - 3120	TB6-2RI
Chromium	1/1	12.4	13MW11	7/7	3.9 - 13.4	TB4-2RI
Cobalt	1/1	4.1	13MW11	7/7	2.2 - 4.1	TB4-2RI
Copper	1/1	17.8	13MW11	7/7	6.6 - 10.8	TB4-2RI
Iron	1/1	9560	13MW11	7/7	4310 - 9070	TB4-2RI
Lead	3/3	149 - 178	13MW11	8/8	2 - 404	13TB11
Magnesium	1/1	2330	13MW11	7/7	1150 - 2570	TB4-2RI
Manganese	1/1	153	13MW11	7/7	94.5 - 208	13MW17
Mercury	1/1	0.11	13MW11	0/7	ND	ND
Nickel	1/1	8.2	13MW11	7/7	3.8 - 10.1	TB4-2RI
Potassium	1/1	1590	13MW11	7/7	1120 - 2570	13MW6
Sodium	1/1	184	13MW11	6/7	114 - 250	13MW10
Vanadium	1/1	16.8	13MW11	7/7	6 - 17.1	TB4-2RI
Zinc	1/1	54.3	13MW11	7/7	14 - 24.5	13MW6
TCLP METALS (mg/L)						
Barium	3/3	0.26 - 0.303	13TB9	4/4	0.044	13TB11
Cadmium	2/3	0.0024 - 0.0026	13TB9	0/4	ND	ND
Chromium	2/3	0.0032 - 0.014	13MW11	1/4	0.01	13MW10
Lead	3/3	0.104 - 8.6	13MW11	2/4	0.2 - 3.43	13TB11
Silver	0/3	ND	ND	1/3	0.008	13MW17

TABLE 5-8

SUMMARY OF SOIL ANALYTICAL RESULTS - ZONE 2
LOWER SUBASE
NSB-NLON, GROTON, CONNECTICUT
PAGE 3 OF 3

Analyte	SHALLOW SOILS (<4 FEET)[1]			DEEP SOILS (>4 FEET)[2]		
	Frequency of Detection	Concentration Range	Location of Maximum Detection	Frequency of Detection	Concentration Range	Location of Maximum Detection
SPLP (mg/L)						
Lead	NA	NA	ND	1/3	0.0015	TB6-2RI
TOTAL PETROLEUM HYDROCARBONS (mg/kg)						
TPH	8/9	26.8 - 856	13TB8	7/13	16.3 - 8210	GS-22L

1 Includes samples 13MW11(2-4), 13TB8-0103, 13TB9-0103, LS2SB0010101, LS2SB0020101, S2SB0030101, LS2SB0040101, LS2SB0050101, LS2SB0060101, LS2SB0070101.

2 Includes samples 13MW10(6-8), 13MW17(8-10), 13MW6(14-16), 13TB11-0406, FPTB14L-04, FPTB15L-09, FPTB16L-11, FPTB17L-11, FPTB18L-05, FPTB22L-07, FPTB24L-07, LS2SB0010201, LS2SB0020201, LS2SB0030201, LS2SB0040401, LS2SB0050301, LS2SB0060301, SBFD001 (field duplicate of LS2SB0060301), LS2SB0070201.

ND - Not Detected

NA - Not Analyzed

TABLE 5-9

SUMMARY OF PHASE I SOIL FLUORESCENCE SPECTROSCOPY DATA - ZONE 2
LOWER SUBASE
NSB-NLON, GROTON, CONNECTICUT

Sample	Sample Depth (ft)	Observations
13MW6	14-16	Spectra is similar to asphalt/tar.
13MW10	6-8	Spectra is unresolved. Trace concentrations of petroleum hydrocarbons make oil identification impractical.
13MW11	2-4	Spectra is unresolved. Trace concentrations of petroleum hydrocarbons make oil identification impractical.
13MW17	8-10	Spectra is unresolved. Trace concentrations of petroleum hydrocarbons make oil identification impractical.

TABLE 5-10 (PAGE 1 OF 18)

SUMMARY OF POSITIVE GROUNDWATER ANALYTICAL RESULTS FOR ZONE 2
LOWER SUBASE; NSB-NLON; GROTON, CONNECTICUT

SAMPLE NUMBER:	011891-13MW10S	011891-13MW18S	13GW10	13GW10	13GW10-2	13GW10-2
INVESTIGATION:	PH1	PH1	PH2-1	PH2-1	PH2-2	PH2-2
SAMPLE DATE:	01/18/91	01/18/91	03/05/94	03/05/94	06/23/94	06/23/94
LOCATION:	13MW10	13MW10	13MW10	13MW10	13MW10	13MW10
VALIDATED:	VALIDATED	VALIDATED	VALIDATED	VALIDATED	VALIDATED	VALIDATED
FILTERING:	Unfiltered	Unfiltered	Unfiltered	Filtered	Unfiltered	Filtered
FIELD DUPLICATE OF:		011891-13MW10S				
VOLATILES (µg/L)						
1,1,1-TRICHLOROETHANE	5 U	5 U	10 U		10 U	
CARBON DISULFIDE	5 U	5 U	10 U		10 U	
CHLOROFORM	5 U	5 U	1 J		10 U	
TETRACHLOROETHENE	5 U	5 U	10 U		10 U	
SEMIVOLATILES (µg/L)						
BENZOIC ACID			50 U		50 U	
BIS(2-ETHYLHEXYL)PHTHALATE			10 U		0.8 J	
BUTYLBENZYL PHTHALATE			10 U		10 U	
DI-N-BUTYL PHTHALATE			10 U		10 U	
DI-N-OCTYL PHTHALATE			10 U		10 U	
METALS (µg/L)						
ALUMINUM	30 U	30 U	35.4 U	14 U	18.5 U	15 U
ANTIMONY	25 U	25 U	15 U	15 U	13 U	13 U
ARSENIC	3 U	3 U	2 U	2 U	10 U	10
BARIUM	15 U	15 U	5.6 U	5 U	21.7	21.7
BORON	12 R	12 R	297	291	630	627
CADMIUM	2 U	2 U	3.3 J	2 UJ	3 U	3 U
CALCIUM	28200	28100	39800	39300	113000	113000
CHROMIUM	5 U	5 U	3 U	3 U	4 U	4 U
COBALT	5 U	5 U	4 U	4 U	5 U	5 U
COPPER	5 U	5 U	4 J	3.4 J	5 U	5 U
IRON	68.2 J	122 J	78.5 J	15.1 U	50.3 U	37.8 U
LEAD	10 UJ	10 UJ	1 UJ	1 U	2 UJ	20 UJ
MAGNESIUM	57700	57100	76400	75200	215000	212000

TABLE 5-10 (PAGE 2 OF 18)

SUMMARY OF POSITIVE GROUNDWATER ANALYTICAL RESULTS FOR ZONE 2
LOWER SUBASE; NSB-NLON; GROTON, CONNECTICUT

SAMPLE NUMBER:	011891-13MW10S	011891-13MW18S	13GW10	13GW10	13GW10-2	13GW10-2
INVESTIGATION:	PH1	PH1	PH2-1	PH2-1	PH2-2	PH2-2
SAMPLE DATE:	01/18/91	01/18/91	03/05/94	03/05/94	06/23/94	06/23/94
LOCATION:	13MW10	13MW10	13MW10	13MW10	13MW10	13MW10
VALIDATED:	VALIDATED	VALIDATED	VALIDATED	VALIDATED	VALIDATED	VALIDATED
FILTERING:	Unfiltered	Unfiltered	Unfiltered	Filtered	Unfiltered	Filtered
FIELD DUPLICATE OF:		011891-13MW10S				
METALS (µg/L)						
MANGANESE	2 U	2 U	3 U	2.8 U	22.6	22.2
NICKEL	21.8 J	17.4 J	10 U	10 U	11 U	11 U
POTASSIUM	20700	20600	30200 J	30000 J	68800	68100
SELENIUM	2.8	2.2	3 UJ	3 UJ	2 UJ	2 UJ
SILVER	7 U	7 U	2 U	3 U	2 U	2 U
SODIUM	15500 J	499000 J	677000	672000	1850000	1880000
VANADIUM	20 U	20 U	5 U	5 U	4 U	4 U
ZINC	22.9 J	21 J	23.3	14.5 U	37.6	37.7
PETROLEUM HYDROCARBONS (µg/L)						
TPH	3000 U	3000 U	500 U		500 U	
MISCELLANEOUS PARAMETERS						
HARDNESS AS CaCO3 (MG/L)			432		1240	

TABLE 5-10 (PAGE 3 OF 18)
SUMMARY OF POSITIVE GROUNDWATER ANALYTICAL RESULTS FOR ZONE 2
LOWER SUBASE; NSB-NLON; GROTON, CONNECTICUT

SAMPLE NUMBER:	LS2GW13MW1001	LS2GW13MW1001-F	012191-13MW11S	13GW11	13GW11	13GW11-2
INVESTIGATION:	1997RI	1997RI	PH1	PH2-1	PH2-1	PH2-2
SAMPLE DATE:	11/12/97	11/12/97	01/21/91	03/05/94	03/05/94	06/27/94
LOCATION:	13MW10	13MW10	13MW11	13MW11	13MW11	13MW11
VALIDATED:	VALIDATED	VALIDATED	VALIDATED	VALIDATED	VALIDATED	VALIDATED
FILTERING:	Unfiltered	Filtered	Unfiltered	Unfiltered	Filtered	Unfiltered
FIELD DUPLICATE OF:						
VOLATILES (µg/L)						
1,1,1-TRICHLOROETHANE			5 U	10 U		10 U
CARBON DISULFIDE			5 U	10 U		10 U
CHLOROFORM			5 U	10 U		10 U
TETRACHLOROETHENE			5 U	10 U		10 U
SEMIVOLATILES (µg/L)						
BENZOIC ACID				50 U		50 U
BIS(2-ETHYLHEXYL)PHTHALATE	11 U			10 U		10 U
BUTYLBENZYL PHTHALATE	1 J			10 U		10 U
DI-N-BUTYL PHTHALATE	0.9 J			10 U		10 U
DI-N-OCTYL PHTHALATE	11 U			10 U		10 U
METALS (µg/L)						
ALUMINUM	501 U	39.3 U	30 U	67.5 U	20.6 U	42 U
ANTIMONY	2.5 U	2.6 J	25 U	15 U	15.1	3 U
ARSENIC	2.5 U	2.5 U	3 U	4.6 J	3.1 J	4.7
BARIUM	23.7	15.4	15 U	26 U	23.6 U	41.8
BORON			1.5 R	50 U	50 U	108
CADMIUM	0.42 U	0.22 U	2 UJ	2 UJ	2 UJ	1 U
CALCIUM	83400	64500	15300	21600	21900	34100
CHROMIUM	2.8 U	1.0 J	5 U	3 U	3 U	1.2 J
COBALT	2.1	1.0 J	5 U	4 U	4 U	1 U
COPPER	21.8	4.4 U	5 U	34.7	2.5 J	2 U
IRON	9930	13.0 U	3210 J	6620	3320	5470
LEAD	27.7	6.1	2.2 J	23.2 J	1 UJ	2 UJ
MAGNESIUM	194000	149000	4540	7260	7330	15700

TABLE 5-10 (PAGE 4 OF 18)

SUMMARY OF POSITIVE GROUNDWATER ANALYTICAL RESULTS FOR ZONE 2
LOWER SUBASE; NSB-NLON; GROTON, CONNECTICUT

SAMPLE NUMBER:	LS2GW13MW1001	LS2GW13MW1001-F	012191-13MW11S	13GW11	13GW11	13GW11-2
INVESTIGATION:	1997RI	1997RI	PH1	PH2-1	PH2-1	PH2-2
SAMPLE DATE:	11/12/97	11/12/97	01/21/91	03/05/94	03/05/94	06/27/94
LOCATION:	13MW10	13MW10	13MW11	13MW11	13MW11	13MW11
VALIDATED:	VALIDATED	VALIDATED	VALIDATED	VALIDATED	VALIDATED	VALIDATED
FILTERING:	Unfiltered	Filtered	Unfiltered	Unfiltered	Filtered	Unfiltered
FIELD DUPLICATE OF:						
METALS (µg/L)						
MANGANESE	56.0	3.3	278	276	249	356
NICKEL	5.2	0.97 J	18.7 J	10 U	10 U	12 U
POTASSIUM	64400	50100	3970	5980 J	5910 J	9500
SELENIUM	1.9 U	1.9 U	1 UJ	3 UJ	3 UJ	2 U
SILVER	1.1 U	1.3 J	7 UJ	2 U	2.9 U	1 U
SODIUM	1640000 J	1250000 J	39200 J	127000	130000	171000
VANADIUM	3.1	0.63 J	20 U	5 U	5 U	1 U
ZINC	58.2	33.2	14.8 J	20.1	4.2 U	5
PETROLEUM HYDROCARBONS (µg/L)						
TPH	1000 U		2000 U	600		500 U
WATER QUALITY PARAMETERS						
DISSOLVED OXYGEN (MG/L)	1.52					
REDOX POTENTIAL (MV)	2.9					
SALINITY (PPT)	4					
SPECIFIC CONDUCTIVITY (MS/CM)	7.339					
TEMPERATURE (C)	15.59					
MISCELLANEOUS PARAMETERS						
ALKALINITY AS CACO3 (MG/L)	68					
AMMONIA, AS NITROGEN (MG/L)	0.10 U					0.4
CHLORIDE (MG/L)	2000					
DIVALENT IRON (MG/L)	0					
HARDNESS AS CaCO3 (MG/L)	940			84		144
METHANE (UG/L)	5.4 U					
NITRATE, AS NITROGEN (MG/L)	1.1 J					

TABLE 5-10 (PAGE 5 OF 18)
SUMMARY OF POSITIVE GROUNDWATER ANALYTICAL RESULTS FOR ZONE 2
LOWER SUBASE; NSB-NLON; GROTON, CONNECTICUT

SAMPLE NUMBER:	LS2GW13MW1001	LS2GW13MW1001-F	012191-13MW11S	13GW11	13GW11	13GW11-2
INVESTIGATION:	1997RI	1997RI	PH1	PH2-1	PH2-1	PH2-2
SAMPLE DATE:	11/12/97	11/12/97	01/21/91	03/05/94	03/05/94	06/27/94
LOCATION:	13MW10	13MW10	13MW11	13MW11	13MW11	13MW11
VALIDATED:	VALIDATED	VALIDATED	VALIDATED	VALIDATED	VALIDATED	VALIDATED
FILTERING:	Unfiltered	Filtered	Unfiltered	Unfiltered	Filtered	Unfiltered
FIELD DUPLICATE OF:						
MISCELLANEOUS PARAMETERS						
PHOSPHORUS (MG/L)	0.33 J					
SULFATE (MG/L)	390					
TOTAL ORGANIC CARBON (MG/L)	2.4 J					2 U
TOTAL SUSPENDED SOLIDS (MG/L)						8
TURBIDITY (NTU)	2.5					
GENERAL CHEMISTRY						
PH	6.56					

TABLE 5-10 (PAGE 6 OF 18)

SUMMARY OF POSITIVE GROUNDWATER ANALYTICAL RESULTS FOR ZONE 2
LOWER SUBASE; NSB-NLON; GROTON, CONNECTICUT

SAMPLE NUMBER:	13GW112	LS2GW13MW1101	LS2GW13MW1101-F	011591-13MW17S	13GW17	13GW17D
INVESTIGATION:	PH2-2	1997RI	1997RI	PH1	PH2-1	PH2-1
SAMPLE DATE:	06/27/94	11/11/97	11/11/97	01/15/91	03/06/94	03/06/94
LOCATION:	13MW11	13MW11	13MW11	13MW17	13MW17	13MW17
VALIDATED:	VALIDATED	VALIDATED	VALIDATED	VALIDATED	VALIDATED	VALIDATED
FILTERING:	Filtered	Unfiltered	Filtered	Unfiltered	Unfiltered	Unfiltered
FIELD DUPLICATE OF:						13GW17
VOLATILES (µg/L)						
1,1,1-TRICHLOROETHANE				5 U	10 U	10 U
CARBON DISULFIDE				5 U	10 U	10 U
CHLOROFORM				5 U	10 U	10 U
TETRACHLOROETHENE				5 U	10 U	10 U
SEMIVOLATILES (µg/L)						
BENZOIC ACID					50 U	50 U
BIS(2-ETHYLHEXYL)PHTHALATE		11 U			10 U	10 U
BUTYLBENZYL PHTHALATE		11 U			10 U	10 U
DI-N-BUTYL PHTHALATE		11 U			10 U	10 U
DI-N-OCTYL PHTHALATE		3 J			10 U	10 U
METALS (µg/L)						
ALUMINUM	33.9	363 U	25.3 U	30 U	14 U	14 U
ANTIMONY	13.2	4.1 J	4.3 U	25 U	15 U	15 U
ARSENIC	3.8	2.5 U	2.5 U	3 U	2 U	2 U
BARIUM	44.3	31.6	29.1	15 U	10.3 U	6.5 U
BORON	105			5.7 R	116	116
CADMIUM	2 U	0.22 U	0.22 U	2 U	2 UJ	2 UJ
CALCIUM	36500	14600	14900	28600	27200	27400
CHROMIUM	3.5	3.1 U	3.1 U	5 U	3 U	3 U
COBALT	3 U	2.9 U	2.9 U	5 U	4 U	4 U
COPPER	2 U	3.2	1.5 U	5 U	2 U	2 U
IRON	5070	1650	900	225 J	18.6 U	15.2 U
LEAD	2 U	2.7	1.3 U	2.5 J	1.3 J	1.3 J
MAGNESIUM	15500	8050	8210	15000	24300	24500

TABLE 5-10 (PAGE 7 OF 18)
SUMMARY OF POSITIVE GROUNDWATER ANALYTICAL RESULTS FOR ZONE 2
LOWER SUBASE; NSB-NLON; GROTON, CONNECTICUT

SAMPLE NUMBER:	13GW112	LS2GW13MW1101	LS2GW13MW1101-F	011591-13MW17S	13GW17	13GW17D
INVESTIGATION:	PH2-2	1997RI	1997RI	PH1	PH2-1	PH2-1
SAMPLE DATE:	06/27/94	11/11/97	11/11/97	01/15/91	03/06/94	03/06/94
LOCATION:	13MW11	13MW11	13MW11	13MW17	13MW17	13MW17
VALIDATED:	VALIDATED	VALIDATED	VALIDATED	VALIDATED	VALIDATED	VALIDATED
FILTERING:	Filtered	Unfiltered	Filtered	Unfiltered	Unfiltered	Unfiltered
FIELD DUPLICATE OF:						13GW17
METALS (µg/L)						
MANGANESE	387	90.2	79.5	18.6	2 U	2 U
NICKEL	7 U	9.0 U	9.0 U	21.8 J	10 U	10 U
POTASSIUM	9600	8470	8530	7780	10000 J	10400 J
SELENIUM	2 U	1.9 U	1.9 U	1 U	3 UJ	3 UJ
SILVER	2 U	2.8 U	2.8 U	7 U	2 U	2 U
SODIUM	172000	113000	117000	112000	196000	198000
VANADIUM	3 U	2.9 U	3.4 U	20 U	5 U	5 U
ZINC	4.5	15.8 U	8.7 U	19.9 J	5.5 U	5.8 U
PETROLEUM HYDROCARBONS (µg/L)						
TPH		1000 U		3000 U	500 U	500 U
WATER QUALITY PARAMETERS						
DISSOLVED OXYGEN (MG/L)		3.7				
REDOX POTENTIAL (MV)		-105.1				
SALINITY (PPT)		0.44				
SPECIFIC CONDUCTIVITY (MS/CM)		0.871				
TEMPERATURE (C)		19.71				
MISCELLANEOUS PARAMETERS						
ALKALINITY AS CACO3 (MG/L)		67				
AMMONIA, AS NITROGEN (MG/L)		13				
CHLORIDE (MG/L)		210				
DIVALENT IRON (MG/L)		1.2				
HARDNESS AS CaCO3 (MG/L)		76			162	164
METHANE (UG/L)		1000				
NITRATE, AS NITROGEN (MG/L)		1.6 J				

TABLE 5-10 (PAGE 8 OF 18)

SUMMARY OF POSITIVE GROUNDWATER ANALYTICAL RESULTS FOR ZONE 2
LOWER SUBASE; NSB-NLON; GROTON, CONNECTICUT

SAMPLE NUMBER:	13GW112	LS2GW13MW1101	LS2GW13MW1101-F	011591-13MW17S	13GW17	13GW17D
INVESTIGATION:	PH2-2	1997RI	1997RI	PH1	PH2-1	PH2-1
SAMPLE DATE:	06/27/94	11/11/97	11/11/97	01/15/91	03/06/94	03/06/94
LOCATION:	13MW11	13MW11	13MW11	13MW17	13MW17	13MW17
VALIDATED:	VALIDATED	VALIDATED	VALIDATED	VALIDATED	VALIDATED	VALIDATED
FILTERING:	Filtered	Unfiltered	Filtered	Unfiltered	Unfiltered	Unfiltered
FIELD DUPLICATE OF:						13GW17
MISCELLANEOUS PARAMETERS						
PHOSPHORUS (MG/L)		0.19 J				
SULFATE (MG/L)		48				
TOTAL ORGANIC CARBON (MG/L)		4.5 J				
TURBIDITY (NTU)		1.5				
GENERAL CHEMISTRY						
PH		6.76				

TABLE 5-10 (PAGE 9 OF 18)
SUMMARY OF POSITIVE GROUNDWATER ANALYTICAL RESULTS FOR ZONE 2
LOWER SUBASE; NSB-NLON; GROTON, CONNECTICUT

SAMPLE NUMBER:	13GW17	13GW17D	13GW17-2	13GW17-D-2	13GW172	13GW17D-2
INVESTIGATION:	PH2-1	PH2-1	PH2-2	PH2-2	PH2-2	PH2-2
SAMPLE DATE:	03/06/94	03/06/94	06/25/94	06/25/94	06/25/94	06/25/94
LOCATION:	13MW17	13MW17	13MW17	13MW17	13MW17	13MW17
VALIDATED:	VALIDATED	VALIDATED	VALIDATED	VALIDATED	VALIDATED	VALIDATED
FILTERING:	Filtered	Filtered	Unfiltered	Unfiltered	Filtered	Filtered
FIELD DUPLICATE OF:		13GW17-DISS		13MW17-2		13MW172-DISS
VOLATILES (µg/L)						
1,1,1-TRICHLOROETHANE			10 U	10 U		
CARBON DISULFIDE			10 U	10 U		
CHLOROFORM			10 U	10 U		
TETRACHLOROETHENE			10 U	10 U		
SEMIVOLATILES (µg/L)						
BENZOIC ACID			50 U	50 U		
BIS(2-ETHYLHEXYL)PHTHALATE			10 U	10 U		
BUTYLBENZYL PHTHALATE			10 U	10 U		
DI-N-BUTYL PHTHALATE			10 U	10 U		
DI-N-OCTYL PHTHALATE			10 U	10 U		
METALS (µg/L)						
ALUMINUM	17.3 U	17.9 U	10 U	17.3	10 UJ	15 U
ANTIMONY	15 U	15 U	5 U	5 U	6 J	5 U
ARSENIC	2 U	2 U	2 U	2 U	2 U	2 U
BARIUM	5.5 U	5.4 U	37	35.9	36.9 J	37.5 J
BORON	111	112	317	305	307 J	326 J
CADMIUM	2 UJ	2 UJ	1 U	1 U	1 U	1 U
CALCIUM	25900	26400	77000	76500	77300	77900
CHROMIUM	3 U	3 U	1 U	1.1 J	1.3 J	1 U
COBALT	4 U	4 U	1 U	1 U	1 U	1 U
COPPER	2 U	2.3 J	3 U	3 U	3 U	3 U
IRON	8.1 U	9.6 U	17 U	29.2 J	17 U	17 U
LEAD	1 UJ	1.6 J	2 UJ	2.9 J	2 UR	2 UR
MAGNESIUM	23100	23300	90500	88600	90200	91100

TABLE 5-10 (PAGE 10 OF 18)
SUMMARY OF POSITIVE GROUNDWATER ANALYTICAL RESULTS FOR ZONE 2
LOWER SUBASE; NSB-NLON; GROTON, CONNECTICUT

SAMPLE NUMBER:	13GW17	13GW17D	13GW17-2	13GW17-D-2	13GW172	13GW17D-2
INVESTIGATION:	PH2-1	PH2-1	PH2-2	PH2-2	PH2-2	PH2-2
SAMPLE DATE:	03/06/94	03/06/94	06/25/94	06/25/94	06/25/94	06/25/94
LOCATION:	13MW17	13MW17	13MW17	13MW17	13MW17	13MW17
VALIDATED:	VALIDATED	VALIDATED	VALIDATED	VALIDATED	VALIDATED	VALIDATED
FILTERING:	Filtered	Filtered	Unfiltered	Unfiltered	Filtered	Filtered
FIELD DUPLICATE OF:		13GW17-DISS		13MW17-2		13MW172-DISS
METALS (µg/L)						
MANGANESE	2.7 U	2 U	9.6	9.5	1.1 J	1 U
NICKEL	10 U	10 U	3 U	3 U	3 U	3 U
POTASSIUM	9780 J	10000 J	28200	28100	28900	29000
SELENIUM	3 UJ	3 UJ	2 UJ	2 UJ	2.7 J	2 UR
SILVER	2 U	2 U	2 U	2 U	2 U	2 U
SODIUM	187000	189000	749000 J	716000 J	755000 J	771000 J
VANADIUM	5 U	5 U	1 U	1 U	1 U	1 U
ZINC	5.8 U	4.7 U	17.1	15.6	13.5	15.2
PETROLEUM HYDROCARBONS (µg/L)						
TPH			1000 U	1000 U		
MISCELLANEOUS PARAMETERS						
HARDNESS AS CaCO3 (MG/L)			565	556		

TABLE 5-10 (PAGE 11 OF 18)

SUMMARY OF POSITIVE GROUNDWATER ANALYTICAL RESULTS FOR ZONE 2
LOWER SUBASE; NSB-NLON; GROTON, CONNECTICUT

SAMPLE NUMBER:	LS2GW13MW1701	LS2GW13MW1701-F	011891-13MW6S	13GW6	13GW6	13GW6-2
INVESTIGATION:	1997RI	1997RI	PH1	PH2-1	PH2-1	PH2-2
SAMPLE DATE:	10/31/97	10/31/97	01/18/91	03/05/94	03/05/94	06/24/94
LOCATION:	13MW17	13MW17	13MW6	13MW6	13MW6	13MW6
VALIDATED:	VALIDATED	VALIDATED	VALIDATED	VALIDATED	VALIDATED	VALIDATED
FILTERING:	Unfiltered	Filtered	Unfiltered	Unfiltered	Filtered	Unfiltered
FIELD DUPLICATE OF:						
VOLATILES (µg/L)						
1,1,1-TRICHLOROETHANE			5 U	3 J		10 U
CARBON DISULFIDE			5 U	10 U		10 U
CHLOROFORM			5 U	10 U		10 U
TETRACHLOROETHENE			5 U	2 J		10 U
SEMIVOLATILES (µg/L)						
BENZOIC ACID				50 U		50 U
BIS(2-ETHYLHEXYL)PHTHALATE	12 U			10 U		10 U
BUTYLBENZYL PHTHALATE	12 U			10 U		10 U
DI-N-BUTYL PHTHALATE	12 U			10 U		10 U
DI-N-OCTYL PHTHALATE	12 U			10 U		10 U
METALS (µg/L)						
ALUMINUM	10.0 UJ	10.0 UJ	30 U	14 U	19.2 U	23.8
ANTIMONY	2.5 U	2.5 U	25 U	15 U	15 U	5 U
ARSENIC	2.5 U	2.5 U	3 U	2 U	2 U	2 U
BARIUM	21.7	259	21	22.6 U	21.9 U	23.1
BORON			3.6 R	60.8	57	78.8
CADMIUM	0.22 U	0.22 U	2 U	2 UJ	2 UJ	1 U
CALCIUM	63200	58700	31100	35900	34400	35100
CHROMIUM	1.0 U	0.93 U	5 U	3 U	3 U	1 U
COBALT	0.80 U	0.80 U	5 U	4 U	4 U	1 U
COPPER	4.9 U	3.7 U	5 U	2 U	2.2 J	3 U
IRON	96.5 U	13.0 U	46.7 J	27.4 U	12.7 U	17 U
LEAD	8.9	1.3 U	4.2 J	1 UJ	1 UJ	6.1 J
MAGNESIUM	59800	56300	5390	5810	5600	5740

TABLE 5-10 (PAGE 12 OF 18)
SUMMARY OF POSITIVE GROUNDWATER ANALYTICAL RESULTS FOR ZONE 2
LOWER SUBASE; NSB-NLON; GROTON, CONNECTICUT

SAMPLE NUMBER:	LS2GW13MW1701	LS2GW13MW1701-F	011891-13MW6S	13GW6	13GW6	13GW6-2
INVESTIGATION:	1997RI	1997RI	PH1	PH2-1	PH2-1	PH2-2
SAMPLE DATE:	10/31/97	10/31/97	01/18/91	03/05/94	03/05/94	06/24/94
LOCATION:	13MW17	13MW17	13MW6	13MW6	13MW6	13MW6
VALIDATED:	VALIDATED	VALIDATED	VALIDATED	VALIDATED	VALIDATED	VALIDATED
FILTERING:	Unfiltered	Filtered	Unfiltered	Unfiltered	Filtered	Unfiltered
FIELD DUPLICATE OF:						
METALS (µg/L)						
MANGANESE	15.6	5.6	2 U	2 U	2 U	1 U
NICKEL	0.75 U	0.77 J	18.7 J	10 U	10 U	3 U
POTASSIUM	22700	21700	5450	5960 J	6040 J	7030
SELENIUM	11.0 J	1.9 U	1.2	3 UJ	3 UJ	2 U
SILVER	1.1 U	1.1 U	7 U	2 U	2.5 U	2 U
SODIUM	525000	512000	53400 J	56800	55300	64600 J
VANADIUM	0.72 U	0.55 U	20 U	5 U	5 U	1 U
ZINC	7.3 U	132	11.4 J	3.2 U	3.2 U	2.9 U
PETROLEUM HYDROCARBONS (µg/L)						
TPH	1100 U		3000 U	600		1000 U
WATER QUALITY PARAMETERS						
DISSOLVED OXYGEN (MG/L)	12.67					
REDOX POTENTIAL (MV)	127.4					
SALINITY (PPT)	1.65					
SPECIFIC CONDUCTIVITY (MS/CM)	3.129					
TEMPERATURE (C)	17.19					
MISCELLANEOUS PARAMETERS						
ALKALINITY AS CACO3 (MG/L)	52					
AMMONIA, AS NITROGEN (MG/L)	0.10 U					
CHLORIDE (MG/L)	1100					
DIVALENT IRON (MG/L)	0					
HARDNESS AS CaCO3 (MG/L)	530			116		111
METHANE (UG/L)	5.4 U					
NITRATE, AS NITROGEN (MG/L)	2.2					

TABLE 5-10 (PAGE 13 OF 18)
SUMMARY OF POSITIVE GROUNDWATER ANALYTICAL RESULTS FOR ZONE 2
LOWER SUBASE; NSB-NLON; GROTON, CONNECTICUT

SAMPLE NUMBER:	LS2GW13MW1701	LS2GW13MW1701-F	011891-13MW6S	13GW6	13GW6	13GW6-2
INVESTIGATION:	1997RI	1997RI	PH1	PH2-1	PH2-1	PH2-2
SAMPLE DATE:	10/31/97	10/31/97	01/18/91	03/05/94	03/05/94	06/24/94
LOCATION:	13MW17	13MW17	13MW6	13MW6	13MW6	13MW6
VALIDATED:	VALIDATED	VALIDATED	VALIDATED	VALIDATED	VALIDATED	VALIDATED
FILTERING:	Unfiltered	Filtered	Unfiltered	Unfiltered	Filtered	Unfiltered
FIELD DUPLICATE OF:						
MISCELLANEOUS PARAMETERS						
PHOSPHORUS (MG/L)	0.12 J					
SULFATE (MG/L)	140					
TOTAL ORGANIC CARBON (MG/L)	2.6 J					
TURBIDITY (NTU)	2.6					
GENERAL CHEMISTRY						
PH	6.34					

TABLE 5-10 (PAGE 14 OF 18)
SUMMARY OF POSITIVE GROUNDWATER ANALYTICAL RESULTS FOR ZONE 2
LOWER SUBASE; NSB-NLON; GROTON, CONNECTICUT

SAMPLE NUMBER:	13GW62	LS2GW13MW601	LS2GW13MW601-F	012191-NESOMW6S	NESO6	NESO6
INVESTIGATION:	PH2-2	1997RI	1997RI	PH1	PH2-1	PH2-1
SAMPLE DATE:	06/24/94	11/04/97	11/04/97	01/21/91	03/05/94	03/05/94
LOCATION:	13MW6	13MW6	13MW6	NESO6	NESO6	NESO6
VALIDATED:	VALIDATED	VALIDATED	VALIDATED	VALIDATED	VALIDATED	VALIDATED
FILTERING:	Filtered	Unfiltered	Filtered	Unfiltered	Unfiltered	Filtered
FIELD DUPLICATE OF:						
VOLATILES (µg/L)						
1,1,1-TRICHLOROETHANE				5 U	10 U	
CARBON DISULFIDE				2 J	10 U	
CHLOROFORM				5 U	10 U	
TETRACHLOROETHENE				5 U	10 U	
SEMIVOLATILES (µg/L)						
BENZOIC ACID					1 J	
BIS(2-ETHYLHEXYL)PHTHALATE		12 U			10 U	
BUTYLBENZYL PHTHALATE		12 U			10 U	
DI-N-BUTYL PHTHALATE		12 U			10 U	
DI-N-OCTYL PHTHALATE		12 U			10 U	
METALS (µg/L)						
ALUMINUM	24.8 U	95.7 U	12.5 U	30 U	14 U	20.3 U
ANTIMONY	8 J	2.5 U	2.5 U	25 U	15 U	15 U
ARSENIC	2 U	2.5 U	2.5 U	3 U	2 UJ	2 UJ
BARIUM	24.6 J	31.6	25.5	15 U	18.4	17.3 U
BORON	78.4 U			2.4 R	103	101 J
CADMIUM	1 U	0.22 U	0.22 U	2 UJ	2 U	2 U
CALCIUM	37400	32800	31800	20800	58500	57400
CHROMIUM	1 U	0.77 J	0.86 U	5 U	3 U	3 U
COBALT	1 U	0.80 U	0.80 U	5 U	4 U	4 U
COPPER	3 U	9.1 J	0.74 UJ	6.8	2 UJ	5.3
IRON	17 U	145 U	13.0 U	112 J	46.3 U	32.8 U
LEAD	2 UR	17.2	1.3 U	2 J	2 UJ	2 U
MAGNESIUM	6110	5180	4960	5980	27000	26700

TABLE 5-10 (PAGE 15 OF 18)
SUMMARY OF POSITIVE GROUNDWATER ANALYTICAL RESULTS FOR ZONE 2
LOWER SUBASE; NSB-NLON; GROTON, CONNECTICUT

SAMPLE NUMBER:	13GW62	LS2GW13MW601	LS2GW13MW601-F	012191-NESOMW6S	NESO6	NESO6
INVESTIGATION:	PH2-2	1997RI	1997RI	PH1	PH2-1	PH2-1
SAMPLE DATE:	06/24/94	11/04/97	11/04/97	01/21/91	03/05/94	03/05/94
LOCATION:	13MW6	13MW6	13MW6	NESO6	NESO6	NESO6
VALIDATED:	VALIDATED	VALIDATED	VALIDATED	VALIDATED	VALIDATED	VALIDATED
FILTERING:	Filtered	Unfiltered	Filtered	Unfiltered	Unfiltered	Filtered
FIELD DUPLICATE OF:						
METALS (µg/L)						
MANGANESE	1.5 J	2.7	0.90 U	2 U	7.3 U	4.9 U
NICKEL	3 U	0.93 U	0.75 U	23.9 J	12.4 J	10 U
POTASSIUM	7530	7640	6990	3990	13400	12800
SELENIUM	2.2 J	1.9 U	1.9 U	1 UJ	3 UJ	3 U
SILVER	2 U	1.1 U	1.1 U	7 UJ	2 U	2 U
SODIUM	71900 J	82600	73400	48100 J	274000	272000
VANADIUM	1 U	0.55 U	0.55 U	20 U	5 U	5 U
ZINC	3.9 U	14.2 U	5.0 U	34 J	10.5 U	6.4 U
PETROLEUM HYDROCARBONS (µg/L)						
TPH		1200 U		2000 U	500 U	
WATER QUALITY PARAMETERS						
DISSOLVED OXYGEN (MG/L)		53.65 R				
REDOX POTENTIAL (MV)		32.9				
SALINITY (PPT)		0.26				
SPECIFIC CONDUCTIVITY (MS/CM)		0.539				
TEMPERATURE (C)		16.72				
MISCELLANEOUS PARAMETERS						
ALKALINITY AS CACO3 (MG/L)		38 J				
AMMONIA, AS NITROGEN (MG/L)		0.10 U			0.1 U	
CHLORIDE (MG/L)		150				
DIVALENT IRON (MG/L)		0				
HARDNESS AS CaCO3 (MG/L)		87			262	
METHANE (UG/L)		5.4 U				
NITRATE, AS NITROGEN (MG/L)		4.0				

TABLE 5-10 (PAGE 16 OF 18)
SUMMARY OF POSITIVE GROUNDWATER ANALYTICAL RESULTS FOR ZONE 2
LOWER SUBASE; NSB-NLON; GROTON, CONNECTICUT

SAMPLE NUMBER:	13GW62	LS2GW13MW601	LS2GW13MW601-F	012191-NESOMW6S	NESO6	NESO6
INVESTIGATION:	PH2-2	1997RI	1997RI	PH1	PH2-1	PH2-1
SAMPLE DATE:	06/24/94	11/04/97	11/04/97	01/21/91	03/05/94	03/05/94
LOCATION:	13MW6	13MW6	13MW6	NESO6	NESO6	NESO6
VALIDATED:	VALIDATED	VALIDATED	VALIDATED	VALIDATED	VALIDATED	VALIDATED
FILTERING:	Filtered	Unfiltered	Filtered	Unfiltered	Unfiltered	Filtered
FIELD DUPLICATE OF:						
MISCELLANEOUS PARAMETERS						
PHOSPHORUS (MG/L)		0.10 U				
SULFATE (MG/L)		47				
TOTAL ORGANIC CARBON (MG/L)		1.7 J			2 U	
TOTAL SUSPENDED SOLIDS (MG/L)					1 U	
TURBIDITY (NTU)		2.37				
GENERAL CHEMISTRY						
PH		6.22				

TABLE 5-10 (PAGE 17 OF 18)
SUMMARY OF POSITIVE GROUNDWATER ANALYTICAL RESULTS FOR ZONE 2
LOWER SUBASE; NSB-NLON; GROTON, CONNECTICUT

SAMPLE NUMBER:	NESO6-2	NESO6-2	LS2GWNESO601	LS2GWNESO601-F		
INVESTIGATION:	PH2-2	PH2-2	1997RI	1997RI		
SAMPLE DATE:	06/23/94	06/23/94	11/03/97	11/03/97	/ /	/ /
LOCATION:	NESO6	NESO6	NESO6	NESO6		
VALIDATED:	VALIDATED	VALIDATED	VALIDATED	VALIDATED		
FILTERING:	Unfiltered	Filtered	Unfiltered	Filtered		
FIELD DUPLICATE OF:						
VOLATILES (µg/L)						
1,1,1-TRICHLOROETHANE	10 U					
CARBON DISULFIDE	10 U					
CHLOROFORM	10 U					
TETRACHLOROETHENE	10 U					
SEMIVOLATILES (µg/L)						
BENZOIC ACID	50 UJ					
BIS(2-ETHYLHEXYL)PHTHALATE	10 UJ		11 U			
BUTYLBENZYL PHTHALATE	10 UJ		11 U			
DI-N-BUTYL PHTHALATE	10 UJ		11 U			
DI-N-OCTYL PHTHALATE	10 UJ		11 U			
METALS (µg/L)						
ALUMINUM	12.4 U	14.2 U	53.0 U	23.6 U		
ANTIMONY	12 U	5.2 J	2.5 U	2.5 U		
ARSENIC	1.3 J	2 U	2.5 U	2.5 U		
BARIUM	6 UJ	6.3 J	46.5	42.2		
BORON	72.9 U	85.1 J				
CADMIUM	3.1 U	1 U	0.22 U	0.22 U		
CALCIUM	53400 J	56000	63500	58600		
CHROMIUM	3 U	1 U	3.1 U	3.1 U		
COBALT	3 U	1 U	2.9 U	2.9 U		
COPPER	2 U	3 U	1.8 U	1.5 U		
IRON	4 UJ	17 U	41.2 U	17.4 U		
LEAD	2 UR	2 UR	1.3 U	1.3 U		
MAGNESIUM	12900 J	13200	77500	71900		

TABLE 5-10 (PAGE 18 OF 18)
SUMMARY OF POSITIVE GROUNDWATER ANALYTICAL RESULTS FOR ZONE 2
LOWER SUBASE; NSB-NLON; GROTON, CONNECTICUT

SAMPLE NUMBER:	NESO6-2	NESO6-2	LS2GWNESO601	LS2GWNESO601-F		
INVESTIGATION:	PH2-2	PH2-2	1997RI	1997RI		
SAMPLE DATE:	06/23/94	06/23/94	11/03/97	11/03/97	/ /	/ /
LOCATION:	NESO6	NESO6	NESO6	NESO6		
VALIDATED:	VALIDATED	VALIDATED	VALIDATED	VALIDATED		
FILTERING:	Unfiltered	Filtered	Unfiltered	Filtered		
FIELD DUPLICATE OF:						
METALS (µg/L)						
MANGANESE	3.5 U	1.8 J	0.95 J	0.93 U		
NICKEL	9.4 U	3 U	9.0 U	9.0 U		
POTASSIUM	9030	9530	30100	28200		
SELENIUM	2 UR	2 UR	2.5 U	3.0 U		
SILVER	2 U	2 U	2.8 U	2.8 U		
SODIUM	123000	134000 J	697000 J	655000 J		
VANADIUM	3 U	1 U	3.5 U	2.9 U		
ZINC	5.3 U	4.5 U	11.9 U	15.0 U		
PETROLEUM HYDROCARBONS (µg/L)						
TPH	1000 U		1100 U			
MISCELLANEOUS PARAMETERS						
ALKALINITY AS CACO3 (MG/L)			63			
AMMONIA, AS NITROGEN (MG/L)			0.10 U			
CHLORIDE (MG/L)			1200			
DIVALENT IRON (MG/L)			0.0			
HARDNESS AS CaCO3 (MG/L)	184		430			
NITRATE, AS NITROGEN (MG/L)			1.4			
PHOSPHORUS (MG/L)			0.19 U			
SULFATE (MG/L)			190			
TOTAL ORGANIC CARBON (MG/L)			3.9 J			

TABLE 5-11

SUMMARY OF HISTORICAL AND LOWER SUBASE RI GROUNDWATER ANALYTICAL RESULTS - ZONE 2
LOWER SUBASE RI 1997
NSB-NLON, GROTON, CONNECTICUT
PAGE 1 OF 3

Analyte	Historical Data[1]				Lower Subase RI[2]		
	Frequency of Detection	Concentration Range	Maximum Detection		Frequency of Detection	Concentration Range	Location of Maximum Detection
			Location	Investigation[3]			
VOLATILE ORGANICS (μg/L)							
1,1,1-Trichloroethane	1/18	3	13MW6	PH2-1	NA	NA	ND
Carbon disulfide	1/18	2	NESO6	PH1	NA	NA	ND
Chloroform	1/18	1	13MW10	PH2-1	NA	NA	ND
Tetrachloroethene	1/18	2	13MW6	PH2-1	NA	NA	ND
SEMIVOLATILE ORGANICS (μg/L)							
Benzoic acid	1/12	1	NESO6	PH2-1	NA	NA	ND
Bis(2-Ethylhexyl)phthalate	1/12	0.8	13MW10	PH2-2	0/5	ND	ND
Butylbenzyl phthalate	0/12	ND	ND	ND	1/5	1	13MW10
Di-N-butyl phthalate	0/12	ND	ND	ND	1/5	0.9	13MW10
Di-N-octyl phthalate	0/12	ND	ND	ND	1/5	3	13MW11
INORGANICS (μg/L)							
Aluminum	2/18	17.3 - 23.8	13MW6	PH2-2	0/5	ND	ND
Aluminum, filtered	1/12	33.9	13MW11	PH2-2	0/5	ND	ND
Antimony	0/18	ND	ND	ND	1/5	4.1	13MW11
Antimony, filtered	5/12	5.2 - 15.1	13MW11	PH2-1	1/5	2.6	13MW10
Arsenic	3/18	1.3 - 4.7	13MW11	PH2-2	0/5	ND	ND
Arsenic, filtered	3/12	3.1 - 10	13MW10	PH2-2	0/5	ND	ND
Barium	7/18	18.4 - 41.8	13MW11	PH2-2	5/5	21.7 - 46.5	NESO6
Barium, filtered	6/12	6.3 - 44.3	13MW11	PH2-2	5/5	15.4 - 259	13MW17
Boron	10/12	60.8 - 630	13MW10	PH2-2	NA	NA	ND
Boron, filtered	10/12	57 - 627	13MW10	PH2-2	NA	NA	ND
Cadmium	1/18	3.3	13MW10	PH2-1	0/5	ND	ND
Calcium	18/18	15300 - 113000	13MW10	PH2-2	5/5	14600 - 83400	13MW10
Calcium, filtered	12/12	21900 - 113000	13MW10	PH2-2	5/5	14900 - 64500	13MW10
Chromium	2/18	1.1 - 1.2	13MW11	PH2-2	1/5	0.77	13MW6

TABLE 5-11

SUMMARY OF HISTORICAL AND LOWER SUBASE RI GROUNDWATER ANALYTICAL RESULTS - ZONE 2
LOWER SUBASE RI 1997
NSB-NLON, GROTON, CONNECTICUT
PAGE 2 OF 3

Analyte	Historical Data[1]				Lower Subase RI[2]		
	Frequency of Detection	Concentration Range	Maximum Detection		Frequency of Detection	Concentration Range	Location of Maximum Detection
			Location	Investigation[3]			
Chromium, filtered	2/12	1.3 - 3.5	13MW11	PH2-2	1/5	1	13MW10
Cobalt	0/18	ND	ND	ND	1/5	2.1	13MW10
Cobalt, filtered	0/12	ND	ND	ND	1/5	1	13MW10
Copper	3/18	4 - 34.7	13MW11	PH2-1	3/5	3.2 - 21.8	13MW10
Copper, filtered	5/12	2.2 - 5.3	NESO6	PH2-1	0/5	ND	ND
Iron	10/18	29.2 - 6620	13MW11	PH2-1	2/5	1650 - 9930	13MW10
Iron, filtered	2/12	3320 - 5070	13MW11	PH2-2	1/5	900	13MW11
Lead	9/17	1.3 - 23.2	13MW11	PH2-1	4/5	2.7 - 27.7	13MW10
Lead, filtered	1/8	1.6	13MW17	PH2-1	1/5	6.1	13MW10
Magnesium	18/18	4540 - 215000	13MW10	PH2-2	5/5	5180 - 194000	13MW10
Magnesium, filtered	12/12	5600 - 212000	13MW10	PH2-2	5/5	4960 - 149000	13MW10
Manganese	7/18	9.5 - 356	13MW11	PH2-2	5/5	0.95 - 90.2	13MW11
Manganese, filtered	6/12	1.1 - 387	13MW11	PH2-2	3/5	3.3 - 79.5	13MW11
Nickel	7/18	12.4 - 23.9	NESO6	PH1	1/5	5.2	13MW10
Nickel, filtered	0/12	ND	ND	ND	2/5	0.77 - 0.97	13MW10
Potassium	18/18	3970 - 68800	13MW10	PH2-2	5/5	7640 - 64400	13MW10
Potassium, filtered	12/12	5910 - 68100	13MW10	PH2-2	5/5	6990 - 50100	13MW10
Selenium	3/17	1.2 - 2.8	13MW10	PH1	1/5	11	13MW17
Selenium, filtered	2/10	2.2 - 2.7	13MW17	PH2-2	0/5	ND	ND
Silver, filtered	0/12	ND	ND	ND	1/5	1.3	13MW10
Sodium	18/18	15500 - 1850000	13MW10	PH2-2	5/5	82600 - 1640000	13MW10
Sodium, filtered	12/12	55300 - 1880000	13MW10	PH2-2	5/5	73400 - 1250000	13MW10
Vanadium	0/18	ND	ND	ND	1/5	3.1	13MW10
Vanadium, filtered	0/12	ND	ND	ND	1/5	0.63	13MW10
Zinc	12/18	5 - 37.6	13MW10	PH2-2	1/5	58.2	13MW10
Zinc, filtered	4/12	4.5 - 37.7	13MW10	PH2-2	2/5	33.2 - 132	13MW17

TABLE 5-11

SUMMARY OF HISTORICAL AND LOWER SUBASE RI GROUNDWATER ANALYTICAL RESULTS - ZONE 2
LOWER SUBASE RI 1997
NSB-NLON, GROTON, CONNECTICUT
PAGE 3 OF 3

Analyte	Historical Data[1]				Lower Subase RI[2]		
	Frequency of Detection	Concentration Range	Maximum Detection		Frequency of Detection	Concentration Range	Location of Maximum Detection
			Location	Investigation[3]			
TOTAL PETROLEUM HYDROCARBONS (μg/L)							
TPH	2/18	600	13MW11/13MW6	PH2-1	0/5	ND	ND

1 Includes samples 011591-13MW17S, 011891-13MW10S, 011891-13MW18S (field duplicate of 011891-13MW10S), 011891-13MW6S, 012191-13MW11S, 012191-NESOMW6S, 13GW10, 13GW10-2, 13GW11, 13GW11-2, 13GW17, 13GW17D (field duplicate of 13GW17), 13GW6, 13GW6-2, 13MW17-2, 13GW17-D-2 (field duplicate of 13GW17-2), NES06, NES06-2.
2 Includes samples LS2GW13MW1001, LS2GW13MW1101, LS2GW13MW1701, LS2GW13MW601, LS2GWNESO601.
3 PH1 = Phase I RI; PH2-1 = Round 1 of Phase II RI; PH2-2 = Round 2 of Phase II RI.
NA - Not Analyzed.
ND - Not Detected.

TABLE 5-12

SUMMARY OF PHASE I GROUNDWATER FLUORESCENCE SPECTROSCOPY DATA - ZONE 2
LOWER SUBASE
NSB-NLON, GROTON, CONNECTICUT

Sample	Observations
13MW6S	No detection of these compounds was observed.
13MW10S	Spectra is typical of heavy residual fuel oil.
13MW11S	Spectra is unresolved. Trace concentrations of petroleum hydrocarbons make oil identification by fluorescence impractical.
13MW17S	Spectra is similar to waste oil/heavy residual fuel (i.e., No. 6 fuel oil) mixture.
NESOMW6S	Spectra is typical of heavy residual fuel oil.

TABLE 5-13

SUMMARY OF NATURAL ATTENUATION AND WATER QUALITY PARAMETERS - ZONE 2
LOWER SUBASE
NSB-NLON, GROTON, CONNECTICUT

Analyte	Lower Subase RI[1]		
	Frequency of Detection	Concentration Range	Location of Maximum Detection
MISCELLANEOUS			
Alkalinity as CaCO3 (mg/L)	5/5	38 - 68	13MW10
Ammonia, as nitrogen (mg/L)	1/5	13	13MW11
Chloride (mg/L)	5/5	150 - 2000	13MW10
Dissolved oxygen (mg/L)	3/3	1.52 - 12.67	13MW17
Divalent iron (mg/L)	1/5	1.2	13MW11
Methane (mg/L)	1/4	1000	13MW11
Hardness as CaCO3 (mg/L)	5/5	76 - 940	13MW10
Nitrate, as nitrogen (mg/L)	5/5	1.1 - 4	13MW6
pH	4/4	6.22 - 6.76	13MW11
Phosphorus (mg/L)	3/5	0.12 - 0.33	13MW10
Redox potential (mV)	4/4	-105.1 - 127.4	13MW17
Salinity (ppt)	4/4	0.26 - 4	13MW10
Specific conductivity (ms/cm)	4/4	0.539 - 7.339	13MW10
Sulfate (mg/L)	5/5	47 - 390	13MW10
Temperature (C)	4/4	15.59 - 19.71	13MW11
Total organic carbon (mg/L)	5/5	1.7 - 4.5	13MW11
Turbidity (NTU)	4/4	1.5 - 2.6	13MW17

1 Includes samples LS2GW13MW1001, LS2GW13MW1101, LS2GW13MW1701, LS2GW13MW601, and LS2GWNESO601.

TABLE 5-14

CHEMICALS OF CONCERN- ZONE 2
LOWER SUBASE
NSB-NLON, GROTON, CONNECTICUT

Chemicals of Concern[1]		
Shallow Soil (0 - 4 Feet)	**All Soil (0 - 10 Feet)**	**Groundwater[2]**
Benzo(a)anthracene	Methylene Chloride	Chloroform
Benzo(a)pyrene	Benzo(a)anthracene	Tetrachloroethene
Benzo(b)fluoranthene	Benzo(a)pyrene	Antimony
Carbazole	Benzo(b)fluoranthene	Arsenic
Dibenzo(a,h)anthracene	Carbazole	Boron
Indeno(1,2,3-cd)pyrene	Dibenzo(a,h)anthracene	Cadmium (unfiltered only)
Arsenic	Indeno(1,2,3-cd)pyrene	Copper
Beryllium	Arsenic	Iron
Cadmium	Beryllium	Lead (unfiltered only)
Chromium (total)	Cadmium	Manganese
Iron	Chromium (total)	Nickel (unfiltered only)
Nickel	Iron	Sodium
TPH	Lead	Zinc (filtered only)
	Manganese	TPH
	Nickel	
	TPH	

1 Chemical is identified as a Chemical of Concern (COC) if the maximum detection in a single sample exceeds one or more criteria (i.e., Region III COC screening level, State Remediation Standards, Federal Soil Screening Levels, etc.).

2 Unless otherwise noted, the inorganic chemicals presented are COCs for the unfiltered and filtered groundwater sample matrix.

TABLE 5-15

EXPOSURE CONCENTRATIONS FOR DIRECT EXPOSURE CHEMICALS OF CONCERN
ZONE 2
NSB-NLON, GROTON, CONNECTICUT

Direct Exposure Chemical of Concern	Exposure Concentration		
	Surface Soil[1] (mg/kg)	All Soil[1] (mg/kg)	Groundwater[2] (mg/L)
VOLATILE ORGANIC COMPOUNDS			
Chloroform	NA[3]	NA	0.001[4]
Tetrachloroethene	NA	NA	0.002[4]
SEMIVOLATILE ORGANIC COMPOUNDS			
Benzo(a)pyrene	0.19/0.39	0.36	NA
Dibenzo(a,h)anthracene	0.067/0.17	0.10/0.18	NA
METALS			
Antimony	NA	NA	0.0064[4]
Arsenic	1.8[5]	1.3/1.9	0.0018/0.003
Beryllium	0.29[5]	0.14/0.29	NA
Boron	NA	NA	0.177/0.464
Cadmium	NA	NA	0.00088/0.0015
Lead	NA	128/404	0.0055/0.0086
Manganese	NA	145/208	0.0569/0.250

1 UCL if single concentration is presented, otherwise average concentration is used for CTE and maximum detected concentration is used for RME unless otherwise noted. See Section 3.3.1.
2 Average concentration is used for CTE and maximum concentration is used for RME. Maximum is defined as the highest average concentration in a single well, and the average is defined as the overall average concentration of all well-specific averages.
3 NA - Not applicable. Chemical is not a chemical of concern for this medium.
4 Maximum concentration is presented since average concentration exceeds the maximum detected concentration.
5 Maximum detected concentration presented, only sample collected.

TABLE 5-16

ESTIMATED RISKS[1] - ZONE 2
LOWER SUBASE
NSB-NLON, GROTON, CONNECTICUT

Exposure Route	Construction Worker		Full-Time Employee		Future Resident	
	RME[2]	CTE[3]	RME[2]	CTE[3]	RME[2]	CTE[3]
HAZARD INDEX						
Incidental Ingestion of Soil	0.018	0.004	0.004	0.002	0.013	0.002
Dermal Contact with Soil	0.004	0.0003	0.004	0.0009	0.006	0.0008
Total Risk from Soil	0.022	0.004	0.008	0.0029	0.019	0.0028
Dermal Contact with Groundwater	0.078	0.018	NA[4]	NA	NA	NA
Cumulative Risk:	0.100	0.022	0.008	0.0029	0.019	0.0028
INCREMENTAL CANCER RISK						
Incidental Ingestion of Soil	2.2E-07	5.7E-08	1.4E-06	1.2E-07	4.6E-06	2.9E-07
Dermal Contact with Soil	1.7E-07	1.9E-08	5.4E-06	5.7E-07	8.4E-06	4.3E-07
Total Risk from Soil	3.9E-07	7.6E-08	6.8E-06	6.9E-07	1.3E-05	7.2E-07
Dermal Contact with Groundwater	2.1E-08	1.2E-08	NA	NA	NA	NA
Cumulative Risk:	4.1E-07	8.8E-08	6.8E-06	6.9E-07	1.3E-05	7.2E-07

1 Chemical-specific risks presented in Appendix I.6.
2 RME - Reasonable Maximum Exposure.
3 CTE - Central Tendency Exposure.
4 NA - Not applicable; exposure route not evaluated for this receptor.

TABLE 5-17

SUMMARY OF MAJOR CONTRIBUTORS TO RISK – ZONE 2
LOWER SUBASE
NSB-NLON, GROTON, CONNECTICUT

Receptor	Chemical	Cancer Risk	Percent Contribution
Full-time Employee – RME	Benzo(a)pyrene	3.9E-06	57%
	Dibenzo(a,h)anthracene	1.7E-06	25%
	Arsenic	1.3E-06	18%
Future Resident – RME	Benzo(a)pyrene	6.6E-06	51%
	Dibenzo(a,h)anthracene	3.3E-06	25%
	Arsenic	3.1E-06	24%

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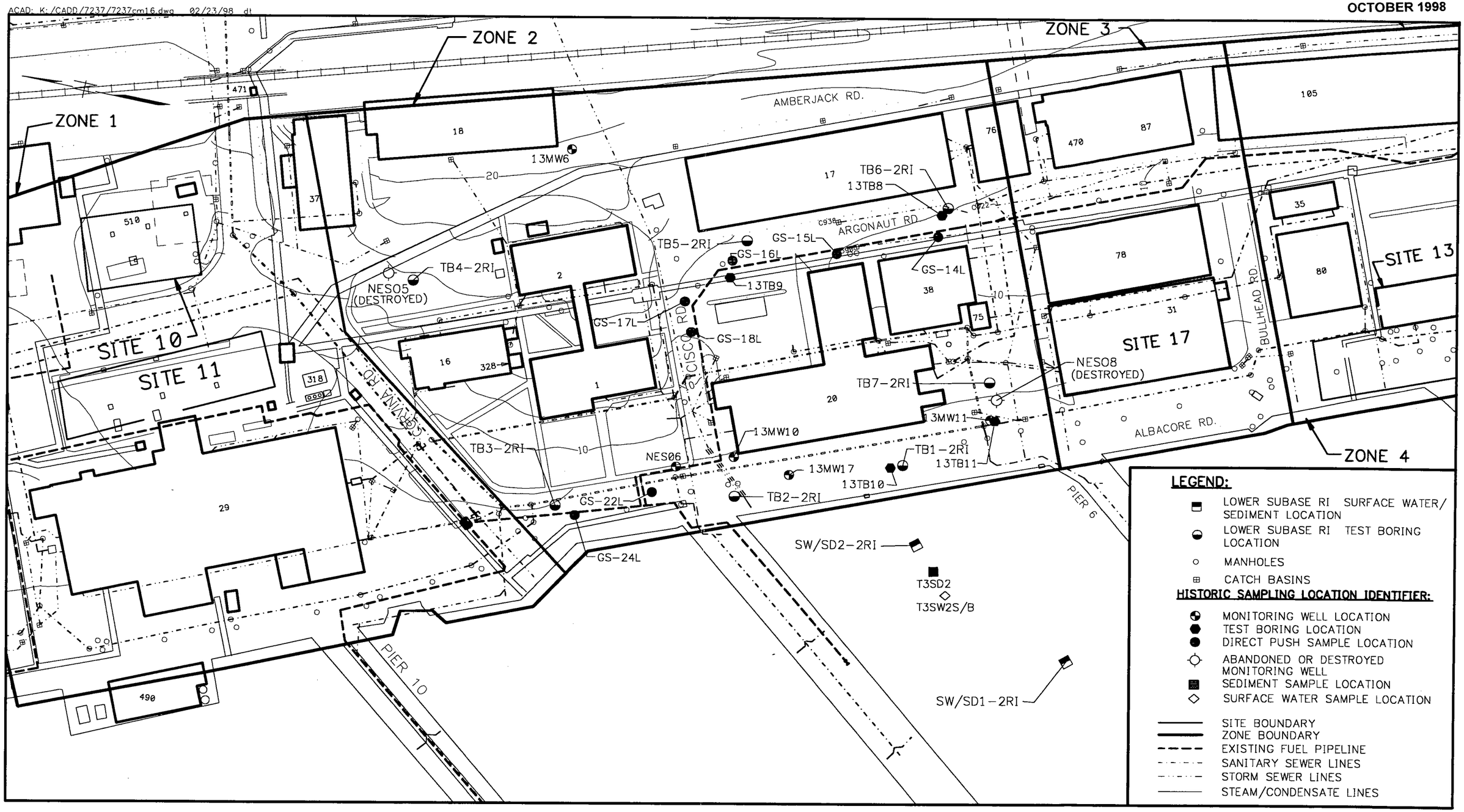


FIGURE 5-1

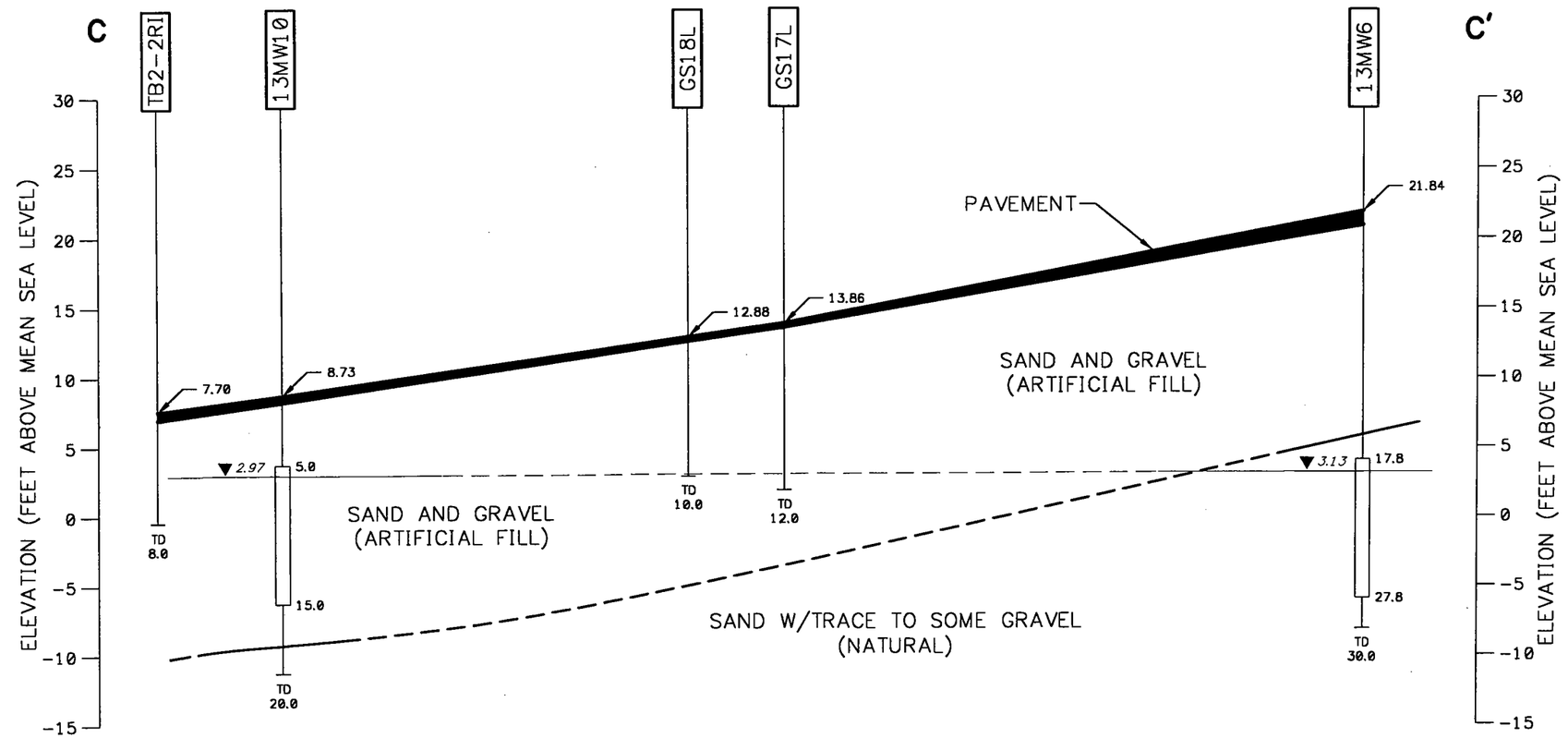
SAMPLE LOCATION MAP
ZONE 2
NSB-NLON, GROTON, CONNECTICUT

Brown & Root Environmental

019809/P

CTO 0260

ACAD: 7237gx03.dwg 09/30/98 HJP



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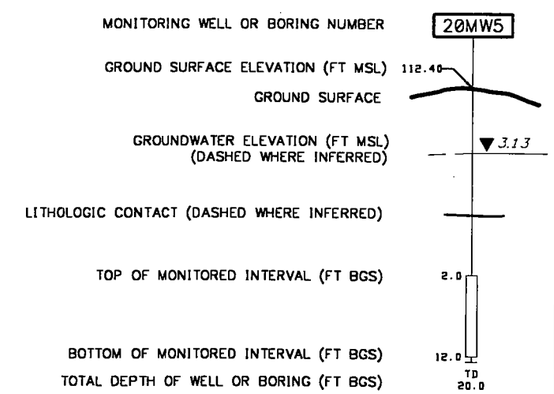
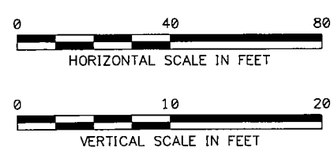




NOTES

1.) ELEVATIONS BASED ON SUBASE VERTICAL DATUM (1982)

2.) POTENTIOMETRIC SURFACE FOR LOW TIDE OCTOBER 27, 1997

3.) SEE DRAWING 5 FOR CROSS SECTION LOCATION

NO.	DATE	REVISIONS	BY	CHKD	APPD	REFERENCES

DRAWN BY MF DATE 2/15/98
CHECKED BY DATE
COST/SCHED-AREA
SCALE AS NOTED

Brown & Root Environmental

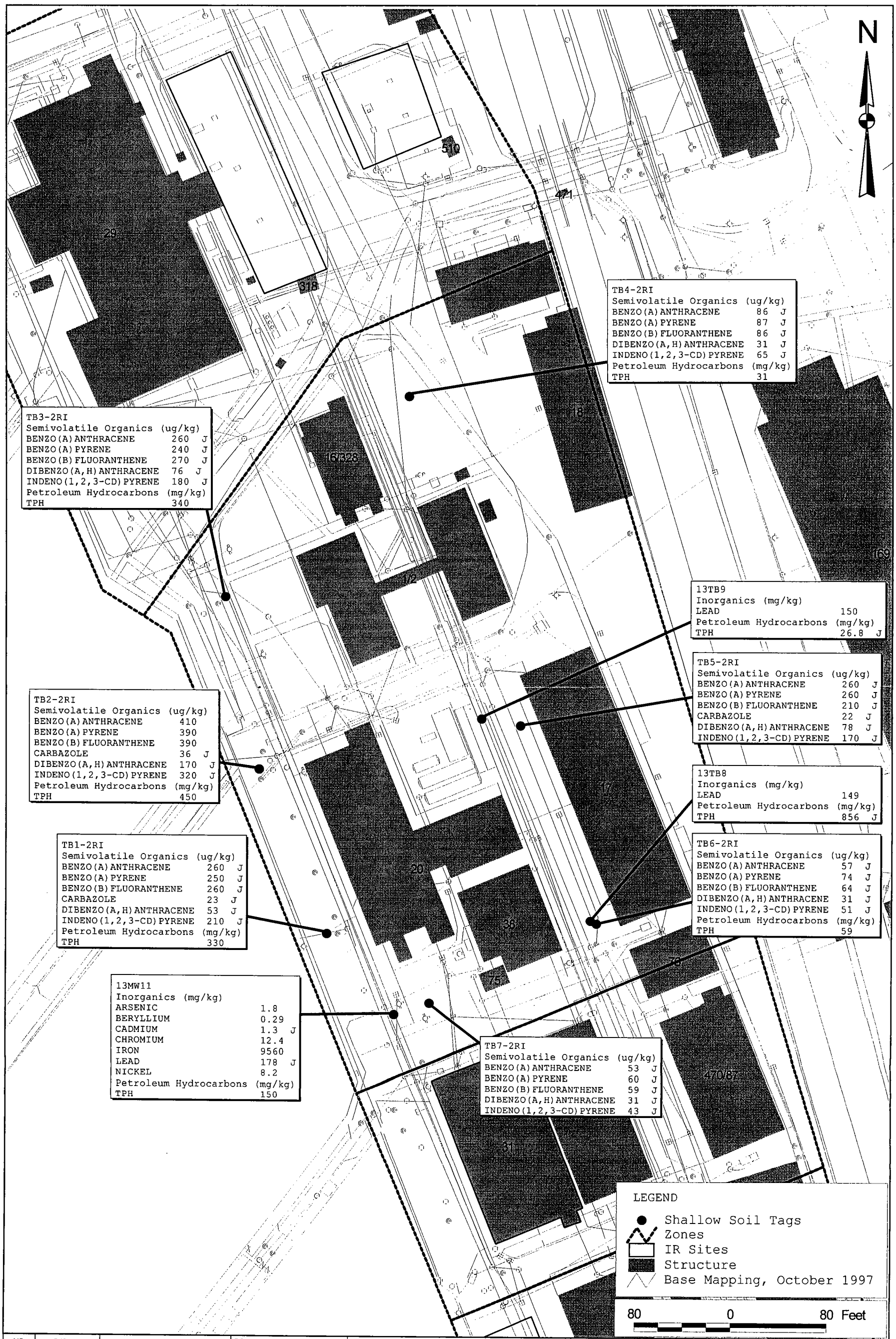
GENERALIZED GEOLOGIC CROSS SECTION C – C'
ZONE 2
LOWER SUBASE RI
NSB-NLON, GROTON, CONNECTICUT

CONTRACT NO. 7237
OWNER NO. 0260
APPROVED BY Gary A. Pick DATE 10/7/98
APPROVED BY DATE
DRAWING NO. FIGURE 5-2
REV. 0

FORM CADD NO. SOUTH_BH.DGN - REV 0 - 02/11/97

P:\GIS\NLON\NLONTAGS.APR 24-FEB-98 SMT ZONE 2 SHALLOW SOIL TAG LAYOUT

019809/P

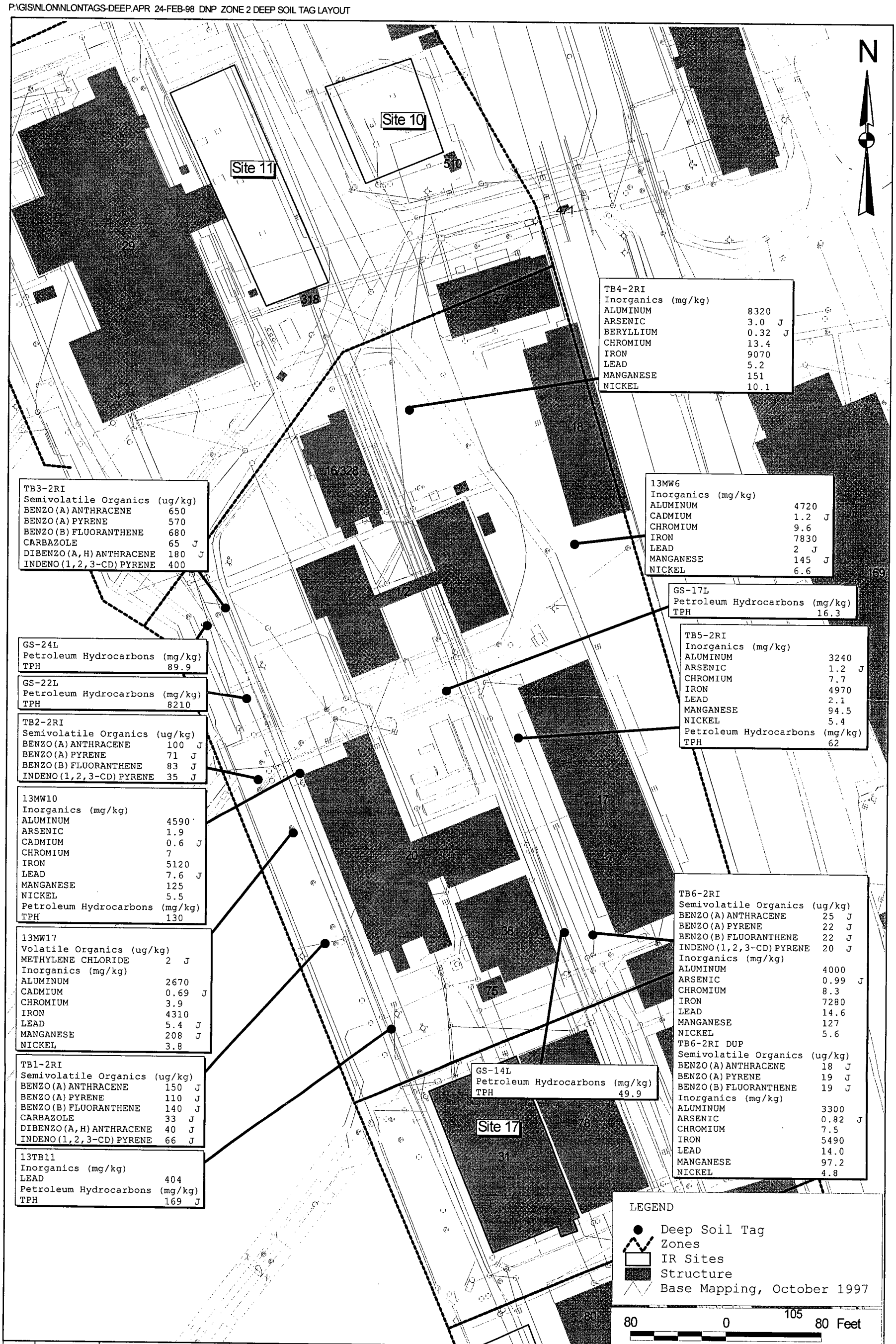


NO.	DATE	REVISIONS	DRAWN BY D. PERRY	DATE 17-FEB-98	Brown & Root Environmental	CONTRACT NO.	OWNER NO.
			CHECKED BY	DATE	ZONE 2 SHALLOW SOIL COPC POSITIVE DETECTS LOWER SUBASE RI NSB-NLON, GROTON, CONNECTICUT	APPROVED BY Cory A Reid	DATE 4/15/98
			COST/SCHED-AREA			APPROVED BY	DATE
			SCALE AS NOTED			DRAWING NO. FIGURE 5-3	REV. 0

REVISION 1
OCTOBER 1998

CTO 0260

P:\GIS\NLON\NLONTAGS-DEEP.APR 24-FEB-98 DNP ZONE 2 DEEP SOIL TAG LAYOUT



NO.	DATE	REVISIONS

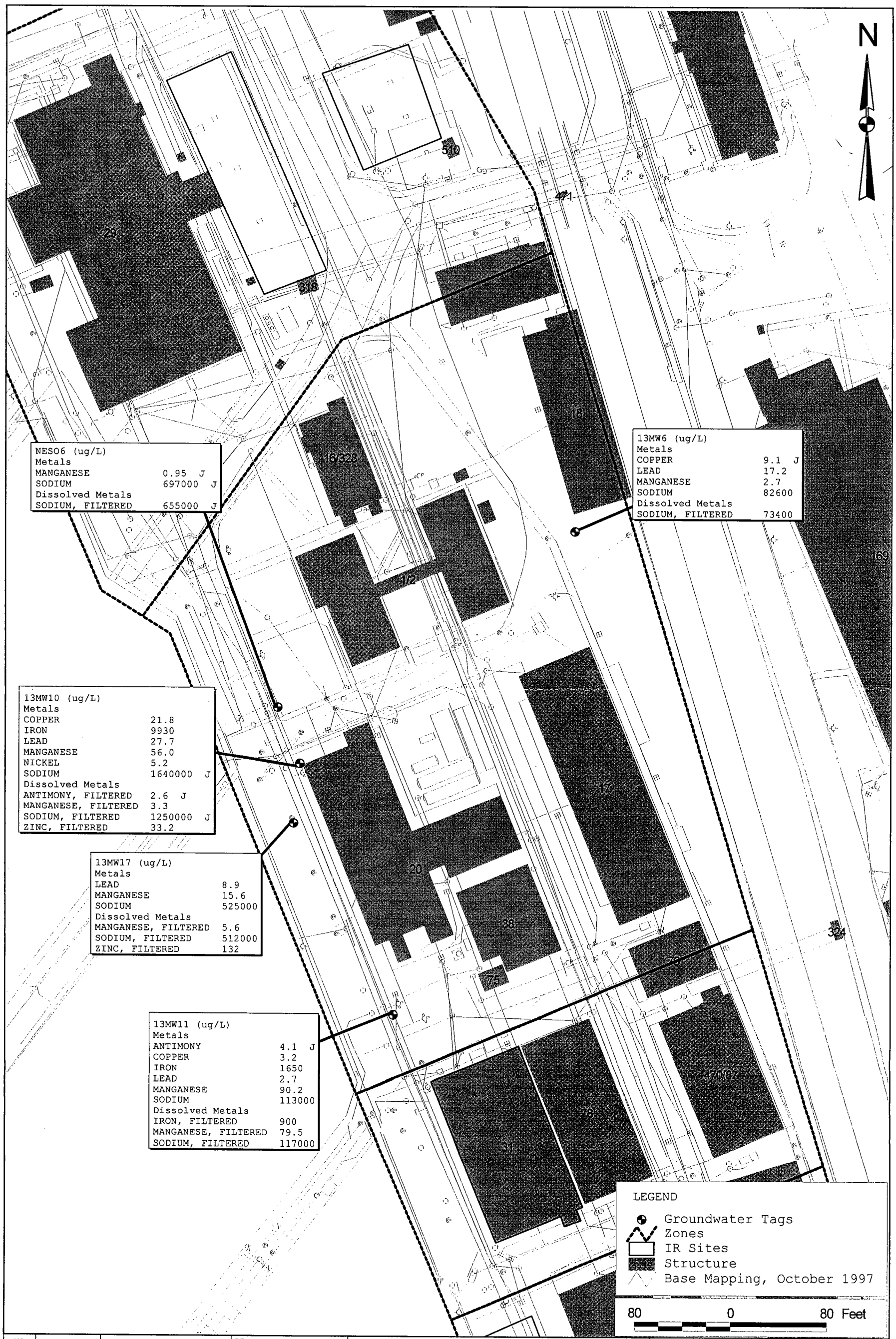
DRAWN BY D. PERRY DATE 24-FEB-98
CHECKED BY DATE
COST/SCHED-AREA
SCALE AS NOTED

Brown & Root Environmental

ZONE 2 DEEP SOIL
COPC POSITIVE DETECTS
LOWER SUBASE RI
NSB-NLON, GROTON, CONNECTICUT

CONTRACT NO. OWNER NO.
APPROVED BY Cory A Reid DATE 4/15/98
APPROVED BY DATE
DRAWING NO. FIGURE 5-4 REV. 0

P:\GIS\NLON\NLONTAGS.APR 25-FEB-98 SMT ZONE 2 GROUNDWATER TAG LAYOUT



NO.	DATE	REVISIONS	DRAWN BY	DATE	Brown & Root Environmental	CONTRACT NO.	OWNER NO.
			S. TABLER	25-FEB-98			
			CHECKED BY	DATE	ZONE 2 GROUNDWATER COPC POSITIVE DETECTS LOWER SUBASE RI NSB-NLON, GROTON, CONNECTICUT	APPROVED BY Cory A Reil	DATE 4/15/98
			COST/SCHED-AREA			APPROVED BY	DATE
			SCALE AS NOTED			DRAWING NO. FIGURE 5-5	REV. 0

6.0 ZONE 3

6.1 SITE DESCRIPTION

Zone 3 extends from Capelin Road along the southern end of Zone 2 to the southern side of Bullhead Road. It includes Site 17 - Hazardous Materials/Solvent Storage Area (Building 31), fuel oil distribution lines, and steam, condensate, and electrical ducts. The Providence and Worcester Railroad borders the eastern edge of Zone 3, and the Thames River lies to the west of it. Figure 6-1 illustrates the Zone 3 and Site 17 boundaries, fuel oil distribution lines, steam and condensate lines, and sewer lines within this zone. Photographs of the Zone 3 site are provided in Appendix G.

6.1.1 Site 17 - Building 31 - Former Battery Overhaul Shop

Building 31 was constructed in 1917 and was originally used as a battery shop until the mid-1950s. Battery overhaul was one of the largest operations conducted at the Subase prior to nuclear power. Old diesel submarines, containing approximately 100 batteries, were routinely serviced in the Battery Overhaul Shop at Building 31. Services ranged from charging batteries to complete battery overhaul. Spent acid from the overhauled batteries was disposed in a spent acid tank located at the Spent Acid Storage and Disposal Area - Site 15 (Envirodyne, 1983).

Building 31 has been used as the main hazardous/flammable materials warehouse since the 1970s. Items such as sulfuric acid, methyl isobutyl ketone, potassium hydroxide, potassium tetraborate, hydrofluoric acid, and nitric acid were stored in containers of up to 55-gallon capacity. In 1992, while the concrete floor of the building was being replaced to comply with RCRA regulations, a yellow discoloration was discovered in the soil beneath the floor slab. Analysis of soil samples revealed elevated levels of lead. As a result, an Action Memorandum was prepared (HNUS, 1993a) that recommended a time-critical removal action to include excavation, on-site solidification of all soils with a total lead concentration of 500 mg/kg or greater or a TCLP leachate lead concentration of 5 mg/L or greater, on-site backfilling, and off-site disposal of contaminated debris. A remedial design was performed (HNUS, 1993b) and the remedial action was completed during the first half of 1995 (HNUS, 1995a). Figure 6-2 shows the cells within Building 31 that were remediated.

6.1.2 Fuel Oil Distribution Lines and Utility Ducts

Fuel oil distribution lines and utility ducts and trenches run through Zone 3. Descriptions of the distribution lines and utility ducts and trenches are provided in Sections 1.4.1.3 and 1.4.1.4, respectively. The location

of the distribution lines and utility ducts are shown in Figure 6-1. In 1996, pressure leak testing was performed on the lines and valves in the fuel distribution system within Zone 3. The results of this testing program are presented in Section 6.2.5.

6.1.3 Storm Sewers

As can be seen on Figure 6-1, one storm sewer discharges to the Thames River within Zone 3. Invert elevations for the storm sewer outfall to the Thames River and the catch basin upgradient of the outfall were not readily available. Based on information obtained for other zones, it is likely that the Zone 3 storm sewer system will be submerged to varying degrees depending on the time of day and time of year. A typical cross-section for Zones 1 through 4, showing the storm sewer system and the variation in the tides, is provided on Figure 1-4 in Section 1.0.

6.2 SITE INVESTIGATIONS

The following investigations were conducted at Zone 3 and are discussed in the following subsections.

- Final Site Investigation - Subsurface Oil Contamination (Wehran, 1987)
- Phase I Remedial Investigation (Atlantic, 1992)
- Action Memorandum for Building 31 (HNUS, 1993a)
- Post Removal Action Report for Building 31 Lead Remediation (HNUS, 1995a)
- Leak Testing Investigation for Fuel Oil Distribution System (Heitkamp, 1996)
- Existing Data Summary Report for Lower Subase Remedial Investigation (B&R Environmental, 1997a)
- Phase II Remedial Investigation (B&R Environmental, 1997b)
- Site Investigation Report for Tank Farm Investigation (B&R Environmental, 1997c)

No sampling or analysis of the stormwater discharging from Zone 3 is conducted under the Navy's NPDES permit. Therefore, no information is available for discussion.

6.2.1 Final Site Investigation Subsurface Oil Contamination

In 1987, Wehran Engineering Corporation completed an investigation to identify and delineate the sources of heavy oils in the subsurface of the Lower Subase (Sites 10, 11, and 13). Activities completed during the investigation included collecting soil samples from soil borings, oil samples from manholes and trenches, and groundwater samples from monitoring wells. These samples were tested to identify the type, degree of weathering, and general concentrations of oil contamination at the three sites. One soil

boring, later converted to a monitoring well, was installed within Zone 3 (WE2) during this investigation. The location is shown on Figure 6-1.

Oil contamination (determined to be No. 6 fuel oil weathered less than a year) was observed in the trench that runs along Argonaut Road from approximately Building 85 (Zone 4) to near the northeastern corner of Building 78 (Zone 3). The fluorescence results indicated trace levels of No. 6 fuel oil in soils collected from the soil boring. The groundwater spectra were typical of waste oil. Wehran recommended inspection of the fuel lines within the trench and subsequent cleaning of the trench.

6.2.2 Phase I Remedial Investigation

An investigation of 11 sites was completed at NSB-NLON by Atlantic Environmental Services from 1990 through 1992. One site, identified as the Lower Subase - Site 13, included the area represented by Zones 1 through 4.

The Lower Subase Phase I field investigation consisted of a utility manhole inspection and waterfront bulkhead inspection for evidence of contamination sources. Also included were a soil gas survey, test boring completion, monitoring well installation, and soil and groundwater sampling.

During the utility manhole inspection, manhole covers were removed and inspected for visual evidence of oil. Four areas of significant petroleum accumulation were observed during the manhole inspection. One of these areas, Manhole 73, southwest of Building 31 and northwest of Building 80 on Albacore Road, was partially located within Zone 3. A thick black oil was observed in a manhole in this area. Possible sources for the accumulation were noted as previous product releases from underground fuel lines or storage tank leaks. The report indicated that there was no evidence of an ongoing release; the petroleum contamination appeared to be related to previous releases.

Inspection of the waterfront bulkhead was conducted from a boat during low tide. During the waterfront inspection, no oil seeps or sheens or evidence of such were observed anywhere along the waterfront at the Lower Subase.

A shallow soil gas survey (at depths of 12 to 18 inches) was also conducted within Zones 1 through 4. The results for Zone 3 indicated low VOCs at the southwestern corner of Building 31 and one area of low VOCs west of Buildings 80 and 79. All the soil gas points to the west of Building 79, extending approximately 100 feet to the eastern side of the building, contained trace or low levels of VOCs. Although most of the area near Building 80 is within Zone 4, a portion extends into Zone 3. The source of the

contamination is likely from Zone 4. These areas were further characterized by the subsurface investigation. One test boring (13TB5) and one soil boring, converted to a monitoring well (13MW12), were installed within Zone 3 and locations are shown in Figure 6-1. Soil and groundwater samples collected from 13MW12 were analyzed for VOCs, inorganics, TPH, and fluorescence. Soils from the test boring were screened in the field for organic vapors and examined visually but were not chemically analyzed.

Based on TPH and fluorescence results, subsurface soil along Bullhead Road contains No. 2 fuel oil/diesel oil, but petroleum contamination is not present in groundwater.

6.2.3 Action Memorandum for Building 31

An action memorandum was prepared by Halliburton NUS to document the decision to conduct a time-critical removal action at Building 31. After discovery of yellow discoloration underneath a concrete slab of Building 31, soil samples were collected underneath the floor at depths of 18 inches to 60 inches. Soils were found to be a RCRA hazardous waste (as defined under 40 CFR 261.24) based on TCLP lead concentrations exceeding 5.0 mg/L. An additional soil and groundwater investigation was conducted to better define the extent of contamination. Twenty-seven borings were drilled inside Building 31, and six borings were drilled outside. Sampling locations for this investigation are shown on Figure 6-2. A total of 101 subsurface soil samples were collected. Three surface soil samples (depths of 0 to 6 inches) were collected between Building 31 and Building 78. All soil samples were analyzed for lead. Also, 28 of the subsurface samples (collected from within Building 31) were analyzed for TCLP lead, and four of these were analyzed for RCRA metals. Four subsurface soil samples were also analyzed for TCL VOCs, SVOCs, pesticides/PCBs, and TAL metals plus cyanide. Four temporary well points (GW-01 to GW-04) were installed to determine groundwater quality within the Building 31 area. Two rounds of samples were collected. With the exception of two groundwater samples collected during the first round, samples were analyzed for total and dissolved RCRA metals. The two groundwater samples collected during the first round of sampling were analyzed for TCL organics and TAL metals plus cyanide (these samples were unfiltered).

Based on the results of sampling and analysis, the areas inside and outside Building 31 with lead concentrations in soil greater than 500 mg/kg were identified, and the proposed action for removal of these soils was identified. The removal action taken at Building 31 is discussed below.

6.2.4 Post Removal Action Report for Building 31 Lead Remediation

The time-critical removal action for Building 31, initiated by the Navy, consisted of excavation of lead-contaminated soil above mean low tide elevation and on-site or off-site treatment and disposal. A clean-up level for lead of 500 mg/kg was set for the removal action. The removal action included on-site solidification and stabilization of soil excavated from within Building 31 and backfilling of the stabilized soil within Building 31, installation of a concrete floor over the backfilled stabilized soil, off-site solidification and stabilization and disposal of contaminated soil excavated from three areas outside of Building 31, and backfilling with clean fill. The three areas outside Building 31 that were excavated include the area between Buildings 31 and 78, the area adjacent to Building 31 along Bullhead Road, and the area adjacent to Building 31 along Albacore Road. The removal action was conducted by National Environmental Services Corporation. Also, demolition debris and excavated materials not suitable for solidification/stabilization were screened for contamination and disposed at an off-site landfill either as hazardous or nonhazardous material. The cells that were excavated as part of the removal action within Building 31 are shown on Figure 6-2.

Based on the results of the post-removal action field verification sampling and analysis, B&R Environmental indicated that the excavation areas beneath Building 31, along Bullhead Road, and between Buildings 31 and 78 were no longer contaminated (i.e., lead concentrations were less than 500 mg/kg in soils above the mean low tide elevation), and no further action was required. Verification sampling after excavation along Albacore Road indicated lead concentrations were still above 500 mg/kg. However, because further excavation of soils along Albacore Road would interfere with base operations, the Navy postponed further removal action in this area, and the excavated area was backfilled with clean soil. Prior to backfilling, a non-woven geotextile liner was installed in the excavation along Albacore Road to prevent further contaminant migration and to allow for easy resumption of future removal actions.

6.2.5 Leak Testing Investigation for Fuel Oil Distribution System

In April and May 1996, Heitkamp performed pressure leak testing on the lines and valves in the fuel distribution system within Zone 3. All sections of the line and various valves tested in the portion of the distribution system within Zone 3 passed the pressure testing procedures.

6.2.6 Site Investigation for Tank Farm Investigation

B&R Environmental conducted an investigation in 1995 of the UST farm along Crystal Lake Road. The primary objectives of the investigation were to define the extent of soil and groundwater contamination from the UST farm, evaluate the impact of the UST farm on the stormwater discharge, and recommend

remedial alternatives, if needed. As part of the tank farm investigation, underground pipelines from the fuel loading dock (Pier 1), throughout a portion of the Lower Subase (Zones 1 through 4), and the gate valve (Building 322) to tanks within the tank farm were investigated. Soil samples were collected along the new and old diesel underground pipeline at approximately 100-foot intervals. The samples were analyzed for TPH. The No. 6 fuel oil lines were not included as part of the investigation because they were installed within concrete-lined trenches, which would prevent or minimize any potential soil and groundwater impact from leaks. Two samples (FPTB12L-08 and FPTB13L-07) and one duplicate (DUP17-111895) were collected within Zone 3 (GS-12L and GS-13L). TPH concentrations were less than 25 mg/kg.

The report recommended that additional integrity inspections be performed to determine the locations of previous line leaks on both active and inactive product lines throughout the Lower Subase. In addition, a records review was recommended to identify previous leaks based on the results of line inspections and tightness tests.

6.2.7 Phase II Remedial Investigation

B&R Environmental conducted a Phase II RI at 13 sites at NSB-NLON. Soil boring installation and soil and groundwater sampling at Zone 3 were included in the investigation. Six soil samples were collected from four borings (13TB5A, 13TB7, 13TB12, and 13TB18) and analyzed for lead, TPH, and TCLP metals. Groundwater samples were collected from one existing monitoring well (13MW12) and analyzed for VOCs, SVOCs, metals (total and dissolved), and TPH.

Relatively high concentrations of TPH (maximum - 3,400 mg/kg) were found in Zone 3 soil, particularly along Bullhead Road. In addition, lead was detected at 1,320 mg/kg in shallow soil in the vicinity of Building 31 (Site 17).

The Phase II RI recommended that further characterization of the Lower Subase be performed during a separate RI. This characterization effort should emphasize evaluation of the nature and extent of lead, TPH, and SVOCs in soil. Continued groundwater sampling and analyses were also recommended to monitor contamination levels. In addition, a focused data collection effort was recommended that would provide information relevant to an FS to evaluate potential remedial options for the site.

6.2.8 Existing Data Summary Investigation for Lower Subase

The Existing Data Summary Report for the Lower Subase RI was developed as part of the first tier of data collection to accumulate data from several studies, including the Phase II RI, and to identify potential data gaps that would then be filled in during the Lower Subase RI.

With respect to Zone 3, the Existing Data Summary Report recommended that TPH, lead, and SVOC concentrations in the soil be further characterized. In addition, the report recommended that lead levels continue to be monitored in the groundwater, the mobility of lead in shallow and deep soil be determined through sampling and analysis using the SPLP method, the amount of lead entering the Thames River be quantified, and ecological impacts in the Thames River be evaluated. The report also recommended that further characterization activities at Zone 3 be coordinated with sediment sampling of the Thames River in the vicinity of Zone 3 to aid in the identification of source areas and contaminants of concern.

With respect to the fuel oil distribution lines, utility ducts, and storm sewers located in Zone 3, the report recommends that fuel line leak detection systems be evaluated to ensure against leakage, past and present fuel line leaks be identified and repaired, and utility ducts and trenches and storm sewers be inspected, and repaired if necessary and any contaminated material found be removed.

6.2.9 Lower Subase Remedial Investigation

Five test borings (TB1-3RI through TB5-3RI) were installed to the water table in Zone 3. Borings TB3-3RI, TB4-3RI, and TB5-3RI were advanced using DPT. Borings TB1-3RI and TB2-3RI were advanced using HSA techniques and converted to monitoring wells MW1-3RI and MW2-3RI, respectively. Monitoring well screen intervals were installed across the water table. Boring and monitoring well locations are illustrated in Figure 6-1. Boring log sheets and monitoring well construction sheets are provided in Appendix A. Two soil samples were collected from each boring from shallow (0 to 5 feet) and deep (greater than 5 feet) depths. SVOC analysis was performed on all shallow and deep samples. Shallow soil samples from test borings TB1-3RI, TB2-3RI, and TB4-3RI were analyzed for TPH. TAL metals analysis were performed on the shallow and deep soil samples at locations TB1-3RI, TB2-3RI and TB5-3RI. SPLP lead analysis was performed on shallow soil samples collected at TB1-3RI and TB2-3RI and on deep soil samples collected at TB2-3RI and TB5-3RI. Soil sample log sheets are included in Appendix B.1.

Groundwater samples were collected from existing monitoring wells 13MW12 and installed monitoring wells MW1-3RI and MW2-3RI. Groundwater samples were collected using low-flow purging and sampling techniques, as described in Section 2.3.2. Samples were analyzed for TPH, TCL SVOCs, filtered and

unfiltered TAL metals, and natural attenuation parameters. Groundwater sample log sheet and purge data sheets are provided in Appendix B.2.

Two sediment samples (SD1-3RI through SD2-3RI) were collected from locations in the Thames River along Zone 3. Sediment sampling locations are illustrated on Figure 6-1. Surface water quality measurements were taken from each sediment sampling location at the surface and the bottom of the water column. Sediment samples were analyzed for TCL SVOCs, TAL metals, TOC, grain size, AVS/SEM, pH, and ammonia. Surface water quality parameters that were measured included temperature, salinity, turbidity, pH, specific conductance, and dissolved oxygen. Sediment sample log sheets with surface water measurements are provided in Appendix B.3.

6.3 PHYSICAL CHARACTERISTICS

General physical characteristics of the Lower Subase are discussed in Sections 1.3 and 1.4. Site-specific physical characteristics for Zone 3 are discussed in the following subsections.

6.3.1 Topography, Surface Features and Surface Water Features

The ground surface of Zone 3 slopes gently to the Thames River, from an elevation of 10 feet along its eastern side to 8 feet along the waterfront. All of Zone 3 is paved or covered with buildings.

No significant surface water features are located within Zone 3. Surface water runoff in Zone 3 is collected in catch basins and drained through storm sewers to the Thames River, which is adjacent to Zone 3. Catch basins and storm sewers in Zone 3 are shown in Figure 6-1. One storm sewer along Capelin Road discharges to the Thames River at Pier 6.

6.3.2 Soil Characteristics, Geology, and Hydrogeology

The soils of Zone 3 are mapped as Urban Land (USDA, 1983), and the surficial geology is mapped as artificial fill (USGS, 1960). A north-south cross-section of Zone 3 is illustrated in Drawing 7, and a west-east cross-section of Zone 3 is illustrated in Figure 6-3. Based on borings, Zone 3 is underlain by 10 to 20 feet of sand and gravel fill overlying fine sand and silt. The sand and silt units are interpreted as natural stratified drift deposits. The bottom of the sand and silt unit was not encountered during boring installations, and its depth is unknown. Borings in Zone 3 were not advanced to bedrock, and the bedrock depth in Zone 3 is unknown. However, the USGS bedrock map (USGS, 1967) identifies the Mamacoke Formation underlying Zone 3, and the Phase II RI report (B&R Environmental, 1997b) estimates the bedrock to be more than 60 feet below msl (70 feet bgs) in this area.

Extending along the river as far north as boring 13TB12, the wooden pier of the former quay wall is present approximately 6 feet below grade. Sand and gravel fill overlie and underlie the wooden pier, except in the area of 13TB18 where a void space of 4 feet exists beneath the wooden pier. The wooden pier extends to the south into Zone 4.

The unconfined water table in Zone 3 lies within the sand and gravel fill and the underlying sand unit. Depth to the water table ranges from approximately 4 to 5 feet bgs in monitoring wells located along the river to 6 feet bgs at 13MW12 further inland. Groundwater flow is generally to the west toward the Thames River during low and high tides. Tidal influence is restricted to monitoring wells along the Thames River (MW1-3RI and MW2-3RI).

Based on a slug test conducted by Atlantic (1992) in well 13MW12 in Zone 3, the hydraulic conductivity of the sand and gravel fill is 1.7 feet per day. The hydraulic gradient across Zone 3 is 0.00792 from 13MW12 to MW1-3RI, based on water-level data during low tide on October 27, 1997.

The volumetric rate of groundwater discharge through the sand and gravel fill material in Zone 3 to the Thames River was calculated to be 32.3 cubic feet per day, using Darcy's Law $Q = -KA(dh/dl)$, where Q = the volumetric discharge, K = the hydraulic conductivity, A = the cross-sectional area (i.e., the saturated fill thickness by the width of the fill material along the Thames River), and dh/dl = the hydraulic gradient. An average saturated fill thickness of 12 feet and a width of 200 feet of fill along the Thames River in Zone 3 were assumed.

Generic contaminant loading rates for groundwater discharge into the Thames Rive from Zone 3 were generated using an estimated groundwater discharge rate (Q, discounting tidal effects) of 32.3 cubic feet/day; a 0.75 factor applied to this flux rate to account for the lack of groundwater discharge during periods of high tide (assumed to be about 6 hours/day over two tidal cycles); hypothetical solute concentrations (C) of 10, 100, and 1,000 µg/L; and the following mass flux equation: Mass flux = Q x 0.75 x C. The corresponding daily discharge rates from Zone 3 into the Thames River are 0.000015, 0.00015, and 0.0015 lbs/day for solute concentrations of 10, 100, and 1,000 µg/L, respectively. Actual discharge rates for individual dissolved constituents can be approximated by using these generic discharge rates and the average concentration of the constituent. For example, a compound present at an average concentration of 25 µg/L in groundwater would have a loading rate 2.5 times the generic rate calculated for a solute present at the 10 µg/L concentration. This loading estimate does not factor in retardation and degradation of solutes, which may be substantial in some cases and would reduce the loading rate.

6.4 NATURE AND EXTENT OF CONTAMINATION

This section is a discussion of the nature and extent of contamination of Zone 3 at the Lower Subase. The general site location of Zone 3 is shown on Figure 1-2, and a detailed drawing of Zone 3 is shown on Figure 6-1. Soil and groundwater samples were collected during the Phase I, Phase II, and Lower Subase RIs, as well as during the other investigations discussed in Section 6.2. Summaries of the sampling and analytical programs are provided in Tables 6-1 through 6-7. The complete database for Zone 3 is contained in Appendix H of this report, including both chemical and physical parameters for all investigative samples.

6.4.1 Soil

Positive analytical results for all soil samples collected in Zone 3 are presented in Table 6-8. Positive TCLP and SPLP results for soil samples are presented in Tables 6-9 and 6-10, respectively. With the exception of soil samples excavated during the time-critical removal action for Building 31, the analytical results from all Zone 3 soil samples are summarized in Table 6-11. Observations made based on fluorescence spectroscopy of Zone 3 soil samples are summarized in Table 6-12; these observations were obtained from the text of the Final Site Investigation Subsurface Oil Contamination (Wehran, 1987) and the Phase I RI report (Atlantic, 1992). Background concentrations of inorganics in soil, as presented in Table 1-4 and used for comparison with on-site soil concentrations, were taken from the Background Concentrations of Inorganics in Soil Report (Atlantic, 1995b).

Figures 6-4 and 6-5 show, for Zone 3 shallow and deep soil samples, respectively, the locations and concentrations of parameters that were detected in excess of COC selection criteria used in the risk assessment. Drawings 8 through 11, located in Volume III of this RI report, show the distribution of TPH and lead contamination in soil in all zones, including Zone 3, being investigated as part of the Lower Subase RI. Drawings 8 and 10 show TPH and lead isoconcentration contours, respectively, for shallow soils, and Drawings 9 and 11 show the same respective contours for deep soils.

6.4.1.1 Shallow Soil

A majority of the shallow soil samples (0 to 4 feet bgs) collected from Zone 3 were analyzed for lead. A limited number of samples were also analyzed for VOCs, SVOCs, metals, and TPH. A majority of the soil samples were collected within Building 31. A few were also collected along Albacore Road, Bullhead Road, and the northeastern side of Building 78. Lead concentrations were detected at concentrations exceeding background in many shallow soil samples. Cadmium, calcium, mercury, nickel, sodium, and

zinc were also each detected at concentrations greater than background levels in some samples. However, it should be noted that calcium and sodium are natural, abundant constituents in soil.

Lead concentrations in soil samples collected as part of the investigation for the time-critical removal action at Building 31 were as high as 16,000 mg/kg prior to excavation. In addition, TCLP lead concentrations in some of these soil samples exceeded both Connecticut remediation standard pollutant mobility criteria for GB areas and Federal toxicity characteristic regulatory levels. Most lead-contaminated soil underneath and adjacent to Building 31 was remediated in 1995 as part of the removal action.

Drawing 10 shows the distribution of lead in shallow soils from Zone 3 after excavation was complete. The majority of the data points used to generate the contours are associated with sampling locations within Building 31. The contours suggest that lead detected in shallow soils along Albacore Road in Zone 3 is related to the lead contamination of the soils beneath Building 31. Lead at concentrations exceeding 500 mg/kg (the clean-up level for lead used for the removal action) is still present in soils along Albacore Road. Concentrations of lead in the samples collected along Albacore Road range from 513 mg/kg to 4,390 mg/kg. Concentrations of lead in samples collected south of Building 31 along Bullhead Road are all less than the 500 mg/kg clean-up level, ranging from 36.8 mg/kg to 413 mg/kg.

Of the soil remaining after the removal action, concentrations of lead in seven of 13 shallow soil TCLP leachates exceeded the Connecticut remediation standard pollutant mobility criterion for GB classified area but were less than the Federal toxicity characteristic regulatory level. The concentration of lead in the SPLP leachate of one of three shallow soil samples collected along Albacore Road during the Lower Subase RI exceeded the Connecticut remediation standard pollutant mobility criterion but was less than the Federal toxicity characteristic regulatory level for lead. Concerning potential migration, the results of the recent SPLP analyses confirm the results of the historical TCLP analyses.

Acetone (130 µg/kg), chloroform (1 µg/kg), and methylene chloride (4 µg/kg) were detected in the single shallow soil sample analyzed for VOCs. Several SVOCs were detected in the Zone 3 shallow soil samples. PAHs, at concentrations ranging from 17 µg/kg (acenaphthene) to 2,500 µg/kg (pyrene), were most commonly and most frequently detected. With the exception of naphthalene, the maximum concentrations of all SVOCs were detected in the sample collected from boring TB4-3RI, located between the eastern corner of Building 78 and the fuel pipeline.

TPH was detected in all seven of the shallow soil samples analyzed for this parameter. With the exception of the sample collected from location 13TB7 (65.2 mg/kg), TPH concentrations for the Zone 3 shallow soil samples ranged from 450 mg/kg to 1,600 mg/kg. These relatively high concentrations were

detected west, south, and east of Buildings 31 and 78. The maximum concentration was detected at location MW2-3RI, west of Building 31 along Albacore Road. Drawing 8 shows isoconcentration contours of TPH for shallow soil samples collected from the Lower Subase, including Zone 3. Trace levels of No. 6 fuel oil, a heavy fuel oil, were determined to be present in the shallow soil sample collected from Well WE2 (see Table 6-12), located along Bullhead Road, during the Final Site Investigation Subsurface Oil Contamination (Wehran, 1987).

6.4.1.2 Deep Soil

A majority of the deep soil samples (greater than 4 feet bgs) collected from Zone 3 were analyzed for lead. A limited number of samples were also analyzed for VOCs, SVOCs, metals, and TPH. A majority of the soil samples were collected within Building 31. A few were also collected along Albacore Road, Bullhead Road, and the northeastern side of Building 78.

Concentrations of arsenic, cadmium, copper, manganese, selenium, and silver each exceeded NSB-NLON background levels (presented in Table 1-4) in one of the five deep soil samples analyzed for metals, although the locations of the maximum concentrations varied. Concentrations of nickel and zinc exceeded NSB-NLON background levels in two and three deep soil samples, respectively. Lead concentrations measured in the deep soil samples ranged from 2.6 mg/kg to 6,060 mg/kg, which also exceeded the respective background level. Calcium and sodium concentration in all deep soil samples exceeded background levels. However, these chemicals are natural, abundant constituents of soil. With the exception of lead, maximum concentrations of metals in Zone 3 were generally randomly scattered, but within the same order of magnitude as concentrations detected in most of the other zones within the Lower Subase. Typically, the concentrations of these metals were either slightly above (within a factor of 4) or slightly below (within a factor of 4) background levels.

Drawing 11 shows isoconcentration contours of lead concentrations measured in Zone 3 deep soil samples. The majority of the data points used to generate the contours are associated with sampling locations within Building 31. The maximum concentration of lead (6,060 mg/kg) was detected along Albacore Road in a sample collected near the northwestern corner of Building 31. The lead concentrations measured in deep soil samples are roughly the same order of magnitude as the concentrations measured in the shallow soil samples.

Concentrations of lead in three of nine deep soil TCLP leachates exceeded the Connecticut remediation standard pollutant mobility criterion for GB classified area. Unlike shallow soil TCLP leachates, the concentration of lead detected in one deep soil TCLP leachate (from boring SB17, located within Building

31) exceeded the Federal toxicity characteristic regulatory level for lead. The maximum TCLP leachate concentration for deep soil samples (5.88 mg/L) is approximately two times higher than the maximum TCLP leachate concentration for the shallow soil samples (2.89 mg/L). The concentration of lead detected in the single deep soil sample SPLP leachate was less than both the Connecticut mobility criterion and the Federal toxicity characteristic regulatory level. Concerning potential migration, the results of the recent SPLP analyses do not support the results of the historical TCLP analyses.

Six VOCs were detected in one of two deep soil samples analyzed for these compounds (SB22). This sample was collected during the investigation/remediation of Building 31. Acetone, a common laboratory contaminant, was detected at a concentration of 84 µg/kg. All other VOCs were detected at concentrations ranging from 0.8 µg/kg to 6 µg/kg.

Results for SVOCs detected in the Zone 3 deep soil samples generally mirrored those reported for Zone 3 shallow soil samples, although detected SVOC concentrations were slightly higher for deep soils. PAHs, at concentrations ranging from 18 µg/kg (naphthalene) to 4,400 µg/kg (pyrene), were again most commonly and most frequently detected. A majority of the maximum concentrations of SVOCs were once again detected in the sample collected from boring TB4-3RI, although the deep soil sample collected from boring TB5-3RI contained the maximum detected concentrations for several SVOCs. Soil boring TB5-3RI is also located between Building 78 and the fuel pipeline, along the northeastern side of Building 31.

TPH concentrations in deep soil samples ranged from 18.6 mg/kg to 3,400 mg/kg, with the maximum concentration detected in the deep soil sample collected from boring 13MW12. Based on fluorescence analysis from the Phase I RI, an area of No. 2 fuel/diesel oil is present in the vicinity of 13MW12. Drawing 9 shows isoconcentration contours of TPH measured in deep soil. The high detection of TPH at 13MW12 is most likely due to a leak in the fuel pipeline located east and upgradient of the monitoring well. Trace levels of No. 6 fuel oil were also determined to be present in the deep soil sample collected from well WE2 during the Final Site Investigation Subsurface Oil Contamination (Wehran, 1987).

6.4.2 Groundwater

Positive analytical results for all groundwater samples collected from Zone 3 are presented in Table 6-13. Table 6-14 summarizes analytical results for groundwater samples collected from Zone 3 during historical investigations (i.e., prior to the Lower Subase RI) and during the Lower Subase RI. Table 6-15 summarizes observations made based on fluorescence spectroscopy data for Zone 3 groundwater samples; these observations were obtained from the text of the Final Site Investigation - Subsurface Oil Contamination (Wehran, 1987) and the Phase I RI report (Atlantic, 1992). Finally, Table 6-16 summarizes

analytical results for natural attenuation and groundwater quality parameters collected during the Lower Subase RI; these data will be discussed in Section 6.5.3.

Figure 6-6 shows, for data collected during the Lower Subase RI only, the locations and concentrations of parameters that were detected in excess of COC selection criteria used during the risk assessment. Drawings 12 through 14 (Volume III) show the distribution of TPH and lead contamination in groundwater for all zones, including Zone 3, of the Lower Subase. These drawings include only recent groundwater data collected during the Lower Subase RI. Drawing 12 shows isoconcentration contours of TPH concentrations measured in groundwater. Isoconcentration contours of unfiltered (total) and filtered (dissolved) lead concentrations in groundwater are presented on Drawings 13 and 14, respectively.

6.4.2.1 Historical Data

Four temporary wells (GW-01 through GW-04) and one permanent monitoring well (13MW12) were located in Zone 3 prior to the Lower Subase RI. Two rounds of groundwater samples were collected from each temporary well for the investigation completed for the Action Memorandum at Building 31. Three rounds of groundwater samples were collected from well 13MW12 during the Phase I and Phase II RIs.

Analyses for total metals were performed for unfiltered groundwater samples collected during all five sampling rounds. Twenty metals were detected in unfiltered groundwater samples. Of these metals, arsenic, barium, calcium, chromium, iron, lead, magnesium, manganese, nickel, potassium, sodium, and zinc were detected in more than half of the unfiltered groundwater samples. The maximum concentrations of all total metals were detected in groundwater samples collected from the temporary wells within Building 31; a majority of the maximum detections were associated with well GW-02.

Analyses for dissolved metals were performed for filtered groundwater samples from well 13MW12 during the two rounds of sampling for the Phase II RI (in March and June of 1994) and for filtered groundwater samples from wells GW-01 through GW-04 during two rounds of sampling for the Building 31 Action Memorandum. Eleven metals were detected in the filtered groundwater samples. Barium, calcium, iron, magnesium, manganese, potassium, and sodium were detected in all filtered samples. Selenium was only detected in the sample from well 13MW12 during Round 1 of the Phase II RI, and zinc was only detected in the sample from well 13MW12 during Round 2 of the Phase II RI. The concentrations of metals detected in filtered samples were generally less than the concentrations of metals detected in unfiltered samples, although the degree of difference was greater for samples collected from the temporary wells within Building 31 than for samples collected from well 13MW12.

The concentrations of lead in unfiltered groundwater samples collected from beneath Building 31 were substantially higher than concentrations of lead in filtered groundwater samples collected from beneath Building 31. These results indicate that lead is sorbed to the suspended soil particles in the groundwater and may not be soluble. These high levels of lead are most likely due to the former activities within Building 31. Concentrations of lead detected in the unfiltered groundwater samples collected from the temporary wells within Building 31 ranged from 41.5 µg/L to 392 µg/L, and the maximum concentration of lead detected in groundwater samples collected from well 13MW12 was 3.2 µg/L. These results are reasonable because well 13MW12 is located upgradient of the lead contamination that has been associated with Building 31.

No VOCs were detected in groundwater samples during any of the historical sampling rounds. Bis(2-ethylhexyl)phthalate and fluorene were the only SVOCs detected in groundwater. Low concentrations (0.6 µg/L to 1 µg/L) of these two SVOCs were detected in the groundwater sample and field duplicate sample collected from well 13MW12 during Round 2 of Phase II RI sampling. Analysis for SVOCs was not performed for groundwater samples during the Phase I RI. Analysis for SVOCs was performed for groundwater samples from wells GW01 and GW02 during Round 1 of the sampling for the Building 31 Action Memorandum; however, no SVOCs were detected.

None of the groundwater samples collected from the temporary wells were analyzed for TPH. TPH was not detected in any of the samples collected from monitoring well 13MW2 during the Phase I and Phase II RIs. Fluorescence spectroscopy conducted during Phase I RI showed trace TPH at concentrations too low to identify the type of oil or fuel present. Groundwater from a well located along Bullhead Road, installed and sampled before the Phase I RI (WE2), had spectra typical of waste oil.

6.4.2.2 Lower Subase RI

Two additional permanent wells (MW1-3RI and MW2-3RI) were installed and sampled during the Lower Subase RI. Groundwater samples were also collected from well 13MW12 during the Lower Subase RI.

Thirteen metals were detected in the groundwater samples. Barium, calcium, magnesium, manganese, potassium, and sodium were detected in both the filtered and unfiltered samples from all three wells. Lead was detected in the filtered (10.5 µg/L) and unfiltered (9.7 µg/L) groundwater samples collected from well MW2-3RI only. Drawings 13 and 14 depict the distribution of lead in unfiltered and filtered groundwater samples, respectively. Silver was also detected in the filtered (1.6 µg/L) and unfiltered (1.4 µg/L) samples collected from well MW2-3RI. In addition, chromium, iron, nickel, and zinc were each detected in one or two unfiltered samples and antimony, iron, and zinc were each detected in one or two filtered groundwater

samples. Concentrations of metals detected in filtered and unfiltered groundwater samples were generally similar in magnitude, although for some samples dissolved metals results were slightly higher than respective total metals results. The differences were typically minor and would be considered to be within the reporting accuracy of the analytical test. For one sample pair, the laboratory ran different dilutions for the dissolved versus total metals samples and this could be the reason for the difference in the analytical results.

Groundwater samples from these three wells were not analyzed for VOCs. Fluorene was once again detected at a low concentration (0.9 µg/L) in the groundwater sample collected from well 13MW12.

TPH was not detected in any of the three groundwater samples collected during the Lower Subase RI. Based on the sensitivity of the method used for analysis, the reporting limits for TPH were greater than the Connecticut remediation criterion of 500 µg/L. The presence of TPH below the reporting limits could not be confirmed since TPH at concentrations less than the reporting limits would not have been reported. Based on convention, one-half the reporting limit is shown on Drawing 12 for each well. The values provided on Drawing 12 (500 µg/L to 550 µg/L) for Zone 3 samples are equal to or slightly greater than the Connecticut remediation criteria of 500 µg/L.

6.4.3 Surface Water/Sediment

Sediment and surface water samples were collected from the Thames River adjacent to Zone 3. The nature and extent of contamination in Thames River sediment and surface water samples, as well as the impact of the activities and contamination at the Lower Subase (including Zone 3) on the Thames River sediments and surface water, are discussed in Section 11.4.

6.5 CONTAMINANT FATE AND TRANSPORT

6.5.1 General Contaminant Fate and Transport Processes

The major area of concern for Zone 3 is impacted soil, as evidenced by detection of elevated concentrations of lead and other metals in shallow and deep soils relative to background concentrations. In addition, TPH (which is comprised of PAHs and other compounds) was detected in both shallow and deep soil samples.

As noted in Section 3.3.2.9, metals are highly persistent environmental contaminants. They do not biodegrade, photolyze, hydrolyze, etc. The major fate mechanisms for metals are adsorption to the soil matrix (as compared to being part of the soil structure) and bioaccumulation.

In addition, under normal conditions, metals are not very mobile in the environment. Because metals frequently remain bound to particulate matter, the major transport mechanism for metals is bulk movement processes (erosion). However, metals can become mobile in the environment under certain conditions. The mobility of metals is influenced primarily by their physical or chemical properties in conjunction with the physical and chemical properties of the soil matrix. Factors that assist in predicting the mobility of metals are the soil/pore water pH, REDOX potential, and cation exchange capacity. The mobility of metals generally increases with decreasing soil pH and cation exchange capacity. The effect of REDOX potential varies for each metal.

Within Zone 3, metals were detected in shallow soil samples and deep soil samples at elevated levels. The presence of metals in the soil samples may be indicative of the fill material used to construct the Lower Subase. However, the presence of lead in deep soil samples and groundwater samples is more likely the result of handling of lead batteries used in submarines for underwater propulsion until the 1950's. Because of the low pH acid present in the batteries, the lead in the batteries would have been extremely mobile, and if the batteries had been spilled on the ground surface, the lead would have migrated much farther than under normal conditions.

Building 31, as noted earlier, was the Former Battery Overhaul Shop for the Subase until the mid-1950s. Soil beneath the building was remediated in 1995. However, the data indicate that residual lead contamination is still present in the shallow and deep soil in the area between Building 31 and the quay wall. In this area, the concentrations of lead in the shallow soil samples were generally higher than the concentrations in the deep soil samples, indicating that migration of lead has not occurred to a great extent. With the exception of two samples (EXBE05-04 and EXNW08-07), the concentrations of lead detected in the soils under Building 31 are below the clean-up level of 500 mg/kg.

Because the use of the lead acid batteries was discontinued in the 1950's, it is likely that the pH of the media in the area of Zone 3 has increased to its present level (groundwater pH between 6.45 and 6.83 and average soil pH above 6). In soil with a pH of 6 to 8, lead may form insoluble organic lead complexes, or if the soil has less organic matter at the same pH, hydrous lead oxide complexes may form or lead may precipitate out with carbonate or phosphate ions. As long as the pH in the soil remains above 6, the lead present in the soil may continue to be relatively immobile and the lead concentration in the groundwater may decrease over time as it is flushed out.

The lead detected at elevated concentrations in the historical groundwater samples collected at Zone 3 appears to be the result of soil particles in the groundwater samples. The elevated concentrations were

detected in unfiltered samples and filtered samples collected at the same time did not contain lead at elevated concentrations. In addition, groundwater samples collected during the Lower Subase RI did not contain elevated concentrations of lead.

Another factor that may be limiting the concentration of contaminants in the groundwater is the presence of paving over most of the site. The paving serves to limit the amount of infiltration passing through the soil. With limited infiltration, the amount of contaminants that can be leached out of the soil and transported to the groundwater is minimized.

PAHs are generally considered to be fairly immobile in the environment. As noted in Section 3.3.2.4, PAHs have very low solubilities, vapor pressures, and Henry's Law constants, and high K_{oc}s and K_{ow}s. The low-molecular weight PAHs (e.g., acenaphthene, anthracene, fluorene, phenanthrene) are more mobile (higher solubilities, etc.) than the high-molecular-weight PAHs (e.g., benzo(a)pyrene, benzo(a)anthracene, chrysene, etc.). PAHs in soil are much more likely to bind to soil and be transported via mass transport mechanisms than go into solution. PAHs can be degraded via aerobic bacteria, but may be relatively persistent in the absence of microbial population or macronutrients such as phosphorous and nitrogen.

Within Zone 3, TPH, as well as the PAHs, were found in both shallow and deep soils. The presence of these compounds at elevated concentrations at depth appears to be related more to leakage from the fuel pipelines in the area than from downward migration of the compounds from the surface. The highest concentrations of TPH in deep soils are located in the vicinity of the fuel pipelines along Argonaut Road, along the eastern edge of Zone 3. The highest concentrations of TPH in the shallow soils were found along the quay wall and along the boundary with Zone 2.

PAHs were not detected in any of the groundwater samples at Zone 3. As noted above, PAHs have very low solubilities and generally do not enter into solution. The data confirm that PAHs have not migrated into the groundwater in Zone 3.

The major area of concern for Zone 3 is impacted soil, as evidenced by the detection of VOCs and SVOCs (mainly PAHs). Several metals (arsenic, cadmium, copper, lead, manganese, mercury, nickel, selenium, silver, and zinc) were also detected at elevated concentrations (relative to background) in soil at Zone 3.

SVOCs and PAHs are generally considered to be fairly immobile chemicals in the environment. These compounds, when found in the soil, generally do not migrate vertically to a great extent. Instead, they are

more likely to adhere to soil particles and be removed from the site via surface runoff and erosional processes. Fluorene and bis(2-ethylhexyl)phthalate were the only organics detected in groundwater; consequently, it does not appear that significant migration of SVOCs or PAHs has occurred.

6.5.2 Effects of Cross Contamination on Other Zones and the Thames River

TPH is an indicator of petroleum hydrocarbon contamination. PAHs are the primary components of fuel oils such as No. 2 and No. 6, which are used throughout the Lower Subase site and distributed through the fuel oil lines contained in Zone 3. Therefore, TPH contamination detected at the site is assumed to be comprised mainly of PAHs and other SVOCs. As shown in Drawings 8 and 9 in Volume III, concentrations of TPH (mainly PAHs) in shallow and deep soil, respectively, are highest in shallow soil between Building 31 and the quay wall and are elevated along the boundary with Zone 2. The elevated levels of TPH along the Zone 2 boundary in shallow soil may be the result of migration of petroleum hydrocarbons from Zone 3. In deep soil, concentrations of TPH are highest in 13MW12 which is located south of Building 78, near the borders of Zones 3 and 4. The elevated TPH concentrations near Building 78 may be the result of leakage from the fuel pipeline located along Argonaut Road. The results of the krigging of the limited data from Zone 3 indicates that the area of elevated TPH concentrations near Building 78 extends slightly beyond the boundary of Zone 3, and that cross-contamination to Zone 4 has occurred. The krigging results also indicate that elevated TPH concentrations may exist near the quay wall of Zone 3 along the boundary with Zone 4 this contamination and may be the result of cross-contamination from Zone 4.

VOCs and SVOCs (mainly PAHs) were detected in shallow and deep soil at Zone 3. Fluorene was the only organic detected in Zone 3 groundwater. TPH was not detected in groundwater at Zone 3 during the latest sampling round. VOCs and SVOCs (mainly PAHs) were detected in Zone 3 sediment samples. Concentrations of PAHs in sediments were on the same order of magnitude as those concentrations in soil; the concentrations in sediment were slightly higher than those in soil. Also, concentrations of VOCs and SVOCs in Zone 3 sediment samples are generally higher than those detected in sediment samples collected from locations upstream and downstream of the Lower Subase, suggesting that migration of PAHs to the Thames River may have occurred.

Several inorganics (i.e., arsenic, cadmium, copper, lead, manganese, mercury, nickel, selenium, silver, and zinc) were detected in shallow and deep soil samples at concentrations exceeding background levels. These inorganics were also detected in the groundwater samples collected from Zone 3. These inorganics were also detected in Thames River sediment samples at concentrations exceeding background, indicating that migration of some inorganics to the Thames River may have occurred.

As shown in Drawings 10 and 11, lead has been detected at concentrations exceeding background levels in shallow and deep soils. The highest concentrations of lead in Zone 3 soil occur adjacent to the quay wall along the northwest corner of Building 31. An elevated detection of lead was also seen in the deep soil of Zone 2 in the vicinity of the quay wall and the border with Zone 3. It is likely that the lead contamination in both zones is not a function of cross-contamination, but is the result of historical waste handling practices. The reason that the lead contamination is at higher concentrations with depth is that this area was filled in during the 1950s. As shown in Drawings 13 and 14, concentrations of total and dissolved lead are comparable in groundwater samples from the latest round of sampling. This indicates that lead is present in groundwater mainly in the dissolved form and suggests that lead may be migrating with groundwater to the Thames River.

There may be other off-property sources contributing to the contamination detected in Thames River sediments. The Thames River is tidally influenced and contaminants may be migrating in the river from upstream and downstream sources. Also, the contamination may be a result of spillage that may have occurred during historical refueling of submarines and tugboats at the Lower Subase.

6.5.3 Evaluation of Natural Attenuation Data

Soil and groundwater samples were collected in Zone 3 and analyzed in the field or by a fixed-base laboratory. The resulting data provide the information necessary to answer the three following questions:

- Are contaminants present in either medium that could be remediated via natural attenuation or bioremediation?
- Is natural attenuation currently in progress in the groundwater?
- Are the conditions in the groundwater favorable for natural attenuation or bioremediation?

For Zone 3, TPH concentrations in soil and groundwater were contoured and the results are presented on Drawings 8, 9, and 12. Drawings 8 (shallow soil) and 9 (deep soil) show that high levels of TPH (i.e., indicative of petroleum hydrocarbons) are present in soil of Zone 3. The maximum TPH concentrations were detected in MW2-3RI (1,600 mg/kg, shallow soil) and 13MW12 (3,400 mg/kg, deep soil). As discussed in Section 6.4, PAHs and several VOCs were detected in the shallow and deep soil, which confirms the TPH concentrations. Neither TPH nor VOCs were detected in the groundwater above detection limit. Only two SVOCs, bis(2-ethylhexyl)phthalate and fluorene, were detected in the groundwater. Therefore, petroleum hydrocarbons seem to be generally fixed in the soil matrix and not migrating in significant amounts to the groundwater. As discussed previously, petroleum hydrocarbons can be treated successfully in either media via natural attenuation or bioremediation.

The procedure for evaluating natural attenuation data for groundwater was previously outlined in Section 3.3.4 and is followed in this section. Table 6-16 summarizes the parameters that were measured to determine if natural attenuation is occurring in the groundwater of Zone 3. Other information in the table includes parameter-specific concentration ranges and frequency of detections. Drawings showing the distribution of key parameters were also prepared to aid in the interpretation of the data. The drawings that were prepared include the following:

- Drawing 1 - High Tide Potentiometric Surface Map
- Drawing 3 - Low Tide Potentiometric Surface Map
- Drawing 15 - Dissolved Oxygen
- Drawing 16 - REDOX potential
- Drawing 17 - Divalent Iron
- Drawing 18 - Specific Conductivity

The following conclusions were reached after review and evaluation of the data presented in Table 6-16 and Drawings 1, 3, and 15 through 18.

- Dissolved oxygen concentrations were high near the Thames River (MW1-3RI = 9.4 mg/L and MW2-3RI = 6.68 mg/L) and low (13MW12 = 0.48 mg/L) in the southeastern portion of the Zone 3, indicating aerobic and anaerobic regions within Zone 3.

- REDOX potential measurements confirmed the dissolved oxygen concentrations. Higher REDOX potential was measured along the Thames River and low REDOX potential was measured in the southeastern portion of Zone 3. Both aerobic and anaerobic regions are present in Zone 3.

- Nitrate was detected in two of three wells (MW1-3RI and MW2-3RI) at concentrations near or above the general criterion of 1 mg/L. Nitrate was not detected in 13MW12. Nitrate was detected at MW1-6RI at a concentration of 1.4 mg/L. The results indicate that denitrification is occurring in the vicinity of 13MW12.

- Divalent iron was detected in one of three wells (13MW12). The detected concentration exceeded 1 mg/L, which suggests that iron reduction is occurring in the vicinity of 13MW12.

- High concentrations of sulfate (i.e., >20 mg/L) were measured in the groundwater at MW1-3RI and MW2-3RI. Sulfate was not detected in 13MW12. Sulfate was detected at a concentration of 25 mg/L at MW1-6RI. These results indicate that sulfate reduction is occurring in the vicinity of 13MW12.

- Methane was detected in two of three Zone 3 monitoring wells (13MW12 and MW1-3RI). Methane was not detected at MW1-6RI. This information suggests that methanogenesis is occurring in the vicinity of monitoring wells 13MW12 and MW1-3RI.

- Concentrations of alkalinity and hardness were generally normal when compared to concentrations in other zones, but were elevated compared to MW1-6RI.

- The groundwater temperature measured in 13MW12 (21.65°C) was slightly higher than in the other two Zone 3 wells (19.07°C and 18.96°C). All Zone 3 groundwater temperatures were above the temperature of the groundwater at MW1-6RI. The pH for Zone 3 groundwater was normal.

- Ammonia was detected in same two monitoring wells that had low concentrations of nitrate. Because ammonia is an intermediate product of denitrification, these results further suggest that denitrification is occurring.

- Phosphorous was detected in the groundwater and is available as a nutrient.

- As expected, salinity and chloride concentrations were highest in MW1-3RI (1.9 ppt and 1200 mg/L, respectively) and MW2-3RI (6.23 ppt and 3800 mg/L, respectively). These wells are located along the western side of Zone 3. This data is confirmed by the information provided on Drawings 1 and 3, which show that under high tide conditions, the western portion of Zone 3 is tidally influenced.

The information provided above indicates that natural attenuation is occurring in the south-central portion of Zone 3 (i.e., near 13MW12). The fact that TPH, VOCs, and SVOCs were either not detected or were detected very infrequently in the groundwater is most likely the result of a variety of factors (i.e., condition, type, and age of source(s), natural attenuation, mobility of contaminants, unique hydrogeologic conditions, and tidal flushing). Due to the variety of factors influencing Zone 3 and the limited contaminant plume, it is unlikely that bioremediation or other more active remedial technologies are practical or necessary for the groundwater of this zone. It is likely that a combination of monitored natural attenuation or a tiered groundwater monitoring program and source control would be a viable remedial strategy for this zone. If monitored natural attenuation is selected as part of the remedial strategy for Zone 3, additional investigations would need to be completed to provide the preliminary data required for the remedial

alternative and to monitor the progress of the alternative. Monitoring of the non-tidally influenced areas of Zone 3 would provide the best indication that natural attenuation processes are working in the groundwater.

6.6 BASELINE HUMAN HEALTH RISK ASSESSMENT

This section contains the baseline risk assessment performed for soil and groundwater exposures at Zone 3 of the Lower Subase. Section 6.6.1 contains a discussion on the selection of Chemicals of Concern (COCs), Section 6.6.2 contains information on the potential receptors considered and the routes by which they might be exposed, Section 6.6.3 contains the numerical results of the risk assessment, and Section 6.6.4 presents site-specific uncertainties associated with the risk assessment.

6.6.1 Data Evaluation

COCs were identified for Zone 3 of the Lower Subase using risk-based COC screening levels, as described in Section 3.4.3. All validated data collected during the Phase I and II RIs, the Lower Subase RI, and additional investigations, except soil data collected from depths greater than 10 feet, were used to identify COCs. Table 6-17 presents a summary of the COCs for Zone 3. Appendix I.7 contains the COC summary screening tables for the site.

A medium-specific discussion of COCs is presented in the following subsections. Within a given medium, discussions of direct exposure COCs (i.e., those chemicals detected at concentrations in excess of Federal and state direct exposure criteria) and additional COCs are provided. Additional COCs are identified based on contaminant migration tendencies: migration from soil to groundwater and from groundwater to the Thames River. These additional COCs are not quantitatively addressed in the human health risk assessment (i.e., numerical risk estimates are not developed) because they are not considered to be significant contributors to the direct exposure pathways identified for potential human receptors.

6.6.1.1 Soil Chemicals of Concern

The following chemicals were identified as direct exposure COCs for soil based on a comparison of maximum detected concentrations to USEPA Region III COC screening levels for residential land use and Connecticut RSRs for direct exposure (residential and industrial land use):

- PAHs [benzo(a)anthracene, benzo(a)pyrene, benzo(b)fluoranthene, dibenzo(a,h)anthracene, and indeno(1,2,3-cd)pyrene].
- Inorganics (aluminum, arsenic, beryllium, iron, lead, and manganese).

- TPH.

Manganese was selected as a COC for the "all soils" (soil from depths of 0 to 10 feet) category only. TPH was qualitatively identified as a COC for shallow soil because the maximum detected concentration exceeded the Connecticut RSR for residential direct exposure. Detected concentrations of TPH in subsurface soil exceeded the Connecticut RSRs for residential and industrial direct exposure.

Maximum detections in soil were also compared to generic USEPA SSLs for migration from soil to groundwater and Connecticut RSRs for pollutant mobility in a GB classified area. Maximum concentrations of the following chemicals exceeded the generic soil pollutant mobility criteria, indicating the potential for these chemicals to migrate to groundwater and potentially impact the quality of groundwater:

- VOCs (methylene chloride).
- PAHs [benzo(a)anthracene, benzo(a)pyrene, benzo(b)fluoranthene, carbazole, chrysene, dibenzo(a,h)anthracene, and indeno(1,2,3-cd)pyrene].
- Inorganics (antimony, arsenic, cadmium, chromium, nickel, and selenium).
- TPH.

Selenium was selected as a COC for the "all soil" category only. Selenium was not detected in shallow soil.

Under the Connecticut RSR (CTDEP, 1996), concerns regarding the mobility of inorganics in soil are addressed using TCLP and SPLP data. A comparison of site-specific TCLP and SPLP data and state RSRs for pollutant mobility is provided in Tables 6-9 and 6-10. Lead concentrations in the TCLP extracts from several subsurface soil samples exceeded the state criteria. Lead concentrations also exceeded the state criteria in one SPLP extract associated with recent sample collection efforts.

Although the use of generic mobility criteria (rather than site-specific criteria) results in a conservative identification of additional COCs for soil, the mobility of inorganics is supported by the groundwater data available for the site. Of the chemicals previously identified as migration COCs for soil, several inorganics (antimony, arsenic, chromium, nickel, and selenium) were detected in groundwater samples collected from the site. In most cases the COCs were only detected in historical groundwater samples. The results of the TCLP and confirmatory SPLP analyses indicate that lead is potentially migrating from the site at concentrations of concern. A discussion of COCs for groundwater is provided in the following subsection.

6.6.1.2 Groundwater Chemicals of Concern

COCs for groundwater were selected using unfiltered and filtered data. Although groundwater at the site is not currently used or expected to be used in the future as a drinking water supply because of saline conditions, a conservative list of direct exposure COCs was developed for this medium based on a comparison of maximum detected concentrations to EPA Region III COC screening levels for tap water, Federal and state MCLs, and Connecticut RSRs for the protection of groundwater. Inorganic chemicals retained as direct exposure COCs include:

- Inorganics (antimony, arsenic, barium, iron, manganese, and sodium).

Antinomy and barium were identified as COCs for the filtered sample matrix only. Antimony was not detected in unfiltered groundwater samples. Reported concentrations of barium in the unfiltered groundwater samples were less than direct exposure criteria. Sodium was retained as a COC because the maximum detections for this chemical in unfiltered and filtered groundwater samples were in excess of the State Notification Level. However, elevated levels of sodium in groundwater are anticipated because of nearby saltwater intrusion from the Thames River.

Since Zone 3 borders the Thames River, maximum concentrations in groundwater were also compared to the Connecticut Water Quality Standards (WQS) for aquatic life (chronic saltwater criteria) and for the protection of human health (water and organisms). These criteria were used to evaluate the potential for contaminant migration to the water body. The following inorganic chemicals were detected at maximum concentrations in excess of the State WQSs: arsenic, lead, nickel, and zinc.

Nickel was identified as an additional COC for the unfiltered sample matrix only. This chemical was not detected in the filtered groundwater samples. Zinc was identified as an additional COC for the filtered sample matrix only. Reported concentrations of zinc in the unfiltered groundwater samples were less than Connecticut WQSs.

The actual impact on the water quality in the Thames River is not expected to be as significant as the qualitative comparison implies since significant dilution and tidal mixing are anticipated, thereby reducing contaminant concentrations. For example, the maximum detected concentrations of most of the chemicals previously identified as migration COCs (lead, nickel, and zinc) are within one order of magnitude of the Connecticut WQSs. Appropriate alternative surface water protection criteria can be calculated by multiplying the lower of the human health or aquatic life criterion in the latest Connecticut WQSs by a site-specific dilution factor. Recently calculated site-specific dilution factors for the DRMO

(Site 6) and Goss Cove Landfill (Site 8), other NSB-NLON IRP sites located along the Thames River, were 226 and 118, respectively. Consequently, these chemicals are not considered to be problematic since the maximum concentration of these chemicals would be less than the alternative SWPC. In addition, arsenic was only detected in historical groundwater samples. A separate evaluation of the water and sediment quality in the Thames River is provided in Section 11.0.

6.6.1.3 Exposure Point Concentrations

Exposure point concentrations were developed for direct exposure COCs only using the methodologies presented in Section 3.4.1. The average and maximum detected concentrations for shallow soil and groundwater were used for the RME and CTE, respectively, because of the limited data set that is available for the site. The 95 percent UCL was generally used for subsurface soil. Groundwater exposure concentrations were developed using USEPA Region I guidance (USEPA, 1994f). A summary of the exposure point concentrations used to estimate potential risks associated with direct exposure COCs for Zone 3 is provided in Table 6-18.

Compounds considered as essential human nutrients (calcium, magnesium, potassium, and sodium) detected in the site media were not identified as COCs or quantitatively evaluated in the risk assessment. TPH was identified as a direct exposure COC based on a qualitative analysis. However, exposure to this chemical could not be quantitatively evaluated because of the lack of dose-response parameters. In addition, although aluminum and iron may be identified as COCs, USEPA Region I does not advocate a quantitative evaluation of exposure to aluminum and iron because the only available toxicity criteria for these chemicals are provisional reference doses based on daily allowable intakes rather than adverse effect levels. Exposure to these chemicals is addressed in the general uncertainty section of the baseline human health risk assessment, Section 3.4.5.

6.6.2 Exposure Assessment

This section presents a summary of the persons potentially exposed to soil and groundwater at Zone 3 of the Lower Subase, and describes the routes by which they might be exposed. Details on the exposure parameters used in the quantitative risk assessment were provided in Section 3.4.3.

The most likely receptors at this site include any full-time adult employees or military personnel assigned to the various buildings. These persons could be exposed to shallow soil via direct contact (incidental ingestion or dermal contact). They are assumed to be exposed 150 days/year for 6 years for the CTE and for 25 years for the RME.

A construction worker scenario was also evaluated for Zone 3. A construction project is assumed to take between 80 (CTE) and 120 (RME) days in a 1-year period. These persons could come into contact with "all soil" (soil from depths of 0 to 10 feet) via dermal contact and incidental ingestion. These receptors may also be dermally exposed to groundwater during ground-intrusive activities.

Since the site is located along the Thames River and waterfront property is typically regarded as an attractive location for residential development, future residents were evaluated as potential receptors. This exposure scenario is dependent upon Base closure, which is considered to be highly unlikely because of the critical nature of the facility with respect to support of the submarine fleet and national defense. Therefore, this scenario is primarily evaluated for informational purposes only (i.e., to aid in decision making and risk management decisions). Future potential residents are not expected to come in contact with groundwater at the site because saline conditions that exist near the river would preclude domestic use of groundwater. Receptors are assumed to be exposed to "all soil" (soil from depths of 0 to 10 feet) via incidental ingestion and dermal contact. Soil exposures were assumed to occur 150 days/year for a total of 7 years under the CTE and 30 years for the RME.

There are no dermal absorption factors available for beryllium and manganese. As requested by EPA Region I, dermal exposures to these COCs will be evaluated using a generic absorption factor of 0.01 and the results will be discussed in the uncertainty analysis presented in Section 6.6.4.

The identified potential receptors could also be exposed to chemicals in soil via inhalation of fugitive dust and volatile emissions. This exposure pathway is evaluated in a qualitative fashion by a comparison of maximum soil concentrations to generic USEPA SSLs for the inhalation pathway, as summarized in the site-specific COC summary screening tables in Appendix I.7. Maximum detections for all soil chemicals were below the inhalation SSLs, indicating that the inhalation pathway is not expected to be a significant exposure route. Consequently, this exposure route was eliminated from further quantitative risk evaluation.

6.6.3 Risk Characterization

A summary of the quantitative risk assessment for Zone 3 is provided in this section. Total noncarcinogenic and carcinogenic risks for each exposure route, as well as the cumulative risks for the RME and CTE scenarios, are outlined in Table 6-19 for the construction worker, full-time employee, and future resident. Sample calculations are provided in Appendix I.3. Appendix I.7 contains the chemical-specific risks for Zone 3.

6.6.3.1 Noncarcinogenic Risks

Cumulative Hazard Indices (HIs) for all receptors are less than unity, indicating that no averse effects are anticipated under both RME and CTE scenarios.

6.6.3.2 Carcinogenic Risks

Cumulative incremental cancer risks for Zone 3 ranged from 2.4E-7 for the construction worker (CTE) to 3.9E-5 for the future resident (RME). All cancer risks were within or below the USEPA target risk range (1E-4 to 1E-6). The cumulative incremental cancer risk for the future resident (3.9E-5) under the RME scenario exceeded the CTDEP target risk level of 1E-5.

The exposure route of concern for the future resident under the RME scenario is incidental ingestion and dermal contact with soil. As summarized in Table 6-20, benzo(a)pyrene and arsenic are the major contributors to the elevated cancer risk. For the future resident under the RME, the chemical-specific cancer risks for benzo(a)anthracene, benzo(a)pyrene, benzo(b)fluoranthene, dibenzo(a,h)anthracene, indeno(1,2,3,cd) pyrene, and arsenic were in excess of 1E-6 and the chemical specific cancer risk for benzo(a)pyrene exceeded 1E-5. The chemical-specific cancer risks for all other chemicals were less than 1E-6.

6.6.3.3 Exposure to Lead

Lead was identified as a COC for soil at Zone 3. Maximum detections of this chemical in site soil exceeded the associated screening criteria (i.e., the 400 mg/kg OSWER soil screening level for residential land use and the Connecticut RSR). Exposure to lead in soil at Zone 3 was addressed using the USEPA IEUBK Model, as discussed in Section 3.4.3. The UCL for "all soil," and several default parameters, were used to calculate estimated blood-lead levels for children in a residential setting. The estimated geometric mean blood-lead level for children exposed to lead in site soil was 14 µg/dL for CTE and RME scenarios, which is greater than the established level of "concern," 10 µg/dL. The IEUBK model estimates that 73 percent of children are expected to have blood-lead levels greater than 10 µg/dL. This estimate is greater than the acceptable level of 5 percent. Therefore, the IEUBK results indicate that adverse effects are anticipated for children exposed to lead in shallow and subsurface soil at Zone 3.

As discussed in Section 3.4.3, exposures to lead by nonresidential adults were evaluated by use of a slope-factor approach developed by the USEPA Technical Review Workgroup for Lead (USEPA Region I, 1996f and USEPA, 1996g). The estimated 95th percentile fetal blood lead-level in women exposed to lead in site soil was 14.5 µg/dL (RME) and 7.3 µg/dL (CTE) for future employees and 30.2 µg/dL (RME) and 18.1

µg/dL (CTE) for construction workers. These values are greater than the established level of "concern" (10 µg/dL), indicating that adverse effects are anticipated for fetuses of pregnant women workers exposed to lead in shallow and subsurface soil at Zone 3. However, these values are less than the OSHA permissible blood-lead level of 40 µg/dL, indicating that no adverse effects are anticipated for adults exposed to lead in shallow and subsurface soil at Zone 3.

6.6.4 Uncertainties

A detailed discussion of uncertainties associated with the various aspects of risk assessment, in general, was provided in Section 3.4.5. Site-specific uncertainties for Zone 3 risk evaluation are presented below.

Dermal exposure to beryllium and manganese in soil could not be quantitatively evaluated in the risk assessment since there are no dermal absorption factors available for these compounds. Therefore, as requested by EPA Region I, a screening analysis was performed for dermal exposures to beryllium and manganese in soil using a generic absorption factor for inorganics of 0.01. Cancer risks could not be calculated for beryllium and manganese since no oral cancer slope factors are available for these compounds. Hazard indices are as follows:

	Scenario	
Receptor	**RME**	**CTE**
Construction Worker	0.01	0.0009
Full-time Employee	0.0008	0.0001
Future Resident	0.02	0.002

All cumulative hazard indices for the RME and CTE scenarios are more than an order of magnitude less the acceptable level of 1.0. Consequently, no adverse health effects are anticipated as a result of dermal exposure to beryllium and manganese in soil under the conditions evaluated in the risk assessment.

Some inorganic chemicals detected in site soil samples may be attributable to naturally occurring background levels. Background levels for metals in soil at NSB-NLON, developed by Atlantic Environmental Services are presented on Table 1-4. All reported concentrations of aluminum, antimony, barium, beryllium, chromium, cobalt, iron, magnesium, potassium, and vanadium in the site soils were less than the established background levels.

The calculated risks for exposure to soil under current site conditions are to some degree overestimated. Most of the soil samples collected at the site were obtained from locations beneath pavement. All soil samples (currently exposed and beneath pavement) were used to conservatively evaluate potential risk

for the site. Therefore, actual exposure under current site conditions is less than exposure that is assumed for this risk assessment.

6.7 SUMMARY AND RECOMMENDATIONS

This section presents a summary of major findings for Zone 3 of the Lower Subase. A summary of the nature and extent of contamination is provided in Section 6.7.1. Section 6.7.2 includes a summary of contaminant fate and transport information and Section 6.7.3 provides a synopsis of the baseline human health risk assessment for Zone 3. Section 6.7.4 provides recommendations regarding additional action and investigatory efforts for the soil and groundwater of Zone 3. A summary of the ecological risks for the Thames River adjacent to Zone 3 and the corresponding recommendations for the river are provided in Section 11.0.

6.7.1 Nature and Extent of Contamination

High concentrations of lead were detected in the shallow and deep soil samples collected from Zone 3. The high concentrations are most likely the result of historic operations at Building 31. Although a majority of soil under and adjacent to Building 31 has been remediated, some soils in the vicinity of Building 31 still have elevated levels of lead. SVOCs, primarily PAHs, were also detected at relatively high concentrations in both shallow and deep soil samples collected from Zone 3. Based on the locations where the majority of maximum concentrations were detected, it appears that the SVOC contamination may be associated with the fuel pipeline that runs along the eastern side of Building 78. TPH was also detected in soil, with higher concentrations detected in soils along Bullhead Road from Argonaut to Albacore and along Albacore from Capelin to Bullhead Road. Sources of the petroleum contamination are likely pipeline leaks within Zones 3 and 4 and UST leaks within Zone 4. Based on the analytical data available for groundwater samples, it appears that neither SVOCs nor TPH have migrated to groundwater. Lead was detected at concentrations up to 392 µg/L in groundwater collected from beneath Building 31. This concentration was detected in an unfiltered sample taken from a temporary well installed inside of Building 31. Data from temporary wells are considered to be "screening" data. The maximum concentration of lead detected in groundwater samples collected outside of Building 31 was 10.5 µg/L (filtered sample from permanent well MW2-3RI, located on the western side of Building 31 along Albacore Road).

6.7.2 Contaminant Fate and Transport

High concentrations of petroleum hydrocarbons and SVOCs, as well as inorganic concentrations in excess of background, have been detected in the soil of Zone 3. Analytical results from the groundwater sampling activities indicate that the petroleum hydrocarbons in the soil are generally not migrating to the

groundwater but that the inorganic contamination (including lead) may be migrating to the groundwater and to downgradient locations. The data are inconclusive regarding lead cross-contamination from Zone 3 (Building 31) to Zone 2. It is likely that the lead contamination in both zones is the result of historical waste handling practices. It is possible that Zone 4 may be contributing petroleum contamination to the southern end of Zone 3. The Thames River, which is downgradient of Zone 3, showed some potential evidence of cross-contamination with some detections of inorganics and PAHs. An evaluation of natural attenuation indicated that this process may be viable for the soil because of the presence of biodegradable contaminants (i.e., petroleum hydrocarbons and SVOCs). Key parameters indicate that natural attenuation is occurring in a limited portion of the groundwater of Zone 3; however, petroleum-related compounds were generally not detected in the groundwater. Therefore, a tiered groundwater monitoring program versus monitored natural attenuation may be an option that could be evaluated further as part of the remedial strategy for Zone 3.

6.7.3 Baseline Human Health Risk Assessment

The baseline human health risk assessment for Zone 3 focused on three potential receptor groups: construction workers, full-time employees, and future residents. Noncarcinogenic risks for all receptor groups were less than the USEPA and CTDEP acceptable limit of one. Carcinogenic risks for all receptors at all zones were either less than or within USEPA's acceptable target risk range of 1E-4 to 1E-6. The cancer risk for future residents under the RME scenario slightly exceeded the CTDEP target risk level of 1E-5. Benzo(a)pyrene and arsenic are the major contributors to the cancer risk for this receptor. Chemical-specific cancer risks for these two chemicals plus dibenzo(a,h)anthracene, benzo(a)anthracene, benzo(b)fluoranthene, and indeno(1,2,3,cd)pyrene exceed 1E-6.

Lead was detected at concentrations exceeding the 400 mg/kg OSWER soil screening level for residential land use. Evaluation of lead using the IEUBK model for children and the interim slope-factor approach for adults indicates that adverse health effects are anticipated for small children and fetuses of female workers who maybe exposed to lead in shallow and subsurface soil at Zone 3.

Maximum detected concentrations of methylene chloride, PAHs, metals, and TPH in soil exceeded their respective generic mobility criteria which indicates the potential exists for these chemicals to migrate from soil to groundwater. Although the maximum detected concentrations of methylene chloride and PAHs exceeded the generic mobility criteria, these chemicals were not detected in groundwater samples collected at Zone 3. The mobility of some of the inorganic COCs may be supported by the groundwater data and TCLP/SPLP soil data. The maximum detected concentration of antimony and chromium exceeded the generic mobility criteria but were within background levels.

Maximum concentrations in groundwater were compared to Connecticut salt water WQSs since Zone 3 borders the Thames River. Several migration COCs in groundwater were identified as exceeding the Connecticut salt water WQSs. Use of the Connecticut salt water WQSs to determine groundwater impacts on the Thames River is very conservative since the WQSs do not account for the dilutional effects of the groundwater mixing with the river. Appropriate alternative surface water protection criteria can be calculated by multiplying the lower of the human health or aquatic life criterion in the latest Connecticut WQSs by a site-specific dilution factor. Recently calculated site-specific dilution factors for the DRMO (Site 6) and Goss Cove Landfill (Site 8), other NSB-NLON IRP sites located along the Thames River, were 226 and 118, respectively. The maximum detected concentrations of most migration COCs (lead, nickel, and zinc) are within one order of magnitude of the Connecticut WQSs. Therefore, the actual impact on water quality in the Thames River is expected to be minimal because significant dilution is anticipated, thereby reducing chemical concentrations in the Thames River.

6.7.4 Recommendations

It is recommended that this zone, which includes Site 17 (Building 31) and the fuel distribution pipeline, proceed to a feasibility study. Because of the extensive amount of underground utilities in Zone 3 and the nature of the activities conducted at this location (i.e., national security), the feasibility study for this zone should evaluate to the extent possible alternatives that include institutional controls to limit exposure to contaminated soil and a tiered groundwater monitoring program to verify that significant contaminant migration is not occurring. "Hot Spot" removal actions for the lead contamination and cleaning and repair of the Zone 3 storm sewer system should also be evaluated during the feasibility study. These recommendations are based on the following information:

- The nature and extent of organic and inorganic contamination in the soil and groundwater are well defined to the extent practical considering infrastructure limitations.

- The baseline human health risk assessment indicates that the risks associated with Zone 3 are within the USEPA acceptable risk range. There are carcinogenic risks in excess of the CTDEP target risk level to human receptors, but only under the hypothetical future resident scenario. In addition, modeling performed to evaluate exposure to lead showed that sensitive receptors to lead exposure (i.e., children and fetuses of pregnant women) are only at risk in Zone 3 under a future hypothetical scenario, which assumes that soils currently covered by pavement or buildings are available for exposure. Institutional controls and/or "hot spot" removal actions could be used to eliminate this exposure route.

- Although reported concentrations of TPH in site soil samples exceeded the state RSRs for direct exposure and pollutant mobility, the chemical-specific risk assessment for those compounds assumed to be major constituents of the observed TPH contamination indicated minimal risks to potential receptors.

- The groundwater at Zone 3 is not currently or anticipated to be used in the future as a potable water source because it is brackish; therefore, there is no imminent threat to human health.

- The data does not suggest that the petroleum contamination in the soil is significantly migrating to the groundwater. In addition, natural attenuation processes seem to be at work in the groundwater. These processes can reduce concentrations of petroleum contamination that reach the aquifer and convert the petroleum contamination to a less toxic form. Groundwater monitoring will confirm this information.

- Inorganics are potentially migrating from the Zone 3 to the Thames River. However, the ecological risk assessment for the Thames River adjacent to Zone 3 (See Section 11.0) shows that the risks to ecological receptors in the sediment adjacent to Zone 3 are relatively low and that lead is not a significant threat to the ecological receptors. Groundwater monitoring will confirm this information.

- A tiered groundwater monitoring program will allow for further actions to be completed if the results show significant impacts.

- The Thames River provides significant dilution and mixing which minimizes the impact of any contaminant migration from Zone 3.

- The Navy completed a time-critical removal action on soil contaminated with lead underneath and adjacent to Building 31; therefore, a majority of the lead-contaminated soil that historically acted as a source of contamination to other media has been remediated.

- The Navy conducts regular pressure testing and repairs on the fuel distribution lines; therefore, the historical source of petroleum contamination has most likely been eliminated.

- The zone is covered with pavement or buildings, which minimizes direct exposure to the contaminated soil by human receptors.

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TABLE 6-1

SUMMARY OF SAMPLING AND ANALYTICAL PROGRAM - ZONE 3
FINAL SITE INVESTIGATION SUBSURFACE OIL CONTAMINATION
LOWER SUBASE
NSB-NLON, GROTON, CONNECTICUT

Sample ID	Sample Depth (feet below ground)	Analysis									
		Target Compound List (TCL)			TAL Metals		RCRA Metals	Lead	TPH	Fluorescence	Misc
		Volatiles	Semivolatiles	Pesticides/PCBs	Total	Dissolved					
SOIL											
NSB-WE2-12-14	12-14									●	
NSB-WE2-2-4	2-4									●	

● = Sample was analyzed for this parameter.
Blank cell indicates that this analysis was not performed for this sample.

TABLE 6-2

SUMMARY OF SAMPLING AND ANALYTICAL PROGRAM - ZONE 3
PHASE I REMEDIAL INVESTIGATION
LOWER SUBASE
NSB-NLON, GROTON, CONNECTICUT

Sample ID	Sample Depth (feet below ground)	Analysis									
		Target Compound List (TCL)			TAL Metals + Cyanide[2]		RCRA Metals[1]	Lead	TPH	Fluorescence	Misc
		Volatiles	Semivolatiles	Pesticides/PCBs	Total	Dissolved					
SOIL											
13MW12(8-10)	8-10	●			●		●		●	●	
GROUNDWATER											
012191-13MW12S	NA	●			●				●	●	

1 Toxicity Characteristic Leaching Procedure (TCLP) extraction followed by analysis for RCRA metals.
2 Analysis for boron was performed.
NA = Not applicable.
● = Sample was analyzed for this parameter.
Blank cell indicates that this analysis was not performed for this sample.

TABLE 6-3

SUMMARY OF SAMPLING AND ANALYTICAL PROGRAM - ZONE 3
ACTION MEMORANDUM FOR BUILDING 31
LOWER SUBASE
NSB-NLON, GROTON, CONNECTICUT
PAGE 1 OF 5

Sample ID	Sample Depth (feet below ground)	Analysis										
		Target Compound List (TCL)			TAL Metals + Cyanide		RCRA Metals		Lead	TCLP Lead[1]	TPH	Misc[2]
		Volatiles	Semivolatiles	Pesticides/PCBs	Total	Dissolved	Total	Dissolved				
SOIL												
S001-1.0-CLP	0-1								●			
S002-1.0-CLP	0-1								●			
S003-1.0-CLP	0-1								●			
S003-1.0-CLP-D[3]	0-1								●			
SB01-2.0	0-2								●			●
SB01-4.0	2-4								●	●		●
SB01-4.0-D[4]	2-4								●			●
SB01-6.0	4-6								●			●
SB02-2.0	0-2								●	●		●
SB02-2.0-RCRA	0-2						●					
SB02-4.0	2-4	●	●	●	●				●			●
SB02-4.0-D[5]	2-4	●	●	●	●				●			●
SB02-6.0	4-6								●			●
SB03-2.0	0-2								●			●
SB03-4.0	2-4								●	●		●
SB03-6.0	4-6								●			●
SB04-2.0	0-2								●	●		●
SB04-4.0	2-4								●			●
SB04-6.0	4-6								●			●
SB05-2.0	0-2								●	●		●
SB05-2.0-RCRA	0-2						●					
SB05-4.0	2-4								●			●
SB05-6.0	4-6								●			●
SB06-2.0	0-2								●			●
SB06-4.0	2-4								●			●
SB06-4.0-D[6]	2-4								●			●
SB06-6.0	4-6								●	●		●

TABLE 6-3

SUMMARY OF SAMPLING AND ANALYTICAL PROGRAM - ZONE 3
ACTION MEMORANDUM FOR BUILDING 31
LOWER SUBASE
NSB-NLON, GROTON, CONNECTICUT
PAGE 2 OF 5

Sample ID	Sample Depth (feet below ground)	Analysis										
		Target Compound List (TCL)			TAL Metals + Cyanide		RCRA Metals		Lead	TCLP Lead[1]	TPH	Misc[2]
		Volatiles	Semivolatiles	Pesticides/PCBs	Total	Dissolved	Total	Dissolved				
SB07-2.0	0-2								●			●
SB07-4.0	2-4								●			●
SB07-6.0	4-6								●	●		●
SB08-2.0	0-2								●	●		●
SB08-4.0	2-4								●			●
SB08-6.0	4-6								●			●
SB09-2.0	0-2								●	●		●
SB09-4.0	2-4								●			●
SB09-6.0	4-6								●			●
SB10-2.0	0-2								●			●
SB10-4.0	2-4								●	●		●
SB10-6.0	4-6								●			●
SB10-6.0-D[7]	4-6								●			●
SB11-2.0	0-2								●			●
SB11-4.0	2-4								●			●
SB11-6.0	4-6								●	●		●
SB12-2.0	0-2								●			●
SB12-4.0	2-4								●			●
SB12-6.0	4-6								●	●		●
SB13-2.0	0-2								●	●		●
SB13-2.0-D[8]	0-2								●			●
SB13-4.0	2-4								●			●
SB13-6.0	4-6								●			●
SB14-2.0	0-2	●	●	●	●				●			●
SB14-4.0	2-4								●	●		●
SB14-6.0	4-6								●			●
SB15-2.0	0-2								●	●		●
SB15-4.0	2-4								●			●

TABLE 6-3

SUMMARY OF SAMPLING AND ANALYTICAL PROGRAM - ZONE 3
ACTION MEMORANDUM FOR BUILDING 31
LOWER SUBASE
NSB-NLON, GROTON, CONNECTICUT
PAGE 3 OF 5

Sample ID	Sample Depth (feet below ground)	Analysis										
		Target Compound List (TCL)			TAL Metals + Cyanide		RCRA Metals		Lead	TCLP Lead[1]	TPH	Misc[2]
		Volatiles	Semivolatiles	Pesticides/PCBs	Total	Dissolved	Total	Dissolved				
SB15-6.0	4-6								●			●
SB16-2.0	0-2								●	●		●
SB16-4.0	2-4								●			●
SB16-6.0	4-6								●			●
SB17-2.0	0-2								●			●
SB17-4.0	2-4								●			●
SB17-6.0	4-6								●	●		●
SB18-2.0	0-2								●			●
SB18-4.0	2-4	●	●	●	●				●			●
SB18-6.0	4-6								●	●		●
SB18-6.0-RCRA	4-6						●					
SB19-2.0	0-2								●			●
SB19-4.0	2-4								●			●
SB19-6.0	4-6								●	●		●
SB20-2.0	0-2								●	●		●
SB20-4.0	2-4								●			●
SB20-4.0-D[9]	2-4								●			●
SB20-6.0	4-6								●			●
SB21-2.0	0-2								●	●		●
SB21-4.0	2-4								●			●
SB21-6.0	4-6								●			●
SB22-2.0	0-2								●			●
SB22-4.0	2-4								●			●
SB22-6.0	4-6	●	●	●	●				●	●		●
SB23-2.0	0-2								●			●
SB23-4.0	2-4								●			●
SB23-6.0	4-6								●	●		●
SB24-2.0	0-2								●	●		●

TABLE 6-3

SUMMARY OF SAMPLING AND ANALYTICAL PROGRAM - ZONE 3
ACTION MEMORANDUM FOR BUILDING 31
LOWER SUBASE
NSB-NLON, GROTON, CONNECTICUT
PAGE 4 OF 5

Sample ID	Sample Depth (feet below ground)	Analysis										
		Target Compound List (TCL)			TAL Metals + Cyanide		RCRA Metals		Lead	TCLP Lead[1]	TPH	Misc[2]
		Volatiles	Semivolatiles	Pesticides/PCBs	Total	Dissolved	Total	Dissolved				
SB24-4.0	2-4								●			●
SB24-6.0	4-6								●			●
SB25-2.0	0-2								●	●		●
SB25-4.0	2-4								●			●
SB25-4.0-D[10]	2-4								●			●
SB25-6.0	4-6								●			●
SB26-2.0	0-2								●	●		●
SB26-4.0	2-4								●			●
SB26-6.0	4-6								●			●
SB27-2.0	0-2								●	●		●
SB27-4.0	2-4								●			●
SB27-6.0	4-6								●			●
SB28-2.0	0-2								●	●		●
SB28-2.0-RCRA	0-2						●					
SB28-4.0	2-4								●			●
SB29-2.0	0-2								●			●
SB29-2.0-D[11]	0-2								●			●
SB29-4.0	2-4								●			●
SB29-6.0	4-6								●			●
SB30-2.0	0-2								●			●
SB30-4.0	2-4								●			●
SB30-6.0	4-6								●			●
SB31-2.0	0-2								●			●
SB31-2.0-D[12]	0-2								●			●
SB32-2.0	0-2								●			●
SB33-2.0	0-2								●			●
GROUNDWATER												
GW-01-1	NA	●	●	●	●							

TABLE 6-3

SUMMARY OF SAMPLING AND ANALYTICAL PROGRAM - ZONE 3
ACTION MEMORANDUM FOR BUILDING 31
LOWER SUBASE
NSB-NLON, GROTON, CONNECTICUT
PAGE 5 OF 5

Sample ID	Sample Depth (feet below ground)	Analysis										
		Target Compound List (TCL)			TAL Metals + Cyanide		RCRA Metals		Lead	TCLP Lead[1]	TPH	Misc[2]
		Volatiles	Semivolatiles	Pesticides/PCBs	Total	Dissolved	Total	Dissolved				
GW-01-1-D[13]	NA	●	●	●	●							
GW-01-2	NA						●	●				
GW-02-1	NA	●	●	●	●							
GW-02-2	NA						●	●				
GW-02-2-D[14]	NA						●	●				
GW-03-1	NA						●	●				
GW-03-2	NA						●	●				
GW-04-1	NA						●	●				
GW-04-2	NA						●	●				

1 Toxicity Characteristic Leaching Procedure (TCLP) extraction followed by analysis for lead.
2 Miscellaneous parameter includes: pH.
3 S003-1.0-CLP-D is a field duplicate of S003-1.0-CLP.
4 SB01-4.0-D is a field duplicate of SB01-4.0.
5 SB02-4.0-D is a field duplicate of SB02-4.0.
6 SB06-4.0-D is a field duplicate of SB06-4.0.
7 SB10-6.0-D is a field duplicate of SB10-6.0.
8 SB13-2.0-D is a field duplicate of SB13-2.0.
9 SB20-4.0-D is a field duplicate of SB20-4.0.
10 SB25-4.0-D is a field duplicate of SB25-4.0.
11 SB29-2.0-D is a field duplicate of SB29-2.0.
12 SB31-2.0-D is a field duplicate of SB31-2.0.
13 GW-01-1-D is a field duplicate of GW-01-1.
14 GW-02-2-D is a field duplicate of GW-02-2.
NA = Not applicable.
● = Sample was analyzed for this parameter.
Blank cell indicates that this analysis was not performed for this sample.

TABLE 6-4

SUMMARY OF SAMPLING AND ANALYTICAL PROGRAM - ZONE 3
POST REMOVAL ACTION REPORT FOR BUILDING 31 LEAD REMEDIATION
LOWER SUBASE
NSB-NLON, GROTON, CONNECTICUT
PAGE 1 OF 2

Sample ID	Sample Depth (feet below ground)	Analysis								
		Target Compound List (TCL)			TAL Metals		RCRA Metals	Lead	TPH	Misc
		Volatiles	Semivolatiles	Pesticides/PCBs	Total	Dissolved				
2-EXBE78-06	3-3							●		
2-EXBE-ALBCRE-04	5-5							●		
2-EXEW03-07	2-2							●		
2-EXNW09-06	2-2							●		
2-EXNW78-09	0-0							●		
2-EXSW09-06	3-3							●		
2-EXSW78-09	0-0							●		
2-EXWW06-06	6-6							●		
2-EXWW09-06	3-3							●		
2-EXWW-ALBACORE-06	2-2							●		
3-EXEW03-07	2-2							●		
3-EXSW09-06	3-3							●		
4-EXEW03-07	2-2							●		
EXBE01-04	5-5							●		
EXBE01-06	3-3							●		
EXBE02-04	5-5							●		
EXBE03-04	5-5							●		
EXBE05-04	4-4							●		
EXBE06-07	7-7							●		
EXBE07-03	6-6							●		
EXBE78-06	3-3							●		
EXBE-ALBACORE-03	6-6							●		
EXBE-ALBACORE-04	5-5							●		
EXBE-ALBACORE-04-D[1]	5-5							●		
EXBE-BULLHEAD-07	2-2							●		
EXEW02-06	3-3							●		
EXEW03-07	2-2							●		
EXEW07-05	4-4							●		
EXEW07-05-D[2]	4-4							●		
EXEW-BULLHEAD-08	1-1							●		
EXNW02-06	3-3							●		
EXNW03-07	2-2							●		

TABLE 6-4

SUMMARY OF SAMPLING AND ANALYTICAL PROGRAM - ZONE 3
POST REMOVAL ACTION REPORT FOR BUILDING 31 LEAD REMEDIATION
LOWER SUBASE
NSB-NLON, GROTON, CONNECTICUT
PAGE 2 OF 2

Sample ID	Sample Depth (feet below ground)	Analysis								
		Target Compound List (TCL)			TAL Metals		RCRA Metals	Lead	TPH	Misc
		Volatiles	Semivolatiles	Pesticides/PCBs	Total	Dissolved				
EXNW04-06	3-3							●		
EXNW07-05	4-4							●		
EXNW08-07	7-7							●		
EXNW09-06	3-3							●		
EXNW78-09	0-0							●		
EXNW-ALBACORE-06	3-3							●		
EXSW01-07	2-2							●		
EXSW02-06	3-3							●		
EXSW03-07	2-2							●		
EXSW04-06	3-3							●		
EXSW07-04	5-5							●		
EXSW08-07	7-7							●		
EXSW09-06	3-3							●		
EXSW78-09	0-0							●		
EXSW-ALBACORE-06	3-3							●		
EXSW-BULLHEAD-08	1-1							●		
EXWW01-07	2-2							●		
EXWW02-06	3-3							●		
EXWW06-05	5-5							●		
EXWW06-07	7-7							●		
EXWW07-05	4-4							●		
EXWW08-07	7-7							●		
EXWW09-06	3-3							●		
EXWW09-06-D[3]	3-3							●		
EXWW-ALBACORE-06	3-3							●		

1 EXBE-ALBACORE-04-D is a field duplicate of EXBE-ALBACORE-04.
2 EXEW07-05-D is a field duplicate of EXEW07-05.
3 EXWW09-06-D is a field duplicate of EXWW09-06.
● = Sample was analyzed for this parameter.
Blank cell indicates that this analysis was not performed for this sample.

TABLE 6-5

SUMMARY OF SAMPLING AND ANALYTICAL PROGRAM - ZONE 3
TANK FARM INVESTIGATION
LOWER SUBASE
NSB-NLON, GROTON, CONNECTICUT

Sample ID	Sample Depth (feet below ground)	Analysis									
		Target Compound List (TCL)			TAL Metals		RCRA Metals	Lead	TPH	Fluorescence	Misc
		Volatiles	Semivolatiles	Pesticides/PCBs	Total	Dissolved					
SOIL											
FPTB12L-08	8-8								●		
FPTB13L-07	7-7								●		
DUP17-111895[1]	7-7								●		

1 DUP17-111895 is a field duplicate of FPTB13L-07.
● = Sample was analyzed for this parameter.
Blank cell indicates that this analysis was not performed for this sample.

TABLE 6-6

SUMMARY OF SAMPLING AND ANALYTICAL PROGRAM - ZONE 3
PHASE II REMEDIAL INVESTIGATION
LOWER SUBASE
NSB-NLON, GROTON, CONNECTICUT

Sample ID	Sample Depth (feet below ground)	Analysis								
		Target Compound List (TCL)			TAL Metals		RCRA Metals[1]	Lead	TPH	Misc[2]
		Volatiles	Semivolatiles	Pesticides/PCBs	Total	Dissolved				
SOIL										
13TB12-0204-X	2-4							○		
13TB12-0406	4-6						●	●	●	
13TB12-0608-X	6-8							○		
13TB18-0103	1-3						●	●	●	
13TB5A-1.5-3.5	1.5-3.5						●	●	●	
13TB5A-1.5-3.5-X	1.5-3.5							○		
13TB7-0103	1-3						●	●	●	
GROUNDWATER - ROUND 1										
13GW12	NA	●	●		●	●			●	●
GROUNDWATER - ROUND 2										
13GW12-2	NA	●	●		●	●			●	●
13GW12-D-2[3]	NA	●	●		●	●			●	●

1 Toxicity Characteristic Leaching Procedure (TCLP) extraction followed by analysis for RCRA metals.
2 Miscellaneous parameter includes: Hardness (as $CaCO_3$).
3 13GW12-2-D is a field duplicate of 13GW12-2.
4 Analysis for boron was performed.
NA = Not applicable.
● = Sample was analyzed for this parameter.
○ = Sample was analyzed for this parameter using field screening x-ray fluorescence.
Blank cell indicates that this analysis was not performed for this sample.

TABLE 6-7

SUMMARY OF SAMPLING AND ANALYTICAL PROGRAM - ZONE 3
LOWER SUBASE REMEDIAL INVESTIGATION
LOWER SUBASE
NSB-NLON, GROTON, CONNECTICUT

Sample ID	Sample Depth (feet below ground)	Analysis								
		Target Compound List (TCL)			TAL Metals		RCRA Metals[1]	Lead[2]	TPH	Misc[3]
		Volatiles	Semivolatiles	Pesticides/PCBs	Total	Dissolved				
SOIL										
LS3SB0010201	2-4		●		●			●	●	
LS3SB0010301	5-6		●		●					
LS3SB0020201	2-3.5		●		●			●	●	
SBFD010[4]	2-3.5		●		●			●	●	
LS3SB0020401	5-6		●		●			●		
LS3SB0030101	2-4		●							
LS3SB0030201	4-7		●							
LS3SB0040101	2-3		●						●	
SBFD002[5]	2-3		●							
LS3SB0040201	6.5-7.5		●							
LS3SB0050101	2-3.5		●		●					
LS3SB0050201	5-5.5		●		●					
GROUNDWATER										
LS3GW00101	NA		●		●	●			●	●
LS3GW00201	NA		●		●	●			●	●
LS3GW13MW1201	NA		●		●	●			●	●

1 Toxicity Characteristic Leaching Procedure (TCLP) extraction followed by analysis for RCRA metals.
2 Synthetic Precipitation Leaching Procedure (SPLP) extraction followed by analysis for lead.
3 Miscellaneous parameters include: Alkalinity (as $CaCO_3$), Ammonia (as Nitrogen), Chloride, Dissolved Oxygen, Divalent Iron, Hardness (as $CaCO_3$), Nitrate (as Nitrogen), pH, Phosphorous, Redox Potential, Salinity, Specific Conductivity, Sulfate, Temperature, Total Organic Carbon, Turbidity, and Dissolved Methane.
4 SBFD010 is a field duplicate of LS3SB0020201.
5 SBFD002 is a field duplicate of LS3SB0040101.
NA = Not applicable.
● = Sample was analyzed for this parameter.
Blank cell indicates that this analysis was not performed for this sample.

TABLE 6-8 (PAGE 1 OF 52)
SUMMARY OF POSITIVE SOIL ANALYTICAL RESULTS FOR ZONE 3
LOWER SUBASE; NSB-NLON; GROTON, CONNECTICUT

SAMPLE NUMBER:	13MW12(8-10)	13TB12-0204-X	13TB12-0406	13TB12-0608-X	13TB18-0103	13TB5A-1.5-3.5
DEPTH (feet):	8 - 10'	2 - 4'	4 - 6'	6 - 8'	1 - 3'	1.5 - 3.5'
INVESTIGATION:	PH1	PH2-1	PH2-1	PH2-1	PH2-1	PH2-1
SAMPLE DATE:	11/08/90	01/22/94	01/22/94	01/22/94	02/01/94	01/22/94
LOCATION:	13MW12	13TB12	13TB12	13TB12	13TB18	13TB5A
VALIDATED:	VALIDATED	VALIDATED	VALIDATED	VALIDATED	VALIDATED	VALIDATED
SAMPLE TYPE:	GRAB	GRAB	GRAB	GRAB	GRAB	GRAB
STATUS:						
FIELD DUPLICATE OF:						
VOLATILES (µg/kg)						
1,1,1-TRICHLOROETHANE	6 U					
1,1-DICHLOROETHENE	6 U					
2-BUTANONE	13 U					
4-METHYL-2-PENTANONE	13 U					
ACETONE	13 U					
BENZENE	6 U					
CHLOROFORM	6 U					
ETHYLBENZENE	6 U					
METHYLENE CHLORIDE	6 U					
TETRACHLOROETHENE	6 U					
TOLUENE	6 U					
XYLENES, TOTAL	6 U					
METALS (mg/kg)						
ALUMINUM	8120					
ANTIMONY	6.2 UJ					
ARSENIC	2.8					
BARIUM	29.2					
BERYLLIUM	0.33					
CADMIUM	0.83 J					
CALCIUM	1100 J					
CHROMIUM	10.5					
COBALT	4.4					

TABLE 6-8 (PAGE 2 OF 52)
SUMMARY OF POSITIVE SOIL ANALYTICAL RESULTS FOR ZONE 3
LOWER SUBASE; NSB-NLON; GROTON, CONNECTICUT

SAMPLE NUMBER:	13MW12(8-10)	13TB12-0204-X	13TB12-0406	13TB12-0608-X	13TB18-0103	13TB5A-1.5-3.5
DEPTH (feet):	8 - 10'	2 - 4'	4 - 6'	6 - 8'	1 - 3'	1.5 - 3.5'
INVESTIGATION:	PH1	PH2-1	PH2-1	PH2-1	PH2-1	PH2-1
SAMPLE DATE:	11/08/90	01/22/94	01/22/94	01/22/94	02/01/94	01/22/94
LOCATION:	13MW12	13TB12	13TB12	13TB12	13TB18	13TB5A
VALIDATED:	VALIDATED	VALIDATED	VALIDATED	VALIDATED	VALIDATED	VALIDATED
SAMPLE TYPE:	GRAB	GRAB	GRAB	GRAB	GRAB	GRAB
STATUS:						
FIELD DUPLICATE OF:						
METALS (mg/kg)						
COPPER	8.8 J					
IRON	7230					
LEAD	2.6 J	567 J	282 J	107 J	1320 J	151 J
MAGNESIUM	1930					
MANGANESE	88.1					
MERCURY	0.12 U					
NICKEL	7					
POTASSIUM	910 J					
SELENIUM	0.5 U					
SILVER	1.8 U					
SODIUM	114 J					
VANADIUM	15.7					
ZINC	17					
TOTAL PETROLEUM HYDROCARBONS (mg/kg)						
TPH	3400 J		138		450 J	552

TABLE 6-8 (PAGE 3 OF 52)
SUMMARY OF POSITIVE SOIL ANALYTICAL RESULTS FOR ZONE 3
LOWER SUBASE; NSB-NLON; GROTON, CONNECTICUT

SAMPLE NUMBER:	13TB5A-1.5-3.5-X	13TB7-0103	2-EXBE-ALBACORE-0	2-EXBE78-06	2-EXNW09-06	2-EXNW78-09
DEPTH (feet):	1.5 - 3.5'	1 - 3'	5 - 5'	3 - 3'	2 - 2'	0'
INVESTIGATION:	PH2-1	PH2-1	B31PRA	B31PRA	B31PRA	B31PRA
SAMPLE DATE:	01/22/94	01/22/94	04/29/94	04/25/94	06/29/94	04/29/94
LOCATION:	13TB5A	13TB7	2-EXBE-ALBACORE -04	2-EXBE78-06	2-EXNW09-06	2-EXNW78-09
VALIDATED:	VALIDATED	VALIDATED				
SAMPLE TYPE:	GRAB	GRAB	GRAB	GRAB	GRAB	GRAB
STATUS:						
FIELD DUPLICATE OF:						
METALS (mg/kg)						
LEAD	113 J	36.8 J	6060	330	72.7	233
TOTAL PETROLEUM HYDROCARBONS (mg/kg)						
TPH		65.2				

TABLE 6-8 (PAGE 4 OF 52)
SUMMARY OF POSITIVE SOIL ANALYTICAL RESULTS FOR ZONE 3
LOWER SUBASE; NSB-NLON; GROTON, CONNECTICUT

SAMPLE NUMBER:	2-EXSW78-09	2-EXWW-ALBACORE-	2-EXWW06-06	2-EXWW09-06	3-EXSW09-06	4-EXEW03-07
DEPTH (feet):	0'	2 - 2'	6 - 6'	3 - 3'	3 - 3'	2 - 2'
INVESTIGATION:	B31PRA	B31PRA	B31PRA	B31PRA	B31PRA	B31PRA
SAMPLE DATE:	04/25/94	04/29/94	06/21/94	06/29/94	07/07/94	05/24/94
LOCATION:	2-EXSW78-09	2-EXWW-ALBACOR E-06	2-EXWW06-06	2-EXWW09-06	3-EXSW09-06	4-EXEW03-07
VALIDATED:						
SAMPLE TYPE:	GRAB	GRAB	GRAB	GRAB	GRAB	GRAB
STATUS:						
FIELD DUPLICATE OF:						
METALS (mg/kg)						
LEAD	97.9	4390	429	8.4	351	21.4

TABLE 6-8 (PAGE 5 OF 52)
SUMMARY OF POSITIVE SOIL ANALYTICAL RESULTS FOR ZONE 3
LOWER SUBASE; NSB-NLON; GROTON, CONNECTICUT

SAMPLE NUMBER:	EXBE-ALBACORE-04	EXBE-ALBACORE-04-	EXNW-ALBACORE-06	EXBE78-06	EXNW78-09	EXSW78-09
DEPTH (feet):	5 - 5'	5 - 5'	3 - 3'	3 - 3'	0'	0'
INVESTIGATION:	B31PRA	B31PRA	B31PRA	B31PRA	B31PRA	B31PRA
SAMPLE DATE:	04/25/94	04/25/94	04/29/94	04/01/94	04/01/94	04/01/94
LOCATION:	ALBACORE RD	ALBACORE RD	ALBACORE RD	BLDG 31/78 N	BLDG 31/78 N	BLDG 31/78 N
VALIDATED:						
SAMPLE TYPE:	GRAB	GRAB	GRAB	GRAB	GRAB	GRAB
STATUS:	EXCAVATED	EXCAVATED	EXCAVATED	EXCAVATED	EXCAVATED	EXCAVATED
FIELD DUPLICATE OF:		EXBE-ALBACORE-04				
METALS (mg/kg)						
LEAD	1200	1870	724	413	1120	1690

TABLE 6-8 (PAGE 6 OF 52)
SUMMARY OF POSITIVE SOIL ANALYTICAL RESULTS FOR ZONE 3
LOWER SUBASE; NSB-NLON; GROTON, CONNECTICUT

SAMPLE NUMBER:	EXBE01-06	2-EXEW03-07	3-EXEW03-07	EXEW03-07	EXWW06-05	EXEW07-05-D
DEPTH (feet):	3 - 3'	2 - 2'	2 - 2'	2 - 2'	5 - 5'	4 - 4'
INVESTIGATION:	B31PRA	B31PRA	B31PRA	B31PRA	B31PRA	B31PRA
SAMPLE DATE:	03/15/94	04/25/94	05/16/94	03/22/94	06/07/94	05/04/94
LOCATION:	CELL NO 1	CELL NO 3	CELL NO 3	CELL NO 3	CELL NO 6, N	CELL NO 7
VALIDATED:						
SAMPLE TYPE:	GRAB	GRAB	GRAB	GRAB	GRAB	GRAB
STATUS:	EXCAVATED	EXCAVATED	EXCAVATED	EXCAVATED	EXCAVATED	
FIELD DUPLICATE OF:						EXEW07-05
METALS (mg/kg)						
LEAD	1980	4480	1950	1630	1210	27.6

TABLE 6-8 (PAGE 7 OF 52)
SUMMARY OF POSITIVE SOIL ANALYTICAL RESULTS FOR ZONE 3
LOWER SUBASE; NSB-NLON; GROTON, CONNECTICUT

SAMPLE NUMBER:	2-EXSW09-06	EXNW09-06	EXSW09-06	EXWW09-06	EXWW09-06-D	EXBE-ALBACORE-03
DEPTH (feet):	3 - 3'	3 - 3'	3 - 3'	3 - 3'	3 - 3'	6 - 6'
INVESTIGATION:	B31PRA	B31PRA	B31PRA	B31PRA	B31PRA	B31PRA
SAMPLE DATE:	06/29/94	06/23/94	06/24/94	06/23/94	06/23/94	05/16/94
LOCATION:	CELL NO 9	CELL NO 9	CELL NO 9	CELL NO 9	CELL NO 9	EXBE-ALBACORE-0 3
VALIDATED:						
SAMPLE TYPE:	GRAB	GRAB	GRAB	GRAB	GRAB	GRAB
STATUS:	EXCAVATED	EXCAVATED	EXCAVATED	EXCAVATED	EXCAVATED	
FIELD DUPLICATE OF:					EXWW09-06	
METALS (mg/kg)						
LEAD	1940	7420	1690	1990	167	3330

TABLE 6-8 (PAGE 8 OF 52)
SUMMARY OF POSITIVE SOIL ANALYTICAL RESULTS FOR ZONE 3
LOWER SUBASE; NSB-NLON; GROTON, CONNECTICUT

SAMPLE NUMBER:	EXBE-BULLHEAD-07	EXBE01-04	EXBE02-04	EXBE03-04	EXBE05-04	EXBE06-07
DEPTH (feet):	2 - 2'	5 - 5'	5 - 5'	5 - 5'	4 - 4'	7 - 7'
INVESTIGATION:	B31PRA	B31PRA	B31PRA	B31PRA	B31PRA	B31PRA
SAMPLE DATE:	04/29/94	03/22/94	03/15/94	03/22/94	06/11/94	06/11/94
LOCATION:	EXBE-BULLHEAD-07	EXBE01-04	EXBE02-04	EXBE03-04	EXBE05-04	EXBE06-07
VALIDATED:						
SAMPLE TYPE:	GRAB	GRAB	GRAB	GRAB	GRAB	GRAB
STATUS:						
FIELD DUPLICATE OF:						
METALS (mg/kg)						
LEAD	285	49.6	322	134	1290	162

TABLE 6-8 (PAGE 9 OF 52)
SUMMARY OF POSITIVE SOIL ANALYTICAL RESULTS FOR ZONE 3
LOWER SUBASE; NSB-NLON; GROTON, CONNECTICUT

SAMPLE NUMBER:	EXBE07-03	EXEW02-06	EXEW07-05	EXEWBULLHEAD-08	EXNW02-06	EXNW03-07
DEPTH (feet):	6 - 6'	3 - 3'	4 - 4'	1 - 1'	3 - 3'	2 - 2'
INVESTIGATION:	B31PRA	B31PRA	B31PRA	B31PRA	B31PRA	B31PRA
SAMPLE DATE:	05/04/94	03/15/94	05/04/94	04/29/94	03/15/94	03/22/94
LOCATION:	EXBE07-03	EXEW02-06	EXEW07-05	EXEWBULLHEAD-0 8	EXNW02-06	EXNW03-07
VALIDATED:						
SAMPLE TYPE:	GRAB	GRAB	GRAB	GRAB	GRAB	GRAB
STATUS:						
FIELD DUPLICATE OF:						

METALS (mg/kg)

LEAD	15.2	92.4	33.3	134	19.9	24.3

TABLE 6-8 (PAGE 10 OF 52)
SUMMARY OF POSITIVE SOIL ANALYTICAL RESULTS FOR ZONE 3
LOWER SUBASE; NSB-NLON; GROTON, CONNECTICUT

SAMPLE NUMBER:	EXNW04-06	EXNW07-05	EXNW08-07	EXSW-ALBACORE-06	EXSW-BULLHEAD-08	EXSW01-07
DEPTH (feet):	3 - 3'	4 - 4'	7 - 7'	3 - 3'	1 - 1'	2 - 2'
INVESTIGATION:	B31PRA	B31PRA	B31PRA	B31PRA	B31PRA	B31PRA
SAMPLE DATE:	06/23/94	05/04/94	06/11/94	04/25/94	04/29/94	03/15/94
LOCATION:	EXNW04-06	EXNW07-05	EXNW08-07	EXSW-ALBACORE-06	EXSW-BULLHEAD-08	EXSW01-07
VALIDATED:						
SAMPLE TYPE:	GRAB	GRAB	GRAB	GRAB	GRAB	GRAB
STATUS:						
FIELD DUPLICATE OF:						
METALS (mg/kg)						
LEAD	67.4	4.3	1030	4173	341	184

TABLE 6-8 (PAGE 11 OF 52)
SUMMARY OF POSITIVE SOIL ANALYTICAL RESULTS FOR ZONE 3
LOWER SUBASE; NSB-NLON; GROTON, CONNECTICUT

SAMPLE NUMBER:	EXSW02-06	EXSW03-07	EXSW04-06	EXSW07-04	EXSW08-07	EXWW-ALBACORE-06
DEPTH (feet):	3 - 3'	2 - 2'	3 - 3'	5 - 5'	7 - 7'	3 - 3'
INVESTIGATION:	B31PRA	B31PRA	B31PRA	B31PRA	B31PRA	B31PRA
SAMPLE DATE:	03/15/94	03/22/94	06/23/94	05/04/94	06/11/94	04/25/94
LOCATION:	EXSW02-06	EXSW03-07	EXSW04-06	EXSW07-04	EXSW08-07	EXWW-ALBACORE-06
VALIDATED:						
SAMPLE TYPE:	GRAB	GRAB	GRAB	GRAB	GRAB	GRAB
STATUS:						
FIELD DUPLICATE OF:						
METALS (mg/kg)						
LEAD	364	264	10.9	213	234	1880

TABLE 6-8 (PAGE 12 OF 52)
SUMMARY OF POSITIVE SOIL ANALYTICAL RESULTS FOR ZONE 3
LOWER SUBASE; NSB-NLON; GROTON, CONNECTICUT

SAMPLE NUMBER:	EXWW01-07	EXWW02-06	EXWW06-07	EXWW07-05	EXWW08-07	FPTB12L-08
DEPTH (feet):	2 - 2'	3 - 3'	7 - 7'	4 - 4'	7 - 7'	8 - 8'
INVESTIGATION:	B31PRA	B31PRA	B31PRA	B31PRA	B31PRA	TFI96
SAMPLE DATE:	03/15/94	03/15/94	06/11/94	05/04/94	06/11/94	11/17/95
LOCATION:	EXWW01-07	EXWW02-06	EXWW06-07	EXWW07-05	EXWW08-07	GS-12L
VALIDATED:						VALIDATED
SAMPLE TYPE:	GRAB	GRAB	GRAB	GRAB	GRAB	GRAB
STATUS:						
FIELD DUPLICATE OF:						
METALS (mg/kg)						
LEAD	437	7.4	142	2.6	14.4	
TOTAL PETROLEUM HYDROCARBONS (mg/kg)						
TPH						11.1 U

TABLE 6-8 (PAGE 13 OF 52)
SUMMARY OF POSITIVE SOIL ANALYTICAL RESULTS FOR ZONE 3
LOWER SUBASE; NSB-NLON; GROTON, CONNECTICUT

SAMPLE NUMBER:	FPTB13L-07	DUP17-111895	LS3SB0010201	LS3SB0010301	LS3SB0020201	SBFD010
DEPTH (feet):	7 - 7'	7 - 7'	2 - 4'	5 - 6'	2 - 3.5'	2 - 3.5'
INVESTIGATION:	TFI96	TFI96	1997RI	1997RI	1997RI	1997RI
SAMPLE DATE:	11/18/95	11/18/95	09/27/97	09/27/97	09/29/97	09/29/97
LOCATION:	GS-13L	GS-13L	MW1-3RI	MW1-3RI	MW2-3RI	MW2-3RI
VALIDATED:	VALIDATED	VALIDATED	VALIDATED	VALIDATED	VALIDATED	VALIDATED
SAMPLE TYPE:	GRAB	GRAB	GRAB	GRAB	GRAB	GRAB
STATUS:						
FIELD DUPLICATE OF:		FPTB13L-07				LS3SB0020201
SEMIVOLATILES (µg/kg)						
1,2,4-TRICHLOROBENZENE			360 U	400 U	330 U	330 U
2,4-DINITROTOLUENE			360 U	400 U	330 U	330 U
2-CHLOROPHENOL			360 U	400 U	330 U	330 U
2-METHYLNAPHTHALENE			360 U	400 UJ	33 J	28 J
4-CHLORO-3-METHYLPHENOL			360 U	400 U	330 U	330 U
ACENAPHTHENE			360 U	21 J	17 J	330 U
ACENAPHTHYLENE			58 J	400 U	31 J	26 J
ANTHRACENE			51 J	69 J	34 J	27 J
BENZO(A)ANTHRACENE			440	210 J	200 J	140 J
BENZO(A)PYRENE			480 J	170 J	210 J	180 J
BENZO(B)FLUORANTHENE			510 J	270 J	240 J	260 J
BENZO(G,H,I)PERYLENE			210 J	190 J	170 J	330 UJ
BENZO(K)FLUORANTHENE			440 J	150 J	230 J	98 J
BIS(2-ETHYLHEXYL)PHTHALATE			360 U	400 UJ	330 U	330 U
CARBAZOLE			360 U	46 J	22 J	330 U
CHRYSENE			380	180 J	230 J	200 J
DI-N-BUTYL PHTHALATE			360 U	400 U	330 U	330 U
DI-N-OCTYL PHTHALATE			360 UJ	400 UJ	330 UJ	330 UJ
DIBENZO(A,H)ANTHRACENE			150 J	66 J	93 J	150 J
DIBENZOFURAN			360 U	400 U	330 U	330 U
DIETHYL PHTHALATE			360 U	400 U	330 U	330 U
FLUORANTHENE			450	420	250 J	180 J

TABLE 6-8 (PAGE 14 OF 52)
SUMMARY OF POSITIVE SOIL ANALYTICAL RESULTS FOR ZONE 3
LOWER SUBASE; NSB-NLON; GROTON, CONNECTICUT

SAMPLE NUMBER:	FPTB13L-07	DUP17-111895	LS3SB0010201	LS3SB0010301	LS3SB0020201	SBFD010
DEPTH (feet):	7 - 7'	7 - 7'	2 - 4'	5 - 6'	2 - 3.5'	2 - 3.5'
INVESTIGATION:	TFI96	TFI96	1997RI	1997RI	1997RI	1997RI
SAMPLE DATE:	11/18/95	11/18/95	09/27/97	09/27/97	09/29/97	09/29/97
LOCATION:	GS-13L	GS-13L	MW1-3RI	MW1-3RI	MW2-3RI	MW2-3RI
VALIDATED:	VALIDATED	VALIDATED	VALIDATED	VALIDATED	VALIDATED	VALIDATED
SAMPLE TYPE:	GRAB	GRAB	GRAB	GRAB	GRAB	GRAB
STATUS:						
FIELD DUPLICATE OF:		FPTB13L-07				LS3SB0020201
SEMIVOLATILES (µg/kg)						
FLUORENE			360 U	28 J	25 J	330 U
INDENO(1,2,3-CD)PYRENE			220 J	120 J	160 J	120 J
NAPHTHALENE			360 U	400 U	22 J	330 U
PENTACHLOROPHENOL			910 U	1000 U	830 U	830 U
PHENANTHRENE			200 J	330 J	170 J	120 J
PYRENE			710	510	380	310 J
METALS (mg/kg)						
ALUMINUM			5430	5400	5530	5820
ANTIMONY			1.1 J	0.45 UJ	0.64 J	0.42 UJ
ARSENIC			2.6	4.9	1.7	1.4
BARIUM			36.9	22.5	40.2	36.3
BERYLLIUM			0.23 J	0.23 J	0.15 U	0.20 U
CADMIUM			0.10 U	0.05 U	0.06 U	0.04 U
CALCIUM			806	920	1860	1000
CHROMIUM			11.1	11.4	16.5	12.1
COBALT			3.5	3.7	4.3	5.0
COPPER			15.9	17.0	25.4 U	28.4 U
IRON			7570	8420	8530	9040
LEAD			1390	207	512	513
MAGNESIUM			1980	1920	2660	2810
MANGANESE			128	290	160	139
MERCURY			0.23 J	0.05 J	0.05 J	0.02 J

TABLE 6-8 (PAGE 15 OF 52)
SUMMARY OF POSITIVE SOIL ANALYTICAL RESULTS FOR ZONE 3
LOWER SUBASE; NSB-NLON; GROTON, CONNECTICUT

SAMPLE NUMBER:	FPTB13L-07	DUP17-111895	LS3SB0010201	LS3SB0010301	LS3SB0020201	SBFD010
DEPTH (feet):	7 - 7'	7 - 7'	2 - 4'	5 - 6'	2 - 3.5'	2 - 3.5'
INVESTIGATION:	TFI96	TFI96	1997RI	1997RI	1997RI	1997RI
SAMPLE DATE:	11/18/95	11/18/95	09/27/97	09/27/97	09/29/97	09/29/97
LOCATION:	GS-13L	GS-13L	MW1-3RI	MW1-3RI	MW2-3RI	MW2-3RI
VALIDATED:	VALIDATED	VALIDATED	VALIDATED	VALIDATED	VALIDATED	VALIDATED
SAMPLE TYPE:	GRAB	GRAB	GRAB	GRAB	GRAB	GRAB
STATUS:						
FIELD DUPLICATE OF:		FPTB13L-07				LS3SB0020201
METALS (mg/kg)						
NICKEL			9.3	7.8	9.2	10.1
POTASSIUM			1120	1080	1520	1660
SELENIUM			0.33 U	0.60 J	0.63 U	0.42 U
SILVER			0.45 U	0.19 U	0.48 U	0.43 U
SODIUM			167	353	173	174
VANADIUM			14.6	14.8	24.5	24.8
ZINC			68.6	74.1	39.5	37.5
TOTAL PETROLEUM HYDROCARBONS (mg/kg)						
TPH	20.7	18.6	930 J		1600 J	1000 J

TABLE 6-8 (PAGE 16 OF 52)
SUMMARY OF POSITIVE SOIL ANALYTICAL RESULTS FOR ZONE 3
LOWER SUBASE; NSB-NLON; GROTON, CONNECTICUT

SAMPLE NUMBER:	LS3SB0020401	SB01-2.0	SB01-4.0	SB01-4.0-D	SB01-6.0	SB02-2.0
DEPTH (feet):	5 - 6'	0 - 2'	2 - 4'	2 - 4'	4 - 6'	0 - 2'
INVESTIGATION:	1997RI	AMB31	AMB31	AMB31	AMB31	AMB31
SAMPLE DATE:	10/01/97	02/25/93	02/25/93	02/25/93	02/25/93	02/25/93
LOCATION:	MW2-3RI	SB01	SB01	SB01	SB01	SB02
VALIDATED:	VALIDATED	VALIDATED	VALIDATED	VALIDATED	VALIDATED	VALIDATED
SAMPLE TYPE:	GRAB	GRAB	GRAB	GRAB	GRAB	GRAB
STATUS:		EXCAVATED	EXCAVATED	EXCAVATED	EXCAVATED	EXCAVATED
FIELD DUPLICATE OF:				SB01-4.0		
SEMIVOLATILES (µg/kg)						
1,2,4-TRICHLOROBENZENE	330 U					
2,4-DINITROTOLUENE	330 U					
2-CHLOROPHENOL	330 U					
2-METHYLNAPHTHALENE	330 UJ					
4-CHLORO-3-METHYLPHENOL	330 U					
ACENAPHTHENE	330 U					
ACENAPHTHYLENE	330 U					
ANTHRACENE	330 U					
BENZO(A)ANTHRACENE	330 U					
BENZO(A)PYRENE	330 U					
BENZO(B)FLUORANTHENE	330 U					
BENZO(G,H,I)PERYLENE	330 U					
BENZO(K)FLUORANTHENE	330 U					
BIS(2-ETHYLHEXYL)PHTHALATE	330 U					
CARBAZOLE	330 U					
CHRYSENE	330 U					
DI-N-BUTYL PHTHALATE	330 U					
DI-N-OCTYL PHTHALATE	330 U					
DIBENZO(A,H)ANTHRACENE	330 U					
DIBENZOFURAN	330 U					
DIETHYL PHTHALATE	330 U					
FLUORANTHENE	330 U					

TABLE 6-8 (PAGE 17 OF 52)
SUMMARY OF POSITIVE SOIL ANALYTICAL RESULTS FOR ZONE 3
LOWER SUBASE; NSB-NLON; GROTON, CONNECTICUT

SAMPLE NUMBER:	LS3SB0020401	SB01-2.0	SB01-4.0	SB01-4.0-D	SB01-6.0	SB02-2.0
DEPTH (feet):	5 - 6'	0 - 2'	2 - 4'	2 - 4'	4 - 6'	0 - 2'
INVESTIGATION:	1997RI	AMB31	AMB31	AMB31	AMB31	AMB31
SAMPLE DATE:	10/01/97	02/25/93	02/25/93	02/25/93	02/25/93	02/25/93
LOCATION:	MW2-3RI	SB01	SB01	SB01	SB01	SB02
VALIDATED:	VALIDATED	VALIDATED	VALIDATED	VALIDATED	VALIDATED	VALIDATED
SAMPLE TYPE:	GRAB	GRAB	GRAB	GRAB	GRAB	GRAB
STATUS:		EXCAVATED	EXCAVATED	EXCAVATED	EXCAVATED	EXCAVATED
FIELD DUPLICATE OF:				SB01-4.0		
SEMIVOLATILES (µg/kg)						
FLUORENE	330 U					
INDENO(1,2,3-CD)PYRENE	330 U					
NAPHTHALENE	330 U					
PENTACHLOROPHENOL	830 U					
PHENANTHRENE	330 U					
PYRENE	20 J					
METALS (mg/kg)						
ALUMINUM	3510					
ANTIMONY	0.45 UJ					
ARSENIC	1.1					
BARIUM	22.7					
BERYLLIUM	0.21 U					
CADMIUM	0.05 U					
CALCIUM	700					
CHROMIUM	6.1					
COBALT	2.5					
COPPER	7.6					
IRON	5100					
LEAD	207	1490 J	4330 J	1590 J	1180 J	3390 J
MAGNESIUM	1560					
MANGANESE	105					
MERCURY	0.01 UJ					

TABLE 6-8 (PAGE 18 OF 52)
SUMMARY OF POSITIVE SOIL ANALYTICAL RESULTS FOR ZONE 3
LOWER SUBASE; NSB-NLON; GROTON, CONNECTICUT

SAMPLE NUMBER:	LS3SB0020401	SB01-2.0	SB01-4.0	SB01-4.0-D	SB01-6.0	SB02-2.0
DEPTH (feet):	5 - 6'	0 - 2'	2 - 4'	2 - 4'	4 - 6'	0 - 2'
INVESTIGATION:	1997RI	AMB31	AMB31	AMB31	AMB31	AMB31
SAMPLE DATE:	10/01/97	02/25/93	02/25/93	02/25/93	02/25/93	02/25/93
LOCATION:	MW2-3RI	SB01	SB01	SB01	SB01	SB02
VALIDATED:	VALIDATED	VALIDATED	VALIDATED	VALIDATED	VALIDATED	VALIDATED
SAMPLE TYPE:	GRAB	GRAB	GRAB	GRAB	GRAB	GRAB
STATUS:		EXCAVATED	EXCAVATED	EXCAVATED	EXCAVATED	EXCAVATED
FIELD DUPLICATE OF:				SB01-4.0		
METALS (mg/kg)						
NICKEL	5.6					
POTASSIUM	1140					
SELENIUM	0.41 U					
SILVER	0.46 U					
SODIUM	161					
VANADIUM	9.7					
ZINC	18.4					
GENERAL CHEMISTRY						
PH		7.49	7.58	7.5	6.26	9.95

TABLE 6-8 (PAGE 19 OF 52)
SUMMARY OF POSITIVE SOIL ANALYTICAL RESULTS FOR ZONE 3
LOWER SUBASE; NSB-NLON; GROTON, CONNECTICUT

SAMPLE NUMBER:	SB02-2.0-RCRA	SB02-4.0	SB02-4.0-D	SB02-6.0	SB03-2.0	SB03-4.0
DEPTH (feet):	0 - 2'	2 - 4'	2 - 4'	4 - 6'	0 - 2'	2 - 4'
INVESTIGATION:	AMB31	AMB31	AMB31	AMB31	AMB31	AMB31
SAMPLE DATE:	02/25/93	02/25/93	02/25/93	02/25/93	02/25/93	02/25/93
LOCATION:	SB02	SB02	SB02	SB02	SB03	SB03
VALIDATED:	VALIDATED	VALIDATED	VALIDATED	VALIDATED	VALIDATED	VALIDATED
SAMPLE TYPE:	GRAB	GRAB	GRAB	GRAB	GRAB	GRAB
STATUS:	EXCAVATED	EXCAVATED	EXCAVATED	EXCAVATED	EXCAVATED	EXCAVATED
FIELD DUPLICATE OF:			SB02-4.0			
VOLATILES (µg/kg)						
1,1,1-TRICHLOROETHANE		0.8 J	11 U			
1,1-DICHLOROETHENE		3 J	0.6 J			
2-BUTANONE		7 J	2 J			
4-METHYL-2-PENTANONE		10 U	11 U			
ACETONE		120 U	55 U			
BENZENE		0.4 J	11 U			
CHLOROFORM		10 U	11 U			
ETHYLBENZENE		2 J	2 J			
METHYLENE CHLORIDE		39 J	9 J			
TETRACHLOROETHENE		5 J	3 J			
TOLUENE		10 U	11 U			
XYLENES, TOTAL		15 J	9 J			
SEMIVOLATILES (µg/kg)						
1,2,4-TRICHLOROBENZENE		31 J	350 U			
2,4-DINITROTOLUENE		22 J	350 U			
2-CHLOROPHENOL		47 J	350 U			
2-METHYLNAPHTHALENE		23 J	42 J			
4-CHLORO-3-METHYLPHENOL		45 J	350 U			
ACENAPHTHENE		54 J	120 J			
ACENAPHTHYLENE		350 U	22 J			
ANTHRACENE		100 J	280 J			
BENZO(A)ANTHRACENE		260 J	530 J			

TABLE 6-8 (PAGE 20 OF 52)
SUMMARY OF POSITIVE SOIL ANALYTICAL RESULTS FOR ZONE 3
LOWER SUBASE; NSB-NLON; GROTON, CONNECTICUT

SAMPLE NUMBER:	SB02-2.0-RCRA	SB02-4.0	SB02-4.0-D	SB02-6.0	SB03-2.0	SB03-4.0
DEPTH (feet):	0 - 2'	2 - 4'	2 - 4'	4 - 6'	0 - 2'	2 - 4'
INVESTIGATION:	AMB31	AMB31	AMB31	AMB31	AMB31	AMB31
SAMPLE DATE:	02/25/93	02/25/93	02/25/93	02/25/93	02/25/93	02/25/93
LOCATION:	SB02	SB02	SB02	SB02	SB03	SB03
VALIDATED:	VALIDATED	VALIDATED	VALIDATED	VALIDATED	VALIDATED	VALIDATED
SAMPLE TYPE:	GRAB	GRAB	GRAB	GRAB	GRAB	GRAB
STATUS:	EXCAVATED	EXCAVATED	EXCAVATED	EXCAVATED	EXCAVATED	EXCAVATED
FIELD DUPLICATE OF:			SB02-4.0			
SEMIVOLATILES (µg/kg)						
BENZO(A)PYRENE		250 J	460 J			
BENZO(B)FLUORANTHENE		360 J	560 J			
BENZO(G,H,I)PERYLENE		88 J	120 J			
BENZO(K)FLUORANTHENE		310 J	510 J			
BIS(2-ETHYLHEXYL)PHTHALATE		350 U	350 U			
CARBAZOLE		56 J	160 J			
CHRYSENE		330 J	610 J			
DI-N-BUTYL PHTHALATE		350 U	350 U			
DI-N-OCTYL PHTHALATE		350 UJ	350 UJ			
DIBENZO(A,H)ANTHRACENE		58 J	96 J			
DIBENZOFURAN		19 J	66 J			
DIETHYL PHTHALATE		350 U	350 U			
FLUORANTHENE		720 J	1400 J			
FLUORENE		26 J	92 J			
INDENO(1,2,3-CD)PYRENE		160 J	290 J			
NAPHTHALENE		350 U	350 U			
PENTACHLOROPHENOL		60 J	850 U			
PHENANTHRENE		410 J	1000 J			
PYRENE		700 J	1500 J			
PESTICIDES/PCBs (µg/kg)						
4,4'-DDT		6.21	4.8 J			
DIELDRIN		3.5 U	3.5 UJ			

TABLE 6-8 (PAGE 21 OF 52)
SUMMARY OF POSITIVE SOIL ANALYTICAL RESULTS FOR ZONE 3
LOWER SUBASE; NSB-NLON; GROTON, CONNECTICUT

SAMPLE NUMBER:	SB02-2.0-RCRA	SB02-4.0	SB02-4.0-D	SB02-6.0	SB03-2.0	SB03-4.0
DEPTH (feet):	0 - 2'	2 - 4'	2 - 4'	4 - 6'	0 - 2'	2 - 4'
INVESTIGATION:	AMB31	AMB31	AMB31	AMB31	AMB31	AMB31
SAMPLE DATE:	02/25/93	02/25/93	02/25/93	02/25/93	02/25/93	02/25/93
LOCATION:	SB02	SB02	SB02	SB02	SB03	SB03
VALIDATED:	VALIDATED	VALIDATED	VALIDATED	VALIDATED	VALIDATED	VALIDATED
SAMPLE TYPE:	GRAB	GRAB	GRAB	GRAB	GRAB	GRAB
STATUS:	EXCAVATED	EXCAVATED	EXCAVATED	EXCAVATED	EXCAVATED	EXCAVATED
FIELD DUPLICATE OF:			SB02-4.0			
METALS (mg/kg)						
ALUMINUM		9260	9240			
ANTIMONY		10.4	8.4			
ARSENIC	5 J	3	2.8			
BARIUM	57.5	55.6	55.8			
BERYLLIUM		0.32	0.34			
CADMIUM	0.46 U	1.4	0.48			
CALCIUM		3090	7390			
CHROMIUM	11.9	14.9	15.3			
COBALT		5.7	5.9			
COPPER		36.6	33.2			
IRON		10500	9990			
LEAD	5860	3160	2720	383 J	4790 J	5370 J
MAGNESIUM		2790	2670			
MANGANESE		192	175			
MERCURY	0.45 J	0.35	0.56			
NICKEL		9.9	10.3			
POTASSIUM		2080	1870			
SELENIUM	0.27 U	0.21 U	0.22 U			
SILVER	0.85 U	0.86 U	0.89 U			
SODIUM		644	886			
VANADIUM		20.3	19.8			
ZINC		648	184			

TABLE 6-8 (PAGE 22 OF 52)
SUMMARY OF POSITIVE SOIL ANALYTICAL RESULTS FOR ZONE 3
LOWER SUBASE; NSB-NLON; GROTON, CONNECTICUT

SAMPLE NUMBER:	SB02-2.0-RCRA	SB02-4.0	SB02-4.0-D	SB02-6.0	SB03-2.0	SB03-4.0
DEPTH (feet):	0 - 2'	2 - 4'	2 - 4'	4 - 6'	0 - 2'	2 - 4'
INVESTIGATION:	AMB31	AMB31	AMB31	AMB31	AMB31	AMB31
SAMPLE DATE:	02/25/93	02/25/93	02/25/93	02/25/93	02/25/93	02/25/93
LOCATION:	SB02	SB02	SB02	SB02	SB03	SB03
VALIDATED:	VALIDATED	VALIDATED	VALIDATED	VALIDATED	VALIDATED	VALIDATED
SAMPLE TYPE:	GRAB	GRAB	GRAB	GRAB	GRAB	GRAB
STATUS:	EXCAVATED	EXCAVATED	EXCAVATED	EXCAVATED	EXCAVATED	EXCAVATED
FIELD DUPLICATE OF:			SB02-4.0			
GENERAL CHEMISTRY						
PH		9.41	9.41	9.41	4.74	6.74

TABLE 6-8 (PAGE 23 OF 52)
SUMMARY OF POSITIVE SOIL ANALYTICAL RESULTS FOR ZONE 3
LOWER SUBASE; NSB-NLON; GROTON, CONNECTICUT

SAMPLE NUMBER:	SB03-6.0	SB04-2.0	SB04-4.0	SB04-6.0	SB05-2.0	SB05-2.0-RCRA
DEPTH (feet):	4 - 6'	0 - 2'	2 - 4'	4 - 6'	0 - 2'	0 - 2'
INVESTIGATION:	AMB31	AMB31	AMB31	AMB31	AMB31	AMB31
SAMPLE DATE:	02/25/93	02/25/93	02/25/93	02/25/93	02/25/93	02/25/93
LOCATION:	SB03	SB04	SB04	SB04	SB05	SB05
VALIDATED:	VALIDATED	VALIDATED	VALIDATED	VALIDATED	VALIDATED	VALIDATED
SAMPLE TYPE:	GRAB	GRAB	GRAB	GRAB	GRAB	GRAB
STATUS:	EXCAVATED	EXCAVATED	EXCAVATED	EXCAVATED	EXCAVATED	EXCAVATED
FIELD DUPLICATE OF:						
METALS (mg/kg)						
ARSENIC						4.8 J
BARIUM						37.1
CADMIUM						0.43 U
CHROMIUM						12.4
LEAD	106 J	492 J	177 J	301 J	11900 J	460
MERCURY						0.11 UJ
SELENIUM						0.21 UJ
SILVER						0.85 U
GENERAL CHEMISTRY						
PH	6.82	8.75	9.04	11.9	7.24	

TABLE 6-8 (PAGE 24 OF 52)
SUMMARY OF POSITIVE SOIL ANALYTICAL RESULTS FOR ZONE 3
LOWER SUBASE; NSB-NLON; GROTON, CONNECTICUT

SAMPLE NUMBER:	SB05-4.0	SB05-6.0	SB06-2.0	SB06-4.0	SB06-4.0-D	SB06-6.0
DEPTH (feet):	2 - 4'	4 - 6'	0 - 2'	2 - 4'	2 - 4'	4 - 6'
INVESTIGATION:	AMB31	AMB31	AMB31	AMB31	AMB31	AMB31
SAMPLE DATE:	02/25/93	02/25/93	02/25/93	02/25/93	02/25/93	02/25/93
LOCATION:	SB05	SB05	SB06	SB06	SB06	SB06
VALIDATED:				VALIDATED	VALIDATED	
SAMPLE TYPE:	GRAB	GRAB	GRAB	GRAB	GRAB	GRAB
STATUS:	EXCAVATED	EXCAVATED				
FIELD DUPLICATE OF:					SB06-4.0	
METALS (mg/kg)						
LEAD	2990	670	5.9	19.3 U	4.8 U	134
GENERAL CHEMISTRY						
PH	7.45	6.44	6.49	6.27	6.64	6.5

TABLE 6-8 (PAGE 25 OF 52)
SUMMARY OF POSITIVE SOIL ANALYTICAL RESULTS FOR ZONE 3
LOWER SUBASE; NSB-NLON; GROTON, CONNECTICUT

SAMPLE NUMBER:	SB07-2.0	SB07-4.0	SB07-6.0	SB08-2.0	SB08-4.0	SB08-6.0
DEPTH (feet):	0 - 2'	2 - 4'	4 - 6'	0 - 2'	2 - 4'	4 - 6'
INVESTIGATION:	AMB31	AMB31	AMB31	AMB31	AMB31	AMB31
SAMPLE DATE:	02/25/93	02/25/93	02/25/93	02/24/93	02/24/93	02/24/93
LOCATION:	SB07	SB07	SB07	SB08	SB08	SB08
VALIDATED:						
SAMPLE TYPE:	GRAB	GRAB	GRAB	GRAB	GRAB	GRAB
STATUS:				EXCAVATED	EXCAVATED	
FIELD DUPLICATE OF:						
METALS (mg/kg)						
LEAD	13.7	3.1	39.5	962	8.6	30
GENERAL CHEMISTRY						
PH	8.46	6.81	7.59	7.97	4.63	4.95

TABLE 6-8 (PAGE 26 OF 52)
SUMMARY OF POSITIVE SOIL ANALYTICAL RESULTS FOR ZONE 3
LOWER SUBASE; NSB-NLON; GROTON, CONNECTICUT

SAMPLE NUMBER:	SB09-2.0	SB09-4.0	SB09-6.0	SB10-2.0	SB10-4.0	SB10-6.0
DEPTH (feet):	0 - 2'	2 - 4'	4 - 6'	0 - 2'	2 - 4'	4 - 6'
INVESTIGATION:	AMB31	AMB31	AMB31	AMB31	AMB31	AMB31
SAMPLE DATE:	02/24/93	02/24/93	02/24/93	02/24/93	02/24/93	02/24/93
LOCATION:	SB09	SB09	SB09	SB10	SB10	SB10
VALIDATED:						
SAMPLE TYPE:	GRAB	GRAB	GRAB	GRAB	GRAB	GRAB
STATUS:						
FIELD DUPLICATE OF:						
METALS (mg/kg)						
LEAD	27.5	9.8	14.6	7.9	13.7	9.1
GENERAL CHEMISTRY						
PH	8.96	5.54	6.43	7.67	4.6	4.8

TABLE 6-8 (PAGE 27 OF 52)
SUMMARY OF POSITIVE SOIL ANALYTICAL RESULTS FOR ZONE 3
LOWER SUBASE; NSB-NLON; GROTON, CONNECTICUT

SAMPLE NUMBER:	SB10-6.0-D	SB11-2.0	SB11-4.0	SB11-6.0	SB12-2.0	SB12-4.0
DEPTH (feet):	4 - 6'	0 - 2'	2 - 4'	4 - 6'	0 - 2'	2 - 4'
INVESTIGATION:	AMB31	AMB31	AMB31	AMB31	AMB31	AMB31
SAMPLE DATE:	02/24/93	02/24/93	02/24/93	02/24/93	02/24/93	02/24/93
LOCATION:	SB10	SB11	SB11	SB11	SB12	SB12
VALIDATED:						
SAMPLE TYPE:	GRAB	GRAB	GRAB	GRAB	GRAB	GRAB
STATUS:		EXCAVATED	EXCAVATED	EXCAVATED		
FIELD DUPLICATE OF:	SB10-6.0					
METALS (mg/kg)						
LEAD	8.76	9.7	8.4	799	2.8	2.9
GENERAL CHEMISTRY						
PH	4.7	6.16	5.84	11.2	7.7	9.65

TABLE 6-8 (PAGE 28 OF 52)
SUMMARY OF POSITIVE SOIL ANALYTICAL RESULTS FOR ZONE 3
LOWER SUBASE; NSB-NLON; GROTON, CONNECTICUT

SAMPLE NUMBER:	SB12-6.0	SB13-2.0	SB13-2.0-D	SB13-4.0	SB13-6.0	SB14-2.0
DEPTH (feet):	4 - 6'	0 - 2'	0 - 2'	2 - 4'	4 - 6'	0 - 2'
INVESTIGATION:	AMB31	AMB31	AMB31	AMB31	AMB31	AMB31
SAMPLE DATE:	02/24/93	02/24/93	02/24/93	02/24/93	02/24/93	02/25/93
LOCATION:	SB12	SB13	SB13	SB13	SB13	SB14
VALIDATED:						VALIDATED
SAMPLE TYPE:	GRAB	GRAB	GRAB	GRAB	GRAB	GRAB
STATUS:						
FIELD DUPLICATE OF:			SB13-2.0			
VOLATILES (µg/kg)						
1,1,1-TRICHLOROETHANE						11 U
1,1-DICHLOROETHENE						11 U
2-BUTANONE						11 U
4-METHYL-2-PENTANONE						11 U
ACETONE						130
BENZENE						11 U
CHLOROFORM						1 J
ETHYLBENZENE						11 U
METHYLENE CHLORIDE						4 J
TETRACHLOROETHENE						11 U
TOLUENE						11 U
XYLENES, TOTAL						11 U
SEMIVOLATILES (µg/kg)						
1,2,4-TRICHLOROBENZENE						360 U
2,4-DINITROTOLUENE						360 U
2-CHLOROPHENOL						360 U
2-METHYLNAPHTHALENE						360 U
4-CHLORO-3-METHYLPHENOL						360 U
ACENAPHTHENE						360 U
ACENAPHTHYLENE						360 U
ANTHRACENE						360 U
BENZO(A)ANTHRACENE						360 U

TABLE 6-8 (PAGE 29 OF 52)
SUMMARY OF POSITIVE SOIL ANALYTICAL RESULTS FOR ZONE 3
LOWER SUBASE; NSB-NLON; GROTON, CONNECTICUT

SAMPLE NUMBER:	SB12-6.0	SB13-2.0	SB13-2.0-D	SB13-4.0	SB13-6.0	SB14-2.0
DEPTH (feet):	4 - 6'	0 - 2'	0 - 2'	2 - 4'	4 - 6'	0 - 2'
INVESTIGATION:	AMB31	AMB31	AMB31	AMB31	AMB31	AMB31
SAMPLE DATE:	02/24/93	02/24/93	02/24/93	02/24/93	02/24/93	02/25/93
LOCATION:	SB12	SB13	SB13	SB13	SB13	SB14
VALIDATED:						VALIDATED
SAMPLE TYPE:	GRAB	GRAB	GRAB	GRAB	GRAB	GRAB
STATUS:						
FIELD DUPLICATE OF:			SB13-2.0			
SEMIVOLATILES (µg/kg)						
BENZO(A)PYRENE						360 U
BENZO(B)FLUORANTHENE						360 U
BENZO(G,H,I)PERYLENE						360 U
BENZO(K)FLUORANTHENE						360 U
BIS(2-ETHYLHEXYL)PHTHALATE						160 J
CARBAZOLE						360 U
CHRYSENE						360 U
DI-N-BUTYL PHTHALATE						360 U
DI-N-OCTYL PHTHALATE						360 U
DIBENZO(A,H)ANTHRACENE						360 U
DIBENZOFURAN						360 U
DIETHYL PHTHALATE						360 U
FLUORANTHENE						360 U
FLUORENE						360 U
INDENO(1,2,3-CD)PYRENE						360 U
NAPHTHALENE						360 U
PENTACHLOROPHENOL						880 U
PHENANTHRENE						360 U
PYRENE						360 U
PESTICIDES/PCBs (µg/kg)						
4,4'-DDT						3.6 U
DIELDRIN						3.6 U

TABLE 6-8 (PAGE 30 OF 52)
SUMMARY OF POSITIVE SOIL ANALYTICAL RESULTS FOR ZONE 3
LOWER SUBASE; NSB-NLON; GROTON, CONNECTICUT

SAMPLE NUMBER:	SB12-6.0	SB13-2.0	SB13-2.0-D	SB13-4.0	SB13-6.0	SB14-2.0
DEPTH (feet):	4 - 6'	0 - 2'	0 - 2'	2 - 4'	4 - 6'	0 - 2'
INVESTIGATION:	AMB31	AMB31	AMB31	AMB31	AMB31	AMB31
SAMPLE DATE:	02/24/93	02/24/93	02/24/93	02/24/93	02/24/93	02/25/93
LOCATION:	SB12	SB13	SB13	SB13	SB13	SB14
VALIDATED:						VALIDATED
SAMPLE TYPE:	GRAB	GRAB	GRAB	GRAB	GRAB	GRAB
STATUS:						
FIELD DUPLICATE OF:			SB13-2.0			
METALS (mg/kg)						
ALUMINUM						8790
ANTIMONY						5.2 U
ARSENIC						2.2
BARIUM						43.8
BERYLLIUM						0.38
CADMIUM						0.46
CALCIUM						2500
CHROMIUM						16.9
COBALT						5
COPPER						12
IRON						9440
LEAD	8.8	186	463	32.6	42.9	3.1
MAGNESIUM						3260
MANGANESE						155
MERCURY						0.11 U
NICKEL						13.4
POTASSIUM						2130
SELENIUM						0.22 U
SILVER						1.7 U
SODIUM						474
VANADIUM						18.9
ZINC						20.4

TABLE 6-8 (PAGE 31 OF 52)
SUMMARY OF POSITIVE SOIL ANALYTICAL RESULTS FOR ZONE 3
LOWER SUBASE; NSB-NLON; GROTON, CONNECTICUT

SAMPLE NUMBER:	SB12-6.0	SB13-2.0	SB13-2.0-D	SB13-4.0	SB13-6.0	SB14-2.0
DEPTH (feet):	4 - 6'	0 - 2'	0 - 2'	2 - 4'	4 - 6'	0 - 2'
INVESTIGATION:	AMB31	AMB31	AMB31	AMB31	AMB31	AMB31
SAMPLE DATE:	02/24/93	02/24/93	02/24/93	02/24/93	02/24/93	02/25/93
LOCATION:	SB12	SB13	SB13	SB13	SB13	SB14
VALIDATED:						VALIDATED
SAMPLE TYPE:	GRAB	GRAB	GRAB	GRAB	GRAB	GRAB
STATUS:						
FIELD DUPLICATE OF:			SB13-2.0			
GENERAL CHEMISTRY						
PH	8.83	8.78	8.67	8.71	10.1	10.4

TABLE 6-8 (PAGE 32 OF 52)
SUMMARY OF POSITIVE SOIL ANALYTICAL RESULTS FOR ZONE 3
LOWER SUBASE; NSB-NLON; GROTON, CONNECTICUT

SAMPLE NUMBER:	SB14-4.0	SB14-6.0	SB15-2.0	SB15-4.0	SB15-6.0	SB16-2.0
DEPTH (feet):	2 - 4'	4 - 6'	0 - 2'	2 - 4'	4 - 6'	0 - 2'
INVESTIGATION:	AMB31	AMB31	AMB31	AMB31	AMB31	AMB31
SAMPLE DATE:	02/25/93	02/25/93	02/25/93	02/25/93	02/25/93	02/25/93
LOCATION:	SB14	SB14	SB15	SB15	SB15	SB16
VALIDATED:						
SAMPLE TYPE:	GRAB	GRAB	GRAB	GRAB	GRAB	GRAB
STATUS:						EXCAVATED
FIELD DUPLICATE OF:						
METALS (mg/kg)						
LEAD	6.3	5.1	69.2	44.5	40	1060
GENERAL CHEMISTRY						
PH	11.8	10.8	7.1	4.4	5.24	7.79

TABLE 6-8 (PAGE 33 OF 52)
SUMMARY OF POSITIVE SOIL ANALYTICAL RESULTS FOR ZONE 3
LOWER SUBASE; NSB-NLON; GROTON, CONNECTICUT

SAMPLE NUMBER:	SB16-4.0	SB16-6.0	SB17-2.0	SB17-4.0	SB17-6.0	SB18-2.0
DEPTH (feet):	2 - 4'	4 - 6'	0 - 2'	2 - 4'	4 - 6'	0 - 2'
INVESTIGATION:	AMB31	AMB31	AMB31	AMB31	AMB31	AMB31
SAMPLE DATE:	02/25/93	02/25/93	02/24/93	02/24/93	02/24/93	02/25/93
LOCATION:	SB16	SB16	SB17	SB17	SB17	SB18
VALIDATED:						
SAMPLE TYPE:	GRAB	GRAB	GRAB	GRAB	GRAB	GRAB
STATUS:	EXCAVATED		EXCAVATED	EXCAVATED		EXCAVATED
FIELD DUPLICATE OF:						
METALS (mg/kg)						
LEAD	713	339	25	77.3	302	39.1
GENERAL CHEMISTRY						
PH	7.31	4.86	6.69	5.67	7.83	4.64

TABLE 6-8 (PAGE 34 OF 52)
SUMMARY OF POSITIVE SOIL ANALYTICAL RESULTS FOR ZONE 3
LOWER SUBASE; NSB-NLON; GROTON, CONNECTICUT

SAMPLE NUMBER:	SB18-4.0	SB18-6.0	SB18-6.0-RCRA	SB19-2.0	SB19-4.0	SB19-6.0
DEPTH (feet):	2 - 4'	4 - 6'	4 - 6'	0 - 2'	2 - 4'	4 - 6'
INVESTIGATION:	AMB31	AMB31	AMB31	AMB31	AMB31	AMB31
SAMPLE DATE:	02/25/93	02/25/93	02/25/93	02/25/93	02/25/93	02/25/93
LOCATION:	SB18	SB18	SB18	SB19	SB19	SB19
VALIDATED:	VALIDATED	VALIDATED	VALIDATED			
SAMPLE TYPE:	GRAB	GRAB	GRAB	GRAB	GRAB	GRAB
STATUS:	EXCAVATED	EXCAVATED	EXCAVATED			
FIELD DUPLICATE OF:						
VOLATILES (µg/kg)						
1,1,1-TRICHLOROETHANE	4 J					
1,1-DICHLOROETHENE	10 U					
2-BUTANONE	10 U					
4-METHYL-2-PENTANONE	1 J					
ACETONE	83					
BENZENE	10 U					
CHLOROFORM	10 U					
ETHYLBENZENE	10 U					
METHYLENE CHLORIDE	5 J					
TETRACHLOROETHENE	2 J					
TOLUENE	1 J					
XYLENES, TOTAL	11					
SEMIVOLATILES (µg/kg)						
1,2,4-TRICHLOROBENZENE	340 U					
2,4-DINITROTOLUENE	340 U					
2-CHLOROPHENOL	340 U					
2-METHYLNAPHTHALENE	340 U					
4-CHLORO-3-METHYLPHENOL	340 U					
ACENAPHTHENE	340 U					
ACENAPHTHYLENE	340 U					
ANTHRACENE	340 U					
BENZO(A)ANTHRACENE	340 U					

TABLE 6-8 (PAGE 35 OF 52)
SUMMARY OF POSITIVE SOIL ANALYTICAL RESULTS FOR ZONE 3
LOWER SUBASE; NSB-NLON; GROTON, CONNECTICUT

SAMPLE NUMBER:	SB18-4.0	SB18-6.0	SB18-6.0-RCRA	SB19-2.0	SB19-4.0	SB19-6.0
DEPTH (feet):	2 - 4'	4 - 6'	4 - 6'	0 - 2'	2 - 4'	4 - 6'
INVESTIGATION:	AMB31	AMB31	AMB31	AMB31	AMB31	AMB31
SAMPLE DATE:	02/25/93	02/25/93	02/25/93	02/25/93	02/25/93	02/25/93
LOCATION:	SB18	SB18	SB18	SB19	SB19	SB19
VALIDATED:	VALIDATED	VALIDATED	VALIDATED			
SAMPLE TYPE:	GRAB	GRAB	GRAB	GRAB	GRAB	GRAB
STATUS:	EXCAVATED	EXCAVATED	EXCAVATED			
FIELD DUPLICATE OF:						
SEMIVOLATILES (µg/kg)						
BENZO(A)PYRENE	340 U					
BENZO(B)FLUORANTHENE	340 U					
BENZO(G,H,I)PERYLENE	340 U					
BENZO(K)FLUORANTHENE	340 U					
BIS(2-ETHYLHEXYL)PHTHALATE	150 J					
CARBAZOLE	340 U					
CHRYSENE	340 U					
DI-N-BUTYL PHTHALATE	19 J					
DI-N-OCTYL PHTHALATE	18 J					
DIBENZO(A,H)ANTHRACENE	340 U					
DIBENZOFURAN	340 U					
DIETHYL PHTHALATE	340 U					
FLUORANTHENE	340 U					
FLUORENE	340 U					
INDENO(1,2,3-CD)PYRENE	340 U					
NAPHTHALENE	340 U					
PENTACHLOROPHENOL	830 U					
PHENANTHRENE	340 U					
PYRENE	340 U					
PESTICIDES/PCBs (µg/kg)						
4,4'-DDT	3.4 U					
DIELDRIN	75 D					

TABLE 6-8 (PAGE 36 OF 52)
SUMMARY OF POSITIVE SOIL ANALYTICAL RESULTS FOR ZONE 3
LOWER SUBASE; NSB-NLON; GROTON, CONNECTICUT

SAMPLE NUMBER:	SB18-4.0	SB18-6.0	SB18-6.0-RCRA	SB19-2.0	SB19-4.0	SB19-6.0
DEPTH (feet):	2 - 4'	4 - 6'	4 - 6'	0 - 2'	2 - 4'	4 - 6'
INVESTIGATION:	AMB31	AMB31	AMB31	AMB31	AMB31	AMB31
SAMPLE DATE:	02/25/93	02/25/93	02/25/93	02/25/93	02/25/93	02/25/93
LOCATION:	SB18	SB18	SB18	SB19	SB19	SB19
VALIDATED:	VALIDATED	VALIDATED	VALIDATED			
SAMPLE TYPE:	GRAB	GRAB	GRAB	GRAB	GRAB	GRAB
STATUS:	EXCAVATED	EXCAVATED	EXCAVATED			
FIELD DUPLICATE OF:						
METALS (mg/kg)						
ALUMINUM	10800					
ANTIMONY	5.4					
ARSENIC	1.3		2.5 J			
BARIUM	52.9		46.5			
BERYLLIUM	0.36					
CADMIUM	0.69 U		0.43 U			
CALCIUM	3060					
CHROMIUM	14.7		12.5			
COBALT	4.1					
COPPER	65.6					
IRON	12500					
LEAD	53.9	9470 J	689	9.7	15.7	144
MAGNESIUM	3310					
MANGANESE	188					
MERCURY	0.13		0.11 UJ			
NICKEL	11.2					
POTASSIUM	958					
SELENIUM	0.23 U		0.21 UJ			
SILVER	2.5		0.86 U			
SODIUM	269					
VANADIUM	26.2					
ZINC	24.1					

TABLE 6-8 (PAGE 37 OF 52)
SUMMARY OF POSITIVE SOIL ANALYTICAL RESULTS FOR ZONE 3
LOWER SUBASE; NSB-NLON; GROTON, CONNECTICUT

SAMPLE NUMBER:	SB18-4.0	SB18-6.0	SB18-6.0-RCRA	SB19-2.0	SB19-4.0	SB19-6.0
DEPTH (feet):	2 - 4'	4 - 6'	4 - 6'	0 - 2'	2 - 4'	4 - 6'
INVESTIGATION:	AMB31	AMB31	AMB31	AMB31	AMB31	AMB31
SAMPLE DATE:	02/25/93	02/25/93	02/25/93	02/25/93	02/25/93	02/25/93
LOCATION:	SB18	SB18	SB18	SB19	SB19	SB19
VALIDATED:	VALIDATED	VALIDATED	VALIDATED			
SAMPLE TYPE:	GRAB	GRAB	GRAB	GRAB	GRAB	GRAB
STATUS:	EXCAVATED	EXCAVATED	EXCAVATED			
FIELD DUPLICATE OF:						
GENERAL CHEMISTRY						
PH	4.53	5.8		5.11	5.39	11

TABLE 6-8 (PAGE 38 OF 52)
SUMMARY OF POSITIVE SOIL ANALYTICAL RESULTS FOR ZONE 3
LOWER SUBASE; NSB-NLON; GROTON, CONNECTICUT

SAMPLE NUMBER:	SB20-2.0	SB20-4.0	SB20-4.0-D	SB20-6.0	SB21-2.0	SB21-4.0
DEPTH (feet):	0 - 2'	2 - 4'	2 - 4'	4 - 6'	0 - 2'	2 - 4'
INVESTIGATION:	AMB31	AMB31	AMB31	AMB31	AMB31	AMB31
SAMPLE DATE:	02/25/93	02/25/93	02/25/93	02/25/93	02/25/93	02/25/93
LOCATION:	SB20	SB20	SB20	SB20	SB21	SB21
VALIDATED:						
SAMPLE TYPE:	GRAB	GRAB	GRAB	GRAB	GRAB	GRAB
STATUS:						
FIELD DUPLICATE OF:			SB20-4.0			
METALS (mg/kg)						
LEAD	229	26.4	25.8	49.8	69.8	9.3
GENERAL CHEMISTRY						
PH	11	8.67	9.2	9.59	11.6	11.7

TABLE 6-8 (PAGE 39 OF 52)
SUMMARY OF POSITIVE SOIL ANALYTICAL RESULTS FOR ZONE 3
LOWER SUBASE; NSB-NLON; GROTON, CONNECTICUT

SAMPLE NUMBER:	SB21-6.0	SB22-2.0	SB22-4.0	SB22-6.0	SB23-2.0	SB23-4.0
DEPTH (feet):	4 - 6'	0 - 2'	2 - 4'	4 - 6'	0 - 2'	2 - 4'
INVESTIGATION:	AMB31	AMB31	AMB31	AMB31	AMB31	AMB31
SAMPLE DATE:	02/25/93	02/25/93	02/25/93	02/25/93	02/24/93	02/24/93
LOCATION:	SB21	SB22	SB22	SB22	SB23	SB23
VALIDATED:				VALIDATED		
SAMPLE TYPE:	GRAB	GRAB	GRAB	GRAB	GRAB	GRAB
STATUS:						
FIELD DUPLICATE OF:						
VOLATILES (µg/kg)						
1,1,1-TRICHLOROETHANE				6 J		
1,1-DICHLOROETHENE				12 U		
2-BUTANONE				12 U		
4-METHYL-2-PENTANONE				12 U		
ACETONE				84		
BENZENE				12 U		
CHLOROFORM				12 U		
ETHYLBENZENE				12 U		
METHYLENE CHLORIDE				3 J		
TETRACHLOROETHENE				1 J		
TOLUENE				0.8 J		
XYLENES, TOTAL				1 J		
SEMIVOLATILES (µg/kg)						
1,2,4-TRICHLOROBENZENE				380 U		
2,4-DINITROTOLUENE				380 U		
2-CHLOROPHENOL				380 U		
2-METHYLNAPHTHALENE				380 U		
4-CHLORO-3-METHYLPHENOL				380 U		
ACENAPHTHENE				380 U		
ACENAPHTHYLENE				380 U		
ANTHRACENE				34 J		
BENZO(A)ANTHRACENE				21 J		

TABLE 6-8 (PAGE 40 OF 52)
SUMMARY OF POSITIVE SOIL ANALYTICAL RESULTS FOR ZONE 3
LOWER SUBASE; NSB-NLON; GROTON, CONNECTICUT

SAMPLE NUMBER:	SB21-6.0	SB22-2.0	SB22-4.0	SB22-6.0	SB23-2.0	SB23-4.0
DEPTH (feet):	4 - 6'	0 - 2'	2 - 4'	4 - 6'	0 - 2'	2 - 4'
INVESTIGATION:	AMB31	AMB31	AMB31	AMB31	AMB31	AMB31
SAMPLE DATE:	02/25/93	02/25/93	02/25/93	02/25/93	02/24/93	02/24/93
LOCATION:	SB21	SB22	SB22	SB22	SB23	SB23
VALIDATED:				VALIDATED		
SAMPLE TYPE:	GRAB	GRAB	GRAB	GRAB	GRAB	GRAB
STATUS:						
FIELD DUPLICATE OF:						
SEMIVOLATILES (µg/kg)						
BENZO(A)PYRENE				380 U		
BENZO(B)FLUORANTHENE				380 U		
BENZO(G,H,I)PERYLENE				380 U		
BENZO(K)FLUORANTHENE				380 U		
BIS(2-ETHYLHEXYL)PHTHALATE				260 J		
CARBAZOLE				380 U		
CHRYSENE				26 J		
DI-N-BUTYL PHTHALATE				20 J		
DI-N-OCTYL PHTHALATE				380 U		
DIBENZO(A,H)ANTHRACENE				380 U		
DIBENZOFURAN				38 J		
DIETHYL PHTHALATE				380 U		
FLUORANTHENE				89 J		
FLUORENE				380 U		
INDENO(1,2,3-CD)PYRENE				380 U		
NAPHTHALENE				380 U		
PENTACHLOROPHENOL				930 U		
PHENANTHRENE				140 J		
PYRENE				61 J		
PESTICIDES/PCBs (µg/kg)						
4,4'-DDT				3.8 U		
DIELDRIN				3.8 U		

TABLE 6-8 (PAGE 41 OF 52)
SUMMARY OF POSITIVE SOIL ANALYTICAL RESULTS FOR ZONE 3
LOWER SUBASE; NSB-NLON; GROTON, CONNECTICUT

SAMPLE NUMBER:	SB21-6.0	SB22-2.0	SB22-4.0	SB22-6.0	SB23-2.0	SB23-4.0
DEPTH (feet):	4 - 6'	0 - 2'	2 - 4'	4 - 6'	0 - 2'	2 - 4'
INVESTIGATION:	AMB31	AMB31	AMB31	AMB31	AMB31	AMB31
SAMPLE DATE:	02/25/93	02/25/93	02/25/93	02/25/93	02/24/93	02/24/93
LOCATION:	SB21	SB22	SB22	SB22	SB23	SB23
VALIDATED:				VALIDATED		
SAMPLE TYPE:	GRAB	GRAB	GRAB	GRAB	GRAB	GRAB
STATUS:						
FIELD DUPLICATE OF:						
METALS (mg/kg)						
ALUMINUM				7220		
ANTIMONY				3.6 U		
ARSENIC				1.6		
BARIUM				37.9		
BERYLLIUM				0.22 U		
CADMIUM				0.67 U		
CALCIUM				13800		
CHROMIUM				10.5		
COBALT				3.7		
COPPER				12.4		
IRON				7560		
LEAD	6.8	5.4	8.1	32.6	2.8	6.7
MAGNESIUM				2660		
MANGANESE				158		
MERCURY				0.11 U		
NICKEL				5.2		
POTASSIUM				1280		
SELENIUM				0.22 U		
SILVER				1.7		
SODIUM				530		
VANADIUM				14.7		
ZINC				49.9		

TABLE 6-8 (PAGE 42 OF 52)
SUMMARY OF POSITIVE SOIL ANALYTICAL RESULTS FOR ZONE 3
LOWER SUBASE; NSB-NLON; GROTON, CONNECTICUT

SAMPLE NUMBER:	SB21-6.0	SB22-2.0	SB22-4.0	SB22-6.0	SB23-2.0	SB23-4.0
DEPTH (feet):	4 - 6'	0 - 2'	2 - 4'	4 - 6'	0 - 2'	2 - 4'
INVESTIGATION:	AMB31	AMB31	AMB31	AMB31	AMB31	AMB31
SAMPLE DATE:	02/25/93	02/25/93	02/25/93	02/25/93	02/24/93	02/24/93
LOCATION:	SB21	SB22	SB22	SB22	SB23	SB23
VALIDATED:				VALIDATED		
SAMPLE TYPE:	GRAB	GRAB	GRAB	GRAB	GRAB	GRAB
STATUS:						
FIELD DUPLICATE OF:						
GENERAL CHEMISTRY						
PH	10.9	10.8	11.5	11.7	4.51	4.16

TABLE 6-8 (PAGE 43 OF 52)
SUMMARY OF POSITIVE SOIL ANALYTICAL RESULTS FOR ZONE 3
LOWER SUBASE; NSB-NLON; GROTON, CONNECTICUT

SAMPLE NUMBER:	SB23-6.0	SB24-2.0	SB24-4.0	SB24-6.0	SB25-2.0	SB25-4.0
DEPTH (feet):	4 - 6'	0 - 2'	2 - 4'	4 - 6'	0 - 2'	2 - 4'
INVESTIGATION:	AMB31	AMB31	AMB31	AMB31	AMB31	AMB31
SAMPLE DATE:	02/24/93	02/24/93	02/24/93	02/24/93	02/24/93	02/24/93
LOCATION:	SB23	SB24	SB24	SB24	SB25	SB25
VALIDATED:						
SAMPLE TYPE:	GRAB	GRAB	GRAB	GRAB	GRAB	GRAB
STATUS:		EXCAVATED	EXCAVATED			
FIELD DUPLICATE OF:						
METALS (mg/kg)						
LEAD	7.7	16900	4550	4.9	389	26.8
GENERAL CHEMISTRY						
PH	4.47	6.45	5.16	4.23	7.8	8.84

TABLE 6-8 (PAGE 44 OF 52)
SUMMARY OF POSITIVE SOIL ANALYTICAL RESULTS FOR ZONE 3
LOWER SUBASE; NSB-NLON; GROTON, CONNECTICUT

SAMPLE NUMBER:	SB25-4.0-D	SB25-6.0	SB26-2.0	SB26-4.0	SB26-6.0	SB27-2.0
DEPTH (feet):	2 - 4'	4 - 6'	0 - 2'	2 - 4'	4 - 6'	0 - 2'
INVESTIGATION:	AMB31	AMB31	AMB31	AMB31	AMB31	AMB31
SAMPLE DATE:	02/24/93	02/24/93	02/24/93	02/24/93	02/24/93	02/24/93
LOCATION:	SB25	SB25	SB26	SB26	SB26	SB27
VALIDATED:						
SAMPLE TYPE:	GRAB	GRAB	GRAB	GRAB	GRAB	GRAB
STATUS:						
FIELD DUPLICATE OF:	SB25-4.0					
METALS (mg/kg)						
LEAD	351	7	30.1	3	25.4	19.8
GENERAL CHEMISTRY						
PH	8.83	4.56	11.5	10.1	11.6	11.1

TABLE 6-8 (PAGE 45 OF 52)
SUMMARY OF POSITIVE SOIL ANALYTICAL RESULTS FOR ZONE 3
LOWER SUBASE; NSB-NLON; GROTON, CONNECTICUT

SAMPLE NUMBER:	SB27-4.0	SB27-6.0	SB28-2.0	SB28-2.0-RCRA	SB28-4.0	SB29-2.0
DEPTH (feet):	2 - 4'	4 - 6'	0 - 2'	0 - 2'	2 - 4'	0 - 2'
INVESTIGATION:	AMB31	AMB31	AMB31	AMB31	AMB31	AMB31
SAMPLE DATE:	02/24/93	02/24/93	02/26/93	02/26/93	02/26/93	02/26/93
LOCATION:	SB27	SB27	SB28	SB28	SB28	SB29
VALIDATED:			VALIDATED	VALIDATED		
SAMPLE TYPE:	GRAB	GRAB	GRAB	GRAB	GRAB	GRAB
STATUS:			EXCAVATED	EXCAVATED	EXCAVATED	EXCAVATED
FIELD DUPLICATE OF:						
METALS (mg/kg)						
ARSENIC				4.6 J		
BARIUM				35.8		
CADMIUM				0.42 U		
CHROMIUM				11.5		
LEAD	4	3.5	5840	8840	3330	723
MERCURY				0.12 J		
SELENIUM				0.5 U		
SILVER				0.85 U		
GENERAL CHEMISTRY						
PH	10.9	7.37	6.78		7.2	6.59

TABLE 6-8 (PAGE 46 OF 52)
SUMMARY OF POSITIVE SOIL ANALYTICAL RESULTS FOR ZONE 3
LOWER SUBASE; NSB-NLON; GROTON, CONNECTICUT

SAMPLE NUMBER:	SB29-2.0-D	SB29-4.0	SB29-6.0	SB30-2.0	SB30-4.0	SB30-6.0
DEPTH (feet):	0 - 2'	2 - 4'	4 - 6'	0 - 2'	2 - 4'	4 - 6'
INVESTIGATION:	AMB31	AMB31	AMB31	AMB31	AMB31	AMB31
SAMPLE DATE:	02/26/93	02/26/93	02/26/93	02/26/93	02/26/93	02/26/93
LOCATION:	SB29	SB29	SB29	SB30	SB30	SB30
VALIDATED:						
SAMPLE TYPE:	GRAB	GRAB	GRAB	GRAB	GRAB	GRAB
STATUS:	EXCAVATED					
FIELD DUPLICATE OF:	SB29-2.0					
METALS (mg/kg)						
LEAD	556	238	127	413	163	57.2
GENERAL CHEMISTRY						
PH	6.56	6.9	7.46	6.45	7.04	7.84

TABLE 6-8 (PAGE 47 OF 52)
SUMMARY OF POSITIVE SOIL ANALYTICAL RESULTS FOR ZONE 3
LOWER SUBASE; NSB-NLON; GROTON, CONNECTICUT

SAMPLE NUMBER:	SB31-2.0	SB31-2.0-D	SB32-2.0	SB33-2.0	S001-1.0-CLP	S002-1.0-CLP
DEPTH (feet):	0 - 2'	0 - 2'	0 - 2'	0 - 2'	0 - 1'	0 - 1'
INVESTIGATION:	AMB31	AMB31	AMB31	AMB31	AMB31	AMB31
SAMPLE DATE:	02/26/93	02/26/93	02/26/93	02/26/93	02/15/93	02/15/93
LOCATION:	SB31	SB31	SB32	SB33	SO01	SO02
VALIDATED:						
SAMPLE TYPE:	GRAB	GRAB	GRAB	GRAB	GRAB	GRAB
STATUS:	EXCAVATED	EXCAVATED			EXCAVATED	EXCAVATED
FIELD DUPLICATE OF:		SB31-2.0				
METALS (mg/kg)						
LEAD	2330	1980	31.4	123	4640	2030
GENERAL CHEMISTRY						
PH	8.11	8.17	7.75	9.63		

TABLE 6-8 (PAGE 48 OF 52)
SUMMARY OF POSITIVE SOIL ANALYTICAL RESULTS FOR ZONE 3
LOWER SUBASE; NSB-NLON; GROTON, CONNECTICUT

SAMPLE NUMBER:	S003-1.0-CLP	S003-1.0-CLP-D	LS3SB0030101	LS3SB0030201	LS3SB0040101	SBFD002
DEPTH (feet):	0 - 1'	0 - 1'	2 - 4'	4 - 7'	2 - 3'	2 - 3'
INVESTIGATION:	AMB31	AMB31	1997RI	1997RI	1997RI	1997RI
SAMPLE DATE:	02/15/93	02/15/93	09/23/97	09/23/97	09/23/97	09/23/97
LOCATION:	SO03	SO03	TB3-3RI	TB3-3RI	TB4-3RI	TB4-3RI
VALIDATED:			VALIDATED	VALIDATED	VALIDATED	VALIDATED
SAMPLE TYPE:	GRAB	GRAB	GRAB	GRAB	GRAB	GRAB
STATUS:	EXCAVATED	EXCAVATED				
FIELD DUPLICATE OF:		S003-1.0				LS3SB0040101
SEMIVOLATILES (µg/kg)						
1,2,4-TRICHLOROBENZENE			430 U	360 U	360 U	360 U
2,4-DINITROTOLUENE			430 U	360 U	360 U	360 U
2-CHLOROPHENOL			430 U	360 U	360 U	360 U
2-METHYLNAPHTHALENE			430 U	360 U	360 U	37 J
4-CHLORO-3-METHYLPHENOL			430 U	360 U	360 U	360 U
ACENAPHTHENE			430 U	360 U	33 J	360 U
ACENAPHTHYLENE			430 U	360 U	360 U	340 J
ANTHRACENE			430 U	360 U	48 J	130 J
BENZO(A)ANTHRACENE			430 U	120 J	180 J	1500 J
BENZO(A)PYRENE			23 J	140 J	210 J	1000 J
BENZO(B)FLUORANTHENE			25 J	150 J	230 J	1300 J
BENZO(G,H,I)PERYLENE			27 J	110 J	170 J	850 J
BENZO(K)FLUORANTHENE			430 U	81 J	150 J	740 J
BIS(2-ETHYLHEXYL)PHTHALATE			430 U	360 U	360 U	360 J
CARBAZOLE			430 U	360 U	30 J	34 J
CHRYSENE			24 J	130 J	190 J	1400 J
DI-N-BUTYL PHTHALATE			430 U	360 U	360 U	360 U
DI-N-OCTYL PHTHALATE			430 U	360 U	360 U	360 U
DIBENZO(A,H)ANTHRACENE			430 U	51 J	79 J	400 J
DIBENZOFURAN			430 U	360 U	360 U	360 U
DIETHYL PHTHALATE			430 U	360 U	360 U	20 J
FLUORANTHENE			33 J	150 J	360	2200 J

TABLE 6-8 (PAGE 49 OF 52)
SUMMARY OF POSITIVE SOIL ANALYTICAL RESULTS FOR ZONE 3 LOWER SUBASE; NSB-NLON; GROTON, CONNECTICUT

SAMPLE NUMBER:	S003-1.0-CLP	S003-1.0-CLP-D	LS3SB0030101	LS3SB0030201	LS3SB0040101	SBFD002
DEPTH (feet):	0 - 1'	0 - 1'	2 - 4'	4 - 7'	2 - 3'	2 - 3'
INVESTIGATION:	AMB31	AMB31	1997RI	1997RI	1997RI	1997RI
SAMPLE DATE:	02/15/93	02/15/93	09/23/97	09/23/97	09/23/97	09/23/97
LOCATION:	SO03	SO03	TB3-3RI	TB3-3RI	TB4-3RI	TB4-3RI
VALIDATED:			VALIDATED	VALIDATED	VALIDATED	VALIDATED
SAMPLE TYPE:	GRAB	GRAB	GRAB	GRAB	GRAB	GRAB
STATUS:	EXCAVATED	EXCAVATED				
FIELD DUPLICATE OF:		S003-1.0				LS3SB0040101
SEMIVOLATILES (µg/kg)						
FLUORENE			430 U	360 U	26 J	64 J
INDENO(1,2,3-CD)PYRENE			23 J	100 J	160 J	870 J
NAPHTHALENE			430 U	360 U	360 U	360 U
PENTACHLOROPHENOL			1100 U	910 U	910 U	910 U
PHENANTHRENE			430 U	360 U	250 J	910 J
PYRENE			33 J	150 J	380	2500
METALS (mg/kg)						
LEAD	2290	2300				
TOTAL PETROLEUM HYDROCARBONS (mg/kg)						
TPH					610	

TABLE 6-8 (PAGE 50 OF 52)
SUMMARY OF POSITIVE SOIL ANALYTICAL RESULTS FOR ZONE 3
LOWER SUBASE; NSB-NLON; GROTON, CONNECTICUT

SAMPLE NUMBER:	LS3SB0040201	LS3SB0050101	LS3SB0050201			
DEPTH (feet):	6.5 - 7.5'	2 - 3.5'	5 - 5.5'			
INVESTIGATION:	1997RI	1997RI	1997RI			
SAMPLE DATE:	09/23/97	09/25/97	09/25/97	/ /	/ /	/ /
LOCATION:	TB4-3RI	TB5-3RI	TB5-3RI			
VALIDATED:	VALIDATED	VALIDATED	VALIDATED			
SAMPLE TYPE:	GRAB	GRAB	GRAB			
STATUS:						
FIELD DUPLICATE OF:						
SEMIVOLATILES (µg/kg)						
1,2,4-TRICHLOROBENZENE	330 U	360 U	360 U			
2,4-DINITROTOLUENE	330 U	360 U	360 U			
2-CHLOROPHENOL	330 U	360 U	360 U			
2-METHYLNAPHTHALENE	25 J	360 U	300 J			
4-CHLORO-3-METHYLPHENOL	330 U	360 U	360 U			
ACENAPHTHENE	69 J	360 U	200 J			
ACENAPHTHYLENE	330 U	360 U	360 U			
ANTHRACENE	350	23 J	360 UJ			
BENZO(A)ANTHRACENE	2100	41 J	430 J			
BENZO(A)PYRENE	950	34 J	940 J			
BENZO(B)FLUORANTHENE	1500	72 J	200 J			
BENZO(G,H,I)PERYLENE	640	66 J	330 J			
BENZO(K)FLUORANTHENE	870	360 U	200 J			
BIS(2-ETHYLHEXYL)PHTHALATE	330 U	360 U	360 U			
CARBAZOLE	270 J	360 U	360 UJ			
CHRYSENE	1500	55 J	1500 J			
DI-N-BUTYL PHTHALATE	330 U	360 U	360 UJ			
DI-N-OCTYL PHTHALATE	330 U	360 UJ	360 UJ			
DIBENZO(A,H)ANTHRACENE	330 J	360 U	360 UJ			
DIBENZOFURAN	35 J	360 U	81 J			
DIETHYL PHTHALATE	330 U	360 U	360 U			
FLUORANTHENE	4200	60 J	160 J			

TABLE 6-8 (PAGE 51 OF 52)
SUMMARY OF POSITIVE SOIL ANALYTICAL RESULTS FOR ZONE 3
LOWER SUBASE; NSB-NLON; GROTON, CONNECTICUT

SAMPLE NUMBER:	LS3SB0040201	LS3SB0050101	LS3SB0050201			
DEPTH (feet):	6.5 - 7.5'	2 - 3.5'	5 - 5.5'			
INVESTIGATION:	1997RI	1997RI	1997RI			
SAMPLE DATE:	09/23/97	09/25/97	09/25/97	/ /	/ /	/ /
LOCATION:	TB4-3RI	TB5-3RI	TB5-3RI			
VALIDATED:	VALIDATED	VALIDATED	VALIDATED			
SAMPLE TYPE:	GRAB	GRAB	GRAB			
STATUS:						
FIELD DUPLICATE OF:						
SEMIVOLATILES (µg/kg)						
FLUORENE	83 J	360 U	370			
INDENO(1,2,3-CD)PYRENE	640	44 J	150 J			
NAPHTHALENE	18 J	41 J	42 J			
PENTACHLOROPHENOL	830 U	910 U	910 UJ			
PHENANTHRENE	1700	36 J	1300 J			
PYRENE	4400	73 J	1600 J			
METALS (mg/kg)						
ALUMINUM		4610	5980			
ANTIMONY		0.51 UJ	0.51 UJ			
ARSENIC		0.93 J	1.5			
BARIUM		25.8	41.7			
BERYLLIUM		0.16 U	0.21			
CADMIUM		0.05 U	0.07 U			
CALCIUM		602	5970			
CHROMIUM		7.6 J	19.3			
COBALT		2.4	5.1			
COPPER		6.4	73.6			
IRON		7520	9230			
LEAD		11.9 J	64.4 J			
MAGNESIUM		1720	2760			
MANGANESE		114	148			
MERCURY		0.005 UJ	0.005 UJ			

TABLE 6-8 (PAGE 52 OF 52)
SUMMARY OF POSITIVE SOIL ANALYTICAL RESULTS FOR ZONE 3
LOWER SUBASE; NSB-NLON; GROTON, CONNECTICUT

SAMPLE NUMBER:	LS3SB0040201	LS3SB0050101	LS3SB0050201			
DEPTH (feet):	6.5 - 7.5'	2 - 3.5'	5 - 5.5'			
INVESTIGATION:	1997RI	1997RI	1997RI			
SAMPLE DATE:	09/23/97	09/25/97	09/25/97	/ /	/ /	/ /
LOCATION:	TB4-3RI	TB5-3RI	TB5-3RI			
VALIDATED:	VALIDATED	VALIDATED	VALIDATED			
SAMPLE TYPE:	GRAB	GRAB	GRAB			
STATUS:						
FIELD DUPLICATE OF:						
METALS (mg/kg)						
NICKEL		5.4	13.2			
POTASSIUM		1210	1420			
SELENIUM		0.39 U	0.42 J			
SILVER		0.22 U	0.35 J			
SODIUM		92.7	219			
VANADIUM		10.0	21.7			
ZINC		18.0	37.7			

TABLE 6-9 (PAGE 1 OF 6)

SUMMARY OF POSITIVE TCLP ANALYTICAL RESULTS FOR ZONE 3 LOWER SUBASE; NSB-NLON; GROTON, CONNECTICUT

SAMPLE NUMBER:	13MW12(8-10)	13TB12-0406	13TB18-0103	13TB5A-1.5-3.5	13TB7-0103	SB01-4.0
DEPTH (feet):	8 - 10'	4 - 6'	1 - 3'	1.5 - 3.5'	1 - 3'	2 - 4'
INVESTIGATION:	PH1	PH2-1	PH2-1	PH2-1	PH2-1	AMB31
SAMPLE DATE:	11/08/90	01/22/94	02/01/94	01/22/94	01/22/94	02/25/93
LOCATION:	13MW12	13TB12	13TB18	13TB5A	13TB7	SB01
VALIDATED:	VALIDATED	VALIDATED	VALIDATED	VALIDATED	VALIDATED	
SAMPLE TYPE:	GRAB	GRAB	GRAB	GRAB	GRAB	GRAB
STATUS:						EXCAVATED
FIELD DUPLICATE OF:						
TCLP METALS (mg/L)*						
BARIUM (100.0/10.0)	0.21	0.0632	0.264	0.211	0.237	
CHROMIUM (5.0/0.5)	0.071 J	0.0047 J	0.0062 U	0.0061	0.0125	
LEAD (5.0/0.15)	0.1 U	0.651 J	0.05 U	0.429 J	0.266 J	10.5

*Federal Toxicity Characteristic Regulatory Level (58 FR 46049)/Connecticut Remediation Standard Pollutant Mobility Criteria for GB Waters

TABLE 6-9 (PAGE 2 OF 6)

SUMMARY OF POSITIVE TCLP ANALYTICAL RESULTS FOR ZONE 3
LOWER SUBASE; NSB-NLON; GROTON, CONNECTICUT

SAMPLE NUMBER:	SB02-2.0	SB03-4.0	SB04-2.0	SB05-2.0	SB06-6.0	SB07-6.0
DEPTH (feet):	0 - 2'	2 - 4'	0 - 2'	0 - 2'	4 - 6'	4 - 6'
INVESTIGATION:	AMB31	AMB31	AMB31	AMB31	AMB31	AMB31
SAMPLE DATE:	02/25/93	02/25/93	02/25/93	02/25/93	02/25/93	02/25/93
LOCATION:	SB02	SB03	SB04	SB05	SB06	SB07
VALIDATED:						
SAMPLE TYPE:	GRAB	GRAB	GRAB	GRAB	GRAB	GRAB
STATUS:	EXCAVATED	EXCAVATED	EXCAVATED	EXCAVATED		
FIELD DUPLICATE OF:						
TCLP METALS (mg/L)*						
LEAD (5.0/0.15)	22.8	12.6	0.591	27.5	1.7	0.0546

*Federal Toxicity Characteristic Regulatory Level (58 FR 46049)/Connecticut Remediation Standard Pollutant Mobility Criteria for GB Waters

TABLE 6-9 (PAGE 3 OF 6)

SUMMARY OF POSITIVE TCLP ANALYTICAL RESULTS FOR ZONE 3 LOWER SUBASE; NSB-NLON; GROTON, CONNECTICUT

SAMPLE NUMBER:	SB08-2.0	SB09-2.0	SB10-4.0	SB11-6.0	SB12-6.0	SB13-2.0
DEPTH (feet):	0 - 2'	0 - 2'	2 - 4'	4 - 6'	4 - 6'	0 - 2'
INVESTIGATION:	AMB31	AMB31	AMB31	AMB31	AMB31	AMB31
SAMPLE DATE:	02/24/93	02/24/93	02/24/93	02/24/93	02/24/93	02/24/93
LOCATION:	SB08	SB09	SB10	SB11	SB12	SB13
VALIDATED:						
SAMPLE TYPE:	GRAB	GRAB	GRAB	GRAB	GRAB	GRAB
STATUS:	EXCAVATED			EXCAVATED		
FIELD DUPLICATE OF:						
TCLP METALS (mg/L)*						
LEAD (5.0/0.15)	5.81	0.0293	0.026 U	6	0.0698	0.232

*Federal Toxicity Characteristic Regulatory Level (58 FR 46049)/Connecticut Remediation Standard Pollutant Mobility Criteria for GB Waters

TABLE 6-9 (PAGE 4 OF 6)
SUMMARY OF POSITIVE TCLP ANALYTICAL RESULTS FOR ZONE 3
LOWER SUBASE; NSB-NLON; GROTON, CONNECTICUT

SAMPLE NUMBER:	SB14-4.0	SB15-2.0	SB16-2.0	SB17-6.0	SB18-6.0	SB19-6.0
DEPTH (feet):	2 - 4'	0 - 2'	0 - 2'	4 - 6'	4 - 6'	4 - 6'
INVESTIGATION:	AMB31	AMB31	AMB31	AMB31	AMB31	AMB31
SAMPLE DATE:	02/25/93	02/25/93	02/25/93	02/24/93	02/25/93	02/25/93
LOCATION:	SB14	SB15	SB16	SB17	SB18	SB19
VALIDATED:						
SAMPLE TYPE:	GRAB	GRAB	GRAB	GRAB	GRAB	GRAB
STATUS:			EXCAVATED		EXCAVATED	
FIELD DUPLICATE OF:						
TCLP METALS (mg/L)*						
LEAD (5.0/0.15)	0.026 U	0.154	9.13	5.88	13.6	0.815

Federal Toxicity Characteristic Regulatory Level (58 FR 46049)/Connecticut Remediation Standard Pollutant Mobility Criteria for GB Waters

TABLE 6-9 (PAGE 5 OF 6)

SUMMARY OF POSITIVE TCLP ANALYTICAL RESULTS FOR ZONE 3
LOWER SUBASE; NSB-NLON; GROTON, CONNECTICUT

SAMPLE NUMBER:	SB20-2.0	SB21-2.0	SB22-6.0	SB23-6.0	SB24-2.0	SB25-2.0
DEPTH (feet):	0 - 2'	0 - 2'	4 - 6'	4 - 6'	0 - 2'	0 - 2'
INVESTIGATION:	AMB31	AMB31	AMB31	AMB31	AMB31	AMB31
SAMPLE DATE:	02/25/93	02/25/93	02/25/93	02/24/93	02/24/93	02/24/93
LOCATION:	SB20	SB21	SB22	SB23	SB24	SB25
VALIDATED:						
SAMPLE TYPE:	GRAB	GRAB	GRAB	GRAB	GRAB	GRAB
STATUS:					EXCAVATED	
FIELD DUPLICATE OF:						
TCLP METALS (mg/L)*						
LEAD (5.0/0.15)	1.02	0.0932	0.0709	0.026 U	4.87	2.89

*Federal Toxicity Characteristic Regulatory Level (58 FR 46049)/Connecticut Remediation Standard Pollutant Mobility Criteria for GB Waters

TABLE 6-9 (PAGE 6 OF 6)

SUMMARY OF POSITIVE TCLP ANALYTICAL RESULTS FOR ZONE 3
LOWER SUBASE; NSB-NLON; GROTON, CONNECTICUT

SAMPLE NUMBER:	SB26-2.0	SB27-2.0	SB28-2.0			
DEPTH (feet):	0 - 2'	0 - 2'	0 - 2'			
INVESTIGATION:	AMB31	AMB31	AMB31			
SAMPLE DATE:	02/24/93	02/24/93	02/26/93	/ /	/ /	/ /
LOCATION:	SB26	SB27	SB28			
VALIDATED:						
SAMPLE TYPE:	GRAB	GRAB	GRAB			
STATUS:			EXCAVATED			
FIELD DUPLICATE OF:						
TCLP METALS (mg/L)*						
LEAD (5.0/0.15)	0.125	0.196	113			

. ederal Toxicity Characteristic Regulatory Level (58 FR 46049)/Conn. .cut Remediation Standard Pollutant Mobility Criteria for GB Waters

TABLE 6-10

SUMMARY OF POSITIVE SPLP ANALYTICAL RESULTS FOR ZONE 3 LOWER SUBASE; NSB-NLON; GROTON, CONNECTICUT

SAMPLE NUMBER:	LS3SB0010201	LS3SB0020201	SBFD010	LS3SB0020401		
DEPTH (feet):	2 - 4'	2 - 3.5'	2 - 3.5'	5 - 6'		
INVESTIGATION:	1997RI	1997RI	1997RI	1997RI		
SAMPLE DATE:	09/27/97	09/29/97	09/29/97	10/01/97	/ /	/ /
LOCATION:	MW1-3RI	MW2-3RI	MW2-3RI	MW2-3RI		
VALIDATED:	VALIDATED	VALIDATED	VALIDATED	VALIDATED		
SAMPLE TYPE:	GRAB	GRAB	GRAB	GRAB		
STATUS:						
FIELD DUPLICATE OF:			LS3SB0020201			
SPLP METALS (mg/L)*						
LEAD (5.0/0.15)	0.478 J	0.12 J	0.0402 J	0.0458 J		

*Federal Toxicity Characteristic Regulatory Level (58 FR 46049)/Connecticut Remediation Standard Pollutant Mobility Criteria for GB Waters

TABLE 6-11

SUMMARY OF SOIL ANALYTICAL RESULTS - ZONE 3
LOWER SUBASE
NSB-NLON, GROTON, CONNECTICUT
PAGE 1 OF 3

Analyte	SHALLOW SOILS (<4 FEET)[1]			DEEP SOILS (>4 FEET)[2]		
	Frequency of Detection	Concentration Range	Location of Maximum Detection	Frequency of Detection	Concentration Range	Location of Maximum Detection
VOLATILE ORGANICS (ug/kg)						
1,1,1-Trichloroethane	0/1	ND	ND	1/2	6	SB22
Acetone	1/1	130	SB14	1/2	84	SB22
Chloroform	1/1	1	SB14	0/2	ND	ND
Methylene chloride	1/1	4	SB14	1/2	3	SB22
Tetrachloroethene	0/1	ND	ND	1/2	1	SB22
Toluene	0/1	ND	ND	1/2	0.8	SB22
Xylenes, total	0/1	ND	ND	1/2	1	SB22
SEMIVOLATILE ORGANICS (ug/kg)						
2-Methylnaphthalene	3/8	28 - 37	TB4-3RI	2/6	25 - 300	TB5-3RI
Acenaphthene	2/8	17 - 33	TB4-3RI	3/6	21 - 200	TB5-3RI
Acenaphthylene	4/8	26 - 340	TB4-3RI	0/6	ND	ND
Anthracene	6/8	23 - 130	TB4-3RI	3/6	34 - 350	TB4-3RI
Benzo(a)anthracene	6/8	41 - 1500	TB4-3RI	5/6	21 - 2100	TB4-3RI
Benzo(a)pyrene	7/8	23 - 1000	TB4-3RI	4/6	140 - 950	TB4-3RI
Benzo(b)fluoranthene	7/8	25 - 1300	TB4-3RI	4/6	150 - 1500	TB4-3RI
Benzo(g,h,i)perylene	6/8	27 - 850	TB4-3RI	4/6	110 - 640	TB4-3RI
Benzo(k)fluoranthene	5/8	98 - 740	TB4-3RI	4/6	81 - 870	TB4-3RI
Bis(2-Ethylhexyl)phthalate	2/8	160 - 360	TB4-3RI	1/6	260	SB22
Carbazole	3/8	22 - 34	TB4-3RI	2/6	46 - 270	TB4-3RI
Chrysene	7/8	24 - 1400	TB4-3RI	5/6	26 - 1500	TB4-3RI/TB5-3RI
Di-N-butyl phthalate	0/8	ND	ND	1/6	20	SB22
Dibenzo(a,h)anthracene	5/8	79 - 400	TB4-3RI	3/6	51 - 330	TB4-3RI
Dibenzofuran	0/8	ND	ND	3/6	35 - 81	TB5-3RI
Diethyl phthalate	1/8	20	TB4-3RI	0/6	ND	ND
Fluoranthene	7/8	33 - 2200	TB4-3RI	5/6	89 - 4200	TB4-3RI
Fluorene	3/8	25 - 64	TB4-3RI	3/6	28 - 370	TB5-3RI
Indeno(1,2,3-Cd)pyrene	7/8	23 - 870	TB4-3RI	4/6	100 - 640	TB4-3RI
Naphthalene	2/8	22 - 41	TB5-3RI	2/6	18 - 42	TB5-3RI

TABLE 6-11

SUMMARY OF SOIL ANALYTICAL RESULTS - ZONE 3
LOWER SUBASE
NSB-NLON, GROTON, CONNECTICUT
PAGE 2 OF 3

Analyte	SHALLOW SOILS (<4 FEET)[1]			DEEP SOILS (>4 FEET)[2]		
	Frequency of Detection	Concentration Range	Location of Maximum Detection	Frequency of Detection	Concentration Range	Location of Maximum Detection
Phenanthrene	6/8	36 - 910	TB4-3RI	4/6	140 - 1700	TB4-3RI
Pyrene	7/8	33 - 2500	TB4-3RI	6/6	20 - 4400	TB4-3RI
INORGANICS (mg/kg)						
Aluminum	5/5	4610 - 8790	SB14	5/5	3510 - 8120	13MW12
Antimony	2/5	0.64 - 1.1	MW1-3RI	0/5	ND	ND
Arsenic	5/5	0.93 - 2.6	MW1-3RI	5/5	1.1 - 4.9	MW1-3RI
Barium	5/5	25.8 - 43.8	SB14	5/5	22.5 - 41.7	TB5-3RI
Beryllium	2/5	0.23 - 0.38	SB14	3/5	0.21 - 0.33	13MW12
Cadmium	1/5	0.46	SB14	1/5	0.83	13MW12
Calcium	5/5	602 - 2500	SB14	5/5	700 - 13800	SB22
Chromium	5/5	7.6 - 16.9	SB14	5/5	6.1 - 19.3	TB5-3RI
Cobalt	5/5	2.4 - 5	SB14/MW2-3RI	5/5	2.5 - 5.1	TB5-3RI
Copper	3/5	6.4 - 15.9	MW1-3RI	5/5	7.6 - 73.6	TB5-3RI
Iron	5/5	7520 - 9440	SB14	5/5	5100 - 9230	TB5-3RI
Lead	71/73	2.8 - 4390	ALBACORE RD	47/47	2.6 - 6060	ALBACORE RD
Magnesium	5/5	1720 - 3260	SB14	5/5	1560 - 2760	TB5-3RI
Manganese	5/5	114 - 160	MW2-3RI	5/5	88.1 - 290	MW1-3RI
Mercury	3/5	0.02 - 0.23	MW1-3RI	1/5	0.05	MW1-3RI
Nickel	5/5	5.4 - 13.4	SB14	5/5	5.2 - 13.2	TB5-3RI
Potassium	5/5	1120 - 2130	SB14	5/5	910 - 1420	TB5-3RI
Selenium	0/5	ND	ND	2/5	0.42 - 0.6	MW1-3RI
Silver	0/5	ND	ND	2/5	0.35 - 1.7	SB22
Sodium	5/5	92.7 - 474	SB14	5/5	114 - 530	SB22
Vanadium	5/5	10 - 24.8	MW2-3RI	5/5	9.7 - 21.7	TB5-3RI
Zinc	5/5	18 - 68.6	MW1-3RI	5/5	17 - 74.1	MW1-3RI
TCLP METALS (mg/L)						
Barium	3/3	0.211 - 0.264	13TB18	2/2	0.0632 - 0.21	13MW12
Chromium	2/3	0.0061 - 0.0125	13TB7	2/2	0.0047 - 0.071	13MW12
Lead	10/13	0.0293 - 2.89	SB25	7/9	0.0546 - 5.88	SB17

TABLE 6-11

SUMMARY OF SOIL ANALYTICAL RESULTS - ZONE 3
LOWER SUBASE
NSB-NLON, GROTON, CONNECTICUT
PAGE 3 OF 3

Analyte	SHALLOW SOILS (<4 FEET)[1]			DEEP SOILS (>4 FEET)[2]		
	Frequency of Detection	Concentration Range	Location of Maximum Detection	Frequency of Detection	Concentration Range	Location of Maximum Detection
SPLP METALS (mg/L)						
Lead	3/3	0.0402 - 0.478	MW1-3RI	1/1	0.0458	MW2-3RI
TOTAL PETROLEUM HYDROCARBONS (mg/kg)						
TPH	7/7	65.2 - 1600	MW2-3RI	6/8	18.6 - 3400	13MW12

1 Includes samples 13TB12-0204-X, 13TB18-0103, 13TB5A-1.5-3.5, 13TB5A-1.5-3.5-X, 13TB7-0103, 2-EXBE78-06, 2-EXNW09-06, 2-EXNW78-09, 2-EXSW78-09, 2-EXWW-ALBACORE-06, 2-EXWW09-06, 3-EXSW09-06, 4-EXEW03-07, EXBE-BULLHEAD-07, EXEW-BULLHEAD-08, EXEW02-06, EXNW02-06, EXNW03-07, EXNW04-06, EXSW-ALBACORE-06, EXSW-BULLHEAD-08, EXSW01-07, EXSW02-06, EXSW03-07, EXSW04-06, EXWW-ALBACORE-06, EXWW01-07, EXWW02-06, LS3SB0010201, LS3SB0020201, LS3SB0030101, LS3SB0040101, LS3SB0050101, NSB-WE2-2-4, SB06-2.0, SB06-4.0, SB06-4.0-D (field duplicate of SB06-4.0), SB07-2.0, SB07-4.0, SB09-2.0, SB09-4.0, SB10-2.0, SB10-4.0, SB12-2.0, SB12-4.0, SB13-2.0, SB13-2.0-D (field duplicate of SB13-2.0), SB13-4.0, SB14-2.0, SB14-4.0, SB15-2.0, SB15-4.0, SB19-2.0, SB19-4.0, SB20-2.0, SB20-4.0, SB4.0-D (field duplicate of SB20-4.0), SB21-2.0, SB21-4.0, SB22-2.0, SB22-4.0, SB23-2.0, SB23-4.0, SB25-2.0, SB25-4.0, SB25-4.0-D (field duplicate of SB25-4.0), SB26-2.0, SB26-4.0, SB27-2.0, SB27-4.0, SB29-4.0, SB30-2.0, SB30-4.0, SB32-2.0, SB33-2.0, SBFD002 (field duplicate of LS3SB0040101), SBFD0101 (field duplicate of LS3SB0020201-78).

2 Includes samples 13MW12(8-10), 13TB12-0406, 13TB12-0608-X, 2-EXBE-ALBCRE-04, 2-EXWW06-06, DUP17-111895 (field duplicate of FPTB13L-07), EXBE-ALBACORE-03, EXBE-ALBACORE-04-D (field duplicate of EXBE-ALBACORE-04), EXBE01-04, EXBE02-04, EXBE03-04, EXBE05-04, EXBE06-07, EXBE07-03, EXEW07-05, EXEW07-05-D (field duplicate of EXEW07-05), EXNW07-05, EXNW08-07, EXSW07-04, EXSW08-07, EXWW06-07, EXWW07-05, EXWW08-07, FPTB12L-08, FPTB13L-07, LS3SB0010301, LS3SB0020401, LS3SB0030201, LS3SB0040201, LS3SB0050201, NSB-WE2-12-14, SB06-6.0, SB07-6.0, SB08-6.0, SB09-6.0, SB10-6.0, SB10-6.0-D (field duplicate of SB10-6.0), SB12-6.0, SB13-6.0, SB14-6.0, SB15-6.0, SB16-6.0, SB17-6.0, SB19-6.0, SB20-6.0, SB21-6.0, SB22-6.0, SB23-6.0, SB24-6.0, SB25-6.0, SB26-6.0, SB27-6.0, SB29-6.0, SB30-6.0.

ND - Not Detected
NA - Not Analyzed

TABLE 6-12

SUMMARY OF SOIL FLUORESCENCE SPECTROSCOPY DATA - ZONE 3
LOWER SUBASE
NSB-NLON, GROTON, CONNECTICUT

Sample	Depth (ft)	Observations
NSB-WE2-2-4	2-4	Trace levels of a heavy fuel oil (No. 6 fuel oil) detected.
NSB-WE2-12-14	12-14	Trace levels of a heavy fuel oil (No. 6 fuel oil) detected.
13MW12	8-10	Spectra is typical of No. 2 fuel/diesel oil.

TABLE 6-13 (PAGE 1 OF 9)

SUMMARY OF POSITIVE GROUNDWATER ANALYTICAL RESULTS FOR ZONE 3 LOWER SUBASE; NSB-NLON; GROTON, CONNECTICUT

SAMPLE NUMBER:	012191-13MW12S	13GW12	13GW12	13GW12-2	13GW12-D-2	13GW12-2
INVESTIGATION:	PH1	PH2-1	PH2-1	PH2-2	PH2-2	PH2-2
SAMPLE DATE:	01/21/91	03/07/94	03/07/94	06/23/94	06/23/94	06/23/94
LOCATION:	13MW12	13MW12	13MW12	13MW12	13MW12	13MW12
VALIDATED:	VALIDATED	VALIDATED	VALIDATED	VALIDATED	VALIDATED	VALIDATED
FILTERING:	Unfiltered	Unfiltered	Filtered	Unfiltered	Unfiltered	Filtered
FIELD DUPLICATE OF:					13GW12-2	
SEMIVOLATILES (µg/L)						
BIS(2-ETHYLHEXYL)PHTHALATE		10 U		0.6 J	1 J	
FLUORENE		10 U		1 J	1 J	
METALS (µg/L)						
ALUMINUM	30 U	14 U	14 U	15 U	16.5 U	19.7 U
ANTIMONY	25 U	15 U	20.2 U	13 U	13 U	13 U
ARSENIC	3 U	2 UJ	2 UJ	2.6	2.8	3.2
BARIUM	22.4	56.9 J	54.1 J	47	48.1	46.3
BERYLLIUM	1 U	1 U	1 U	1 U	1 U	1 U
CADMIUM	2 UJ	2 U	2 U	3 U	3 U	3 U
CALCIUM	26100	28000	27300	24400	25200	24000
CHROMIUM	5 U	3 UJ	3 UJ	4 U	4 U	4 U
COBALT	5 U	4 U	4 U	5 U	5 U	5 U
COPPER	5 U	2 U	2 U	5 U	5 U	5 U
IRON	3160 J	5480	5200	5930	6040	5800
LEAD	3.2 J	2.2 J	2 UJ	2 UJ	2 UJ	2 UJ
MAGNESIUM	3690	3330 J	3290 J	2980	3070	2940
MANGANESE	253	329	321	284	291	282
MERCURY	0.2 UJ	0.2 UJ	0.2 UJ	0.2 U	0.2 U	0.2 U
NICKEL	19.1 J	10 U	10 U	11 U	11 U	11 U
POTASSIUM	4020	6110	6100	6460	6570	6380
SELENIUM	1 UJ	3 UJ	3.2 J	2 UJ	2 U	2 U
SILVER	7 UJ	2 UJ	2 UJ	2 U	2 U	2 U
SODIUM	39200 J	99700	97700	89400	92400	87000
VANADIUM	20 U	5 U	5 U	4 U	4 U	4 U

TABLE 6-13 (PAGE 2 OF 9)

SUMMARY OF POSITIVE GROUNDWATER ANALYTICAL RESULTS FOR ZONE 3 LOWER SUBASE; NSB-NLON; GROTON, CONNECTICUT

SAMPLE NUMBER:	012191-13MW12S	13GW12	13GW12	13GW12-2	13GW12-D-2	13GW12-2
INVESTIGATION:	PH1	PH2-1	PH2-1	PH2-2	PH2-2	PH2-2
SAMPLE DATE:	01/21/91	03/07/94	03/07/94	06/23/94	06/23/94	06/23/94
LOCATION:	13MW12	13MW12	13MW12	13MW12	13MW12	13MW12
VALIDATED:	VALIDATED	VALIDATED	VALIDATED	VALIDATED	VALIDATED	VALIDATED
FILTERING:	Unfiltered	Unfiltered	Filtered	Unfiltered	Unfiltered	Filtered
FIELD DUPLICATE OF:					13GW12-2	
METALS (µg/L)						
ZINC	27.8 J	3.7 U	9.6 U	3 U	3 U	5.1 J
MISCELLANEOUS PARAMETERS						
HARDNESS AS CaCO3 (MG/L)		88		72	72	

TABLE 6-13 (PAGE 3 OF 9)
SUMMARY OF POSITIVE GROUNDWATER ANALYTICAL RESULTS FOR ZONE 3
LOWER SUBASE; NSB-NLON; GROTON, CONNECTICUT

SAMPLE NUMBER:	13GW12D-2	LS3GW13MW1201	LS3GW13MW1201-F	GW-01-1	GW-01-1-D	GW-01-2
INVESTIGATION:	PH2-2	1997RI	1997RI	AMB31	AMB31	AMB31
SAMPLE DATE:	06/23/94	10/31/97	10/31/97	02/15/93	02/15/93	02/15/93
LOCATION:	13MW12	13MW12	13MW12	GW-01	GW-01	GW-01
VALIDATED:	VALIDATED	VALIDATED	VALIDATED			
FILTERING:	Filtered	Unfiltered	Filtered	Unfiltered	Unfiltered	Unfiltered
FIELD DUPLICATE OF:	13GW12-2-DISS				GW-01-1	
SEMIVOLATILES (µg/L)						
BIS(2-ETHYLHEXYL)PHTHALATE		11 U		10 U	10 U	
FLUORENE		0.9 J		10 U	10 U	
METALS (µg/L)						
ALUMINUM	15 U	10.0 UJ	10.0 UJ	25000 J	14800 J	
ANTIMONY	13 U	2.5 U	2.5 U	17.1 U	16 UJ	
ARSENIC	2.6	2.5 U	2.5 U	8.3 J	5.1 J	6.8
BARIUM	46.3	22.8	24.2	114	69.7	94.1
BERYLLIUM	1 U	0.56 U	0.36 U	1.4	1 U	
CADMIUM	3 U	0.22 U	0.22 U	3 U	3 U	3 U
CALCIUM	24100	16300	16800	9350	8760	
CHROMIUM	4 U	0.80 U	0.76 U	27	12.1	26.2
COBALT	5 U	0.80 U	0.80 U	9.6	6 U	
COPPER	5 U	3.0 U	1.9 U	58.1	35.7	
IRON	5900	3920	3870 J	17600 J	11400 J	
LEAD	2 UJ	1.3 U	1.3 U	73.4 J	47.5 J	41.5
MAGNESIUM	2960	2600	2690	4440	3130	
MANGANESE	286	175	184	454	391	
MERCURY	0.2 U	0.01 UJ	0.02 U	0.36 J	0.32 J	0.3
NICKEL	11 U	0.75 U	0.75 U	90.9	38.4	
POTASSIUM	6050	5590	5400	5570	4970	
SELENIUM	2 UJ	1.9 U	1.9 U	3 U	3 U	10 U
SILVER	2 U	1.1 U	1.1 U	3 U	2 U	2
SODIUM	86800	59600	58100	28800 J	28200 J	
VANADIUM	4 U	0.55 U	0.57 U	36	21.8	

TABLE 6-13 (PAGE 4 OF 9)

SUMMARY OF POSITIVE GROUNDWATER ANALYTICAL RESULTS FOR ZONE 3 LOWER SUBASE; NSB-NLON; GROTON, CONNECTICUT

SAMPLE NUMBER:	13GW12D-2	LS3GW13MW1201	LS3GW13MW1201-F	GW-01-1	GW-01-1-D	GW-01-2
INVESTIGATION:	PH2-2	1997RI	1997RI	AMB31	AMB31	AMB31
SAMPLE DATE:	06/23/94	10/31/97	10/31/97	02/15/93	02/15/93	02/15/93
LOCATION:	13MW12	13MW12	13MW12	GW-01	GW-01	GW-01
VALIDATED:	VALIDATED	VALIDATED	VALIDATED			
FILTERING:	Filtered	Unfiltered	Filtered	Unfiltered	Unfiltered	Unfiltered
FIELD DUPLICATE OF:	13GW12-2-DISS				GW-01-1	
METALS (µg/L)						
ZINC	3 U	4.7 U	4.6 U	141 J	93.2 J	
WATER QUALITY PARAMETERS						
DISSOLVED OXYGEN (MG/L)		0.48				
REDOX POTENTIAL (MV)		-121.5				
SALINITY (PPT)		0.17				
SPECIFIC CONDUCTIVITY (MS/CM)		0.35				
TEMPERATURE (C)		21.65				
MISCELLANEOUS PARAMETERS						
ALKALINITY AS CACO3 (MG/L)		83				
AMMONIA, AS NITROGEN (MG/L)		0.58 J				
CHLORIDE (MG/L)		76				
DIVALENT IRON (MG/L)		2.6				
HARDNESS AS CaCO3 (MG/L)		54				
METHANE (UG/L)		4400				
NITRATE, AS NITROGEN (MG/L)		0.05 U				
PHOSPHORUS (MG/L)		0.39 J				
SULFATE (MG/L)		1.0 U				
TOTAL ORGANIC CARBON (MG/L)		7.9 J				
TURBIDITY (NTU)		5.4				
GENERAL CHEMISTRY						
PH		6.72				

TABLE 6-13 (PAGE 5 OF 9)
SUMMARY OF POSITIVE GROUNDWATER ANALYTICAL RESULTS FOR ZONE 3
LOWER SUBASE; NSB-NLON; GROTON, CONNECTICUT

SAMPLE NUMBER:	GW-01-2-DISS	GW-02-1	GW-02-2	GW-02-2-D	GW-02-2-DISS	GW-02-2-DISS-D
INVESTIGATION:	AMB31	AMB31	AMB31	AMB31	AMB31	AMB31
SAMPLE DATE:	02/15/93	02/15/93	02/15/93	02/15/93	02/15/93	02/15/93
LOCATION:	GW-01	GW-02	GW-02	GW-02	GW-02	GW-02
VALIDATED:						
FILTERING:	Filtered	Unfiltered	Unfiltered	Unfiltered	Filtered	Filtered
FIELD DUPLICATE OF:				GW-02-2		GW-02-2-DISS
SEMIVOLATILES (µg/L)						
BIS(2-ETHYLHEXYL)PHTHALATE		10 U				
FLUORENE		10 U				
METALS (µg/L)						
ALUMINUM		75000 J				
ANTIMONY		16 UJ				
ARSENIC	2 U	2.7 J	2 U	2 U	2 U	2 U
BARIUM	21.8	609	325	368	24	24
BERYLLIUM		6.9				
CADMIUM	3 U	4.8	3 U	3 U	3 U	3 U
CALCIUM		27000				
CHROMIUM	6 U	78	39	30.2	6 U	6 U
COBALT		47.6				
COPPER		142				
IRON		62200 J				
LEAD	1.1	392 J	220	216	1 U	1
MAGNESIUM		17200				
MANGANESE		3890				
MERCURY	0.2 U	1.2 J	0.2 U	0.2 U	0.2 U	0.2 U
NICKEL		133				
POTASSIUM		11000				
SELENIUM	1 U	3 UJ	10 U	10 U	1 U	1 U
SILVER	2 U	7.6 U	4.2	2.9	2 U	2 U
SODIUM		47900 J				
VANADIUM		87.2				

TABLE 6-13 (PAGE 6 OF 9)

SUMMARY OF POSITIVE GROUNDWATER ANALYTICAL RESULTS FOR ZONE 3 LOWER SUBASE; NSB-NLON; GROTON, CONNECTICUT

SAMPLE NUMBER:	GW-01-2-DISS	GW-02-1	GW-02-2	GW-02-2-D	GW-02-2-DISS	GW-02-2-DISS-D
INVESTIGATION:	AMB31	AMB31	AMB31	AMB31	AMB31	AMB31
SAMPLE DATE:	02/15/93	02/15/93	02/15/93	02/15/93	02/15/93	02/15/93
LOCATION:	GW-01	GW-02	GW-02	GW-02	GW-02	GW-02
VALIDATED:						
FILTERING:	Filtered	Unfiltered	Unfiltered	Unfiltered	Filtered	Filtered
FIELD DUPLICATE OF:				GW-02-2		GW-02-2-DISS
METALS (µg/L)						
ZINC		338 J				

TABLE 6-13 (PAGE 7 OF 9)
SUMMARY OF POSITIVE GROUNDWATER ANALYTICAL RESULTS FOR ZONE 3
LOWER SUBASE; NSB-NLON; GROTON, CONNECTICUT

SAMPLE NUMBER:	GW-03-1	GW-03-1-DISS	GW-03-2	GW-03-2-DISS	GW-04-1	GW-04-1-DISS
INVESTIGATION:	AMB31	AMB31	AMB31	AMB31	AMB31	AMB31
SAMPLE DATE:	02/15/93	02/15/93	02/15/93	02/15/93	02/15/93	02/15/93
LOCATION:	GW-03	GW-03	GW-03	GW-03	GW-04	GW-04
VALIDATED:						
FILTERING:	Unfiltered	Filtered	Unfiltered	Filtered	Unfiltered	Filtered
FIELD DUPLICATE OF:						
METALS (µg/L)						
ARSENIC	3.3	1.7	2.4	2 U	2.7	1.2
BARIUM	84.4	36.6	105	44.3	41.8	18.2
CADMIUM	3 U	3 U	3 U	3 U	3 U	3 U
CHROMIUM	9.8	6 U	14.7	6 U	7.4	6 U
LEAD	312	7.3	136	2.2	199	2 U
MERCURY	0.2 U	0.2 U	0.2 U	0.2 U	8.9	0.2 U
SELENIUM	3 U	3 U	1 U	1 U	3 U	3 U
SILVER	2 U	2 U	2 U	2 U	2 U	2 U

TABLE 6-13 (PAGE 8 OF 9)
SUMMARY OF POSITIVE GROUNDWATER ANALYTICAL RESULTS FOR ZONE 3
LOWER SUBASE; NSB-NLON; GROTON, CONNECTICUT

SAMPLE NUMBER:	GW-04-2	GW-04-2-DISS	LS3GW00101	LS3GW00101-F	LS3GW00201	LS3GW00201-F
INVESTIGATION:	AMB31	AMB31	1997RI	1997RI	1997RI	1997RI
SAMPLE DATE:	02/15/93	02/15/93	10/30/97	10/30/97	10/30/97	10/30/97
LOCATION:	GW-04	GW-04	MW1-3RI	MW1-3RI	MW2-3RI	MW2-3RI
VALIDATED:			VALIDATED	VALIDATED	VALIDATED	VALIDATED
FILTERING:	Unfiltered	Filtered	Unfiltered	Filtered	Unfiltered	Filtered
FIELD DUPLICATE OF:						
SEMIVOLATILES (µg/L)						
BIS(2-ETHYLHEXYL)PHTHALATE			12 U		26 U	
FLUORENE			12 U		11 U	
METALS (µg/L)						
ALUMINUM			10.0 UJ	10.0 UJ	10.0 UJ	10.0 UJ
ANTIMONY			2.5 U	2.8 J	2.5 U	2.5 U
ARSENIC	2.1	2 U	2.5 U	2.5 U	2.5 U	2.5 U
BARIUM	43.7	22.2	26.5	294	135	446
BERYLLIUM			0.11 UJ	0.11 UJ	0.11 UJ	0.11 UJ
CADMIUM	3 U	3 U	0.29 U	0.22 U	0.23 U	0.25 U
CALCIUM			33000	36600	129000	136000
CHROMIUM	9.8	6 U	1.8 U	0.68 U	1.3 U	3.6 J
COBALT			0.80 U	0.80 U	0.80 U	0.80 U
COPPER			3.1 U	5.4 U	3.4 U	5.7 U
IRON			13.0 U	13.0 U	30.5 U	106
LEAD	84	1.2	4.4 U	3.2 U	9.7	10.5 J
MAGNESIUM			54100	59900	237000	254000
MANGANESE			43.8	48.0	68.4	99.1
MERCURY	0.2 U	0.2 U	0.03 U	0.04 U	0.06 U	0.05 U
NICKEL			1.3 J	9.0 U	1.6	9.0 U
POTASSIUM			24400	26000	77700	83000
SELENIUM	1 U	1 U	1.9 U	1.9 U	1.9 U	1.9 U
SILVER	2 U	2 U	1.1 U	1.1 U	1.4 J	1.6 J
SODIUM			526000	572000	1930000	2080000
VANADIUM			0.65 U	0.61 U	0.56 U	0.55 U

TABLE 6-13 (PAGE 9 OF 9)
SUMMARY OF POSITIVE GROUNDWATER ANALYTICAL RESULTS FOR ZONE 3
LOWER SUBASE; NSB-NLON; GROTON, CONNECTICUT

SAMPLE NUMBER:	GW-04-2	GW-04-2-DISS	LS3GW00101	LS3GW00101-F	LS3GW00201	LS3GW00201-F
INVESTIGATION:	AMB31	AMB31	1997RI	1997RI	1997RI	1997RI
SAMPLE DATE:	02/15/93	02/15/93	10/30/97	10/30/97	10/30/97	10/30/97
LOCATION:	GW-04	GW-04	MW1-3RI	MW1-3RI	MW2-3RI	MW2-3RI
VALIDATED:			VALIDATED	VALIDATED	VALIDATED	VALIDATED
FILTERING:	Unfiltered	Filtered	Unfiltered	Filtered	Unfiltered	Filtered
FIELD DUPLICATE OF:						
METALS (µg/L)						
ZINC			13.2	118 J	10.8 U	119 J
WATER QUALITY PARAMETERS						
DISSOLVED OXYGEN (MG/L)			9.4		6.68	
REDOX POTENTIAL (MV)			34.1		37.6	
SALINITY (PPT)			1.9		6.73	
SPECIFIC CONDUCTIVITY (MS/CM)			3.603		11.76	
TEMPERATURE (C)			19.07		18.96	
MISCELLANEOUS PARAMETERS						
ALKALINITY AS CACO3 (MG/L)			93		48	
AMMONIA, AS NITROGEN (MG/L)			0.21		0.10 U	
CHLORIDE (MG/L)			1200		3800	
DIVALENT IRON (MG/L)			0		0	
HARDNESS AS CaCO3 (MG/L)			310		1200	
METHANE (UG/L)			810		5.4 U	
NITRATE, AS NITROGEN (MG/L)			0.47		2.4	
PHOSPHORUS (MG/L)			0.33 J		0.31 J	
SULFATE (MG/L)			140		510	
TOTAL ORGANIC CARBON (MG/L)			1.2 J		2.3 J	
TURBIDITY (NTU)			0.8		13.3	
GENERAL CHEMISTRY						
PH			6.83		6.45	

TABLE 6-14

SUMMARY OF HISTORICAL AND LOWER SUBASE RI GROUNDWATER ANALYTICAL RESULTS - ZONE 3
LOWER SUBASE
NSB-NLON, GROTON, CONNECTICUT
PAGE 1 OF 2

Analyte	Historical Data [1]				Lower Subase RI[2]		
	Frequency of Detection	Concentration Range	Maximum Detection		Frequency of Detection	Concentration Range	Location of Maximum Detection
			Location	Investigation[3]			
SEMIVOLATILE ORGANICS (µg/L)							
Bis(2-Ethylhexyl)phthalate	2/6	0.6 - 1.0	13MW12	PH2-2	0/3	ND	ND
Fluorene	2/6	1.0	13MW12	PH2-2	1/3	0.9	13MW12
INORGANICS (µg/L)							
Aluminum	3/7	14800 - 75000	GW-02	AMB31	0/3	ND	ND
Antimony, filtered	0/2	ND	ND	ND	1/3	2.8	MW1-3RI
Arsenic	10/14	2.1 - 8.3	GW-01	AMB31	0/3	ND	ND
Arsenic, filtered	4/9	1/2 - 3.2	13MW12	PH2-2	0/3	ND	ND
Barium	15/15	22.4 - 609	GW-02	AMB31	3/3	22.8 - 135	MW2-3RI
Barium, filtered	10/10	18.2 - 54.1	13MW12	PH2-1	3/3	24.2 - 446	MW2-3RI
Beryllium	2/7	1.4 - 6.9	GW-02	AMB31	0/3	ND	ND
Cadmium	1/14	4.8	GW-02	AMB31	0/3	ND	ND
Calcium	7/7	9350 - 28000	13MW12	PH2-1	3/3	16300 - 129000	MW2-3RI
Calcium, filtered	3/3	24000 - 27300	13MW12	PH2-1	3/3	16800 - 136000	MW2-3RI
Chromium	10/14	7.4 - 78	GW-02	AMB31	1/3	3.6	MW2-3RI
Cobalt	2/7	9.6 - 47.6	GW-02	AMB31	0/3	ND	ND
Copper	3/7	35.7 - 142	GW-02	AMB31	0/3	ND	ND
Iron	7/7	3160 - 62200	GW-02	AMB31	1/3	3920	13MW12
Iron, filtered	3/3	5200 - 5900	13MW12	PH2-2	2/3	106 - 3870	13MW12
Lead	12/14	2.2 - 392	GW-02	AMB31	1/3	9.7	MW2-3RI
Lead, filtered	5/10	1.0 - 7.3	GW-03	AMB31	1/3	10.5	MW2-3RI
Magnesium	7/7	3070 - 17200	GW-02	AMB31	3/3	2600 - 237000	MW2-3RI
Magnesium, filtered	3/3	2940 - 3290	13MW12	PH2-1	3/3	2690 - 254000	MW2-3RI
Manganese	7/7	253 - 3890	GW-02	AMB31	3/3	43.8 - 175	13MW12
Manganese, filtered	3/3	282 - 321	13MW12	PH2-1	3/3	48 - 184	13MW12
Mercury	5/14	0.3 - 8.9	GW-04	AMB31	0/3	ND	ND

TABLE 6-14

SUMMARY OF HISTORICAL AND LOWER SUBASE RI GROUNDWATER ANALYTICAL RESULTS - ZONE 3
LOWER SUBASE
NSB-NLON, GROTON, CONNECTICUT
PAGE 2 OF 2

Analyte	Historical Data (1)				Lower Subase RI(2)		
	Frequency of Detection	Concentration Range	Maximum Detection		Frequency of Detection	Concentration Range	Location of Maximum Detection
			Location	Investigation(3)			
Nickel	4/7	19.1 - 133	GW-02	AMB31	2/3	1.3 - 1.6	MW2-3RI
Potassium	7/7	4020 - 11000	GW-02	AMB31	3/3	5590 - 77700	MW2-3RI
Potassium, filtered	3/3	6050 - 6380	13MW12	PH2-2	3/3	5400 - 83000	MW2-3RI
Selenium, filtered	1/10	3.2	13MW12	PH2-1	0/3	ND	ND
Silver	3/14	2 - 4.2	GW-02	AMB31	1/3	1.4	MW2-3RI
Silver, filtered	0/8	ND	ND	ND	1/3	1.6	MW2-3RI
Sodium	7/7	28200 - 99700	13MW12	PH2-1	3/3	59600 - 1930000	MW2-3RI
Sodium, filtered	3/3	86800 - 99700	13MW12	PH2-1	3/3	58100 - 2080000	MW2-3RI
Vanadium	3/7	21.8 - 82.2	GW-02	AMB31	0/3	ND	ND
Zinc	5/7	3.7 - 338	GW-02	AMB31	1/3	13.2	MW1-3RI
Zinc, filtered	1/3	5.1	13MW12	PH2-2	2/3	118 - 119	MW2-3RI

1 Includes samples 012191-13MW12S, 13GW12, 13GW12-2, 13GW12-D-2 (field duplicate of 13GW12-2), GW-01-1, GW-01-1-D (field duplicate of GW-01-1), GW-01-2, GW-02-1, GW-02-2, GW-02-2-D (field duplicate of GW-02-2), GW-03-1, GW-03-2, GW-04-1, GW-04-2.

2 Includes samples LS3GW00101, LS3GW00201, LS3GW13MW1201.

3 PH2-1 = Round 1 of Phase II RI; PH2-2 = Round 2 of Phase II RI; AMB31 = Action Memorandum for Building 31.

NA - Not Analyzed

ND - Not Detected.

TABLE 6-15

SUMMARY OF GROUNDWATER FLUORESCENCE SPECTROSCOPY DATA - ZONE 3
LOWER SUBASE
NSB-NLON, GROTON, CONNECTICUT

Sample	Observations
NSB-WS-WE2-003	Spectra typical of a waste oil.
13MW12S	Spectra is unresolved. Trace concentrations of petroleum hydrocarbons make oil identification by fluorescence impractical.

TABLE 6-16

SUMMARY OF NATURAL ATTENUATION AND WATER QUALITY PARAMETERS - ZONE 3
LOWER SUBASE
NSB-NLON, GROTON, CONNECTICUT

Analyte	Lower Subase RI[1]		
	Frequency of Detection	Concentration Range	Location of Maximum Detection
MISCELLANEOUS			
Alkalinity as CaCO3 (mg/L)	3/3	48 - 93	MW1-3RI
Ammonia, as nitrogen (mg/L)	2/3	0.21 - 0.58	13MW12
Chloride (mg/L)	3/3	76 - 3800	MW2-3RI
Dissolved oxygen (mg/L)	3/3	0.48 - 9.4	MW1-3RI
Divalent iron (mg/L)	1/3	2.6	13MW12
Hardness as CaCO3 (mg/L)	3/3	54 - 1200	MW2-3RI
Methane (mg/L)	2/3	810-4400	13MW12
Nitrate, as nitrogen (mg/L)	2/3	0.47 - 2.4	MW2-3RI
pH	3/3	6.45 - 6.83	MW1-3RI
Phosphorus (mg/L)	3/3	0.31 - 0.39	13MW12
Redox potential (mV)	3/3	-121.5 - 37.6	MW2-3RI
Salinity (ppt)	3/3	0.17 - 6.73	MW2-3RI
Specific conductivity (ms/cm)	3/3	0.35 - 11.76	MW2-3RI
Sulfate (mg/L)	2/3	140 - 510	MW2-3RI
Temperature (C)	3/3	18.96 - 21.65	13MW12
Total organic carbon (mg/L)	3/3	1.2 - 7.9	13MW12
Turbidity (NTU)	3/3	0.8 - 13.3	MW2-3RI

1 Includes samples LS3GW00101, LS3GW00201, LS3GW13MW1201.

TABLE 6-17

CHEMICALS OF CONCERN - ZONE 3
LOWER SUBASE
NSB-NLON, GROTON, CONNNECTICUT

Chemicals of Concern[1]		
Shallow Soil (0 - 4 Feet)	**All Soil (0 - 10 Feet)**	**Groundwater[2]**
Methylene Chloride	Methylene Chloride	Antimony (filtered only)
Benzo(a)anthracene	Benzo(a)anthracene	Arsenic
Benzo(a)pyrene	Benzo(a)pyrene	Barium (filtered only)
Benzo(b)fluoranthene	Benzo(b)fluoranthene	Iron
Carbazole	Carbazole	Lead
Chyrsene	Chyrsene	Manganese
Dibenzo(a,h)anthracene	Dibenzo(a,h)anthracene	Nickel (unfiltered only)
Indeno(1,2,3-cd)pyrene	Indeno(1,2,3-cd)pyrene	Sodium
Aluminum	Aluminum	Zinc (filtered only)
Antimony	Arsenic	TPH
Arsenic	Beryllium	
Beryllium	Cadmium	
Cadmium	Chromium (total)	
Chromium (total)	Iron	
Iron	Lead	
Lead	Manganese	
Nickel	Nickel	
TPH	Selenium	
	TPH	

1 Chemical is identified as a Chemical of Concern (COC) if the maximum detection in a single sample exceeds one or more criteria (i.e., Region III COC screening level, State Remediation Standards, Federal Soil Screening Levels, etc.).

2 Unless otherwise noted, the inorganic chemicals presented are COCs for the unfiltered and filtered groundwater sample matrix.

TABLE 6-18

EXPOSURE CONCENTRATIONS FOR DIRECT EXPOSURE CHEMICALS OF CONCERN - ZONE 3 LOWER SUBASE NSB-NLON, GROTON, CONNECTICUT

Direct Exposure Chemical of Concern	Exposure Concentration		
	Surface Soil[1] (mg/kg)	All Soil[1] (mg/kg)	Groundwater[2] (mg/L)
Semivolatile Organic Compounds			
Benzo(a)anthracene	0.22/0.44	2.0	NA[3]
Benzo(a)pyrene	0.18/0.48	1.0[4]	NA
Benzo(b)fluoranthene	0.20/0.51	1.3	NA
Dibenzo(a,h)anthracene	0.15[5]	0.29	NA
Indeno(1,2,3-cd)pyrene	0.12/0.22	0.60	NA
Metals			
Antimony, filtered	NA	NA	0.0028[5]
Arsenic	1.9/2.6	2.2/4.9	0.0014/0.0016
Barium, filtered	NA	NA	0.261/0.446
Beryllium	0.23/0.38	0.21/0.38	NA
Lead	400/1390	1390[4]	NA
Manganese	NA	149/290	0.124/0.261

1 UCL if single concentration is presented, otherwise average concentration is used for CTE and maximum detected concentration is used for RME unless otherwise noted. See Section 3.3.1.
2 Average concentration is used for CTE and maximum concentration is used for RME. Maximum is defined as the highest average concentration in a single well, and the average is defined as the overall average concentration of all well-specific averages.
3 NA - Not applicable. Chemical is not a chemical of concern for this medium.
4 Maximum concentration is presented since UCL is greater than maximum detected concentration.
5 Maximum concentration is presented since average concentration exceeds the maximum detected concentration.

TABLE 6-19

ESTIMATED RISKS[1] - ZONE 3
LOWER SUBASE
NSB-NLON, GROTON, CONNECTICUT

Exposure Route	Construction Worker		Full-Time Employee		Future Resident	
	RME[2]	CTE[3]	RME	CTE	RME	CTE
HAZARD INDEX						
Incidental Ingestion of Soil	0.042	0.006	0.005	0.002	0.029	0.004
Dermal Contact with Soil	0.009	0.0006	0.006	0.0009	0.015	0.001
Total Risk from Soil	0.051	0.0066	0.011	0.0029	0.044	0.005
Dermal Contact with Groundwater	0.072	0.025	NA[4]	NA	NA	NA
Cumulative Risk:	0.12	0.032	0.011	0.0029	0.044	0.005
INCREMENTAL CANCER RISK						
Incidental Ingestion of Soil	6.3E-07	1.7E-07	2.0E-06	1.4E-07	1.3E-05	8.4E-07
Dermal Contact with Soil	5.2E-07	6.5E-08	7.3E-06	8.0E-07	2.6E-05	1.5E-06
Total Risk from Soil	1.2E-06	2.4E-07	9.3E-06	9.4E-07	3.9E-05	2.3E-06
Dermal Contact with Groundwater	5.2E-09	3.1E-09	NA	NA	NA	NA
Cumulative Risk:	1.2E-06	2.4E-08	9.3E-06	9.4E-07	3.9E-05	2.3E-06

1 Chemical-specific risks presented in Appendix I.7.
2 RME - Reasonable Maximum Exposure.
3 CTE - Central Tendency Exposure.
4 NA - Not applicable; exposure route not evaluated for this receptor.

TABLE 6-20

SUMMARY OF MAJOR CONTRIBUTORS TO RISK – ZONE 3
LOWER SUBASE
NSB-NLON, GROTON, CONNECTICUT

Receptor	Chemical	Cancer Risk	Percent Contribution
Full-Time Employee – RME	Benzo(a)pyrene	4.8E-06	52%
	Dibenzo(a,h)anthracene	1.5E-06	16%
	Arsenic	1.8E-06	19%
Future Resident – RME	Benzo(a)anthracene	3.7E-06	9%
	Benzo(a)pyrene	1.8E-05	47%
	Benzo(b)fluoranthene	2.4E-06	6%
	Dibenzo(a,h)anthracene	5.3E-06	14%
	Indeno(1,2,3-cd)pyrene	1.1E-06	3%
	Arsenic	7.9E-06	20%

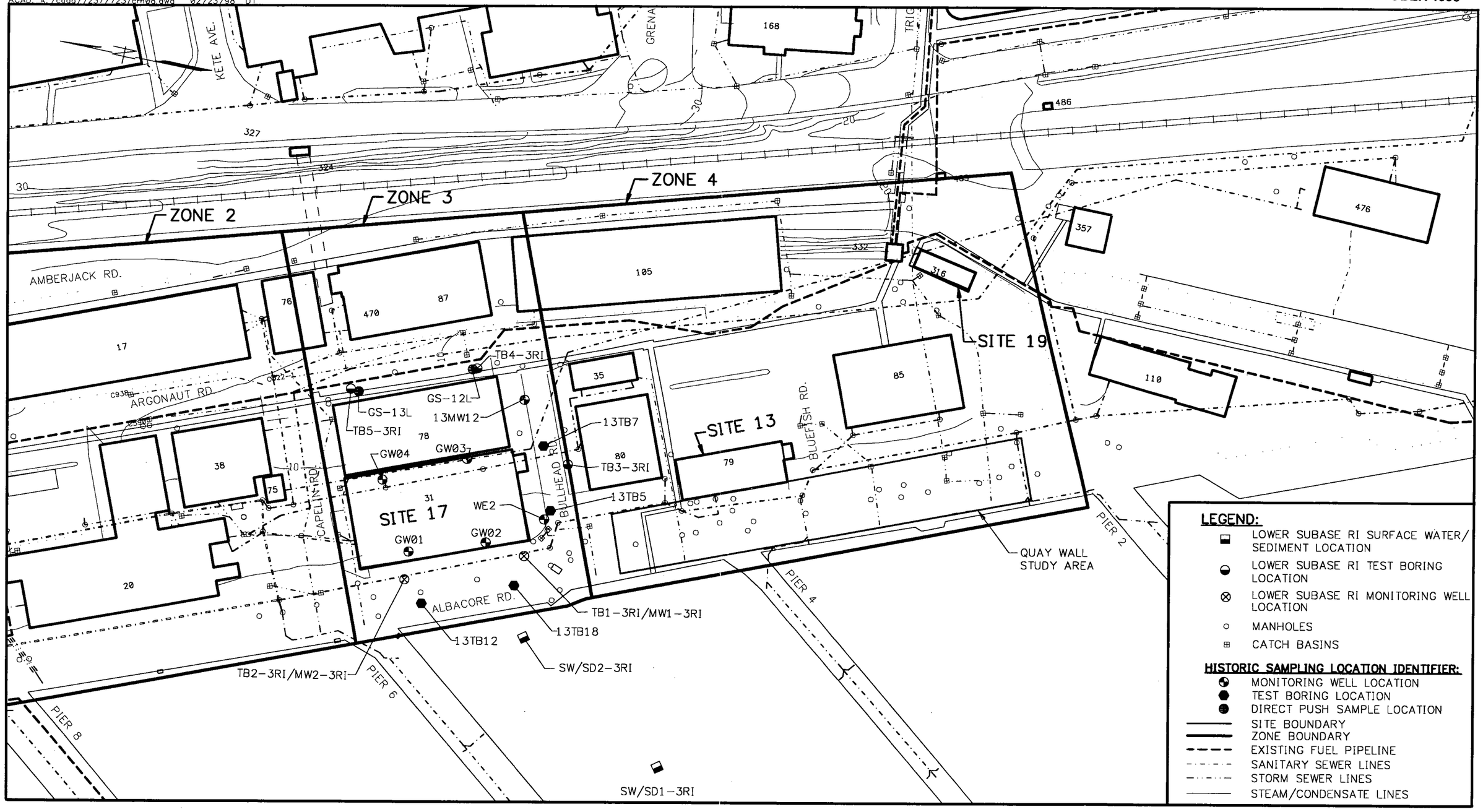

FIGURE 6-1

SAMPLE LOCATION MAP
ZONE 3
NSB-NLON, GROTON, CONNECTICUT

0 80 160
SCALE IN FEET

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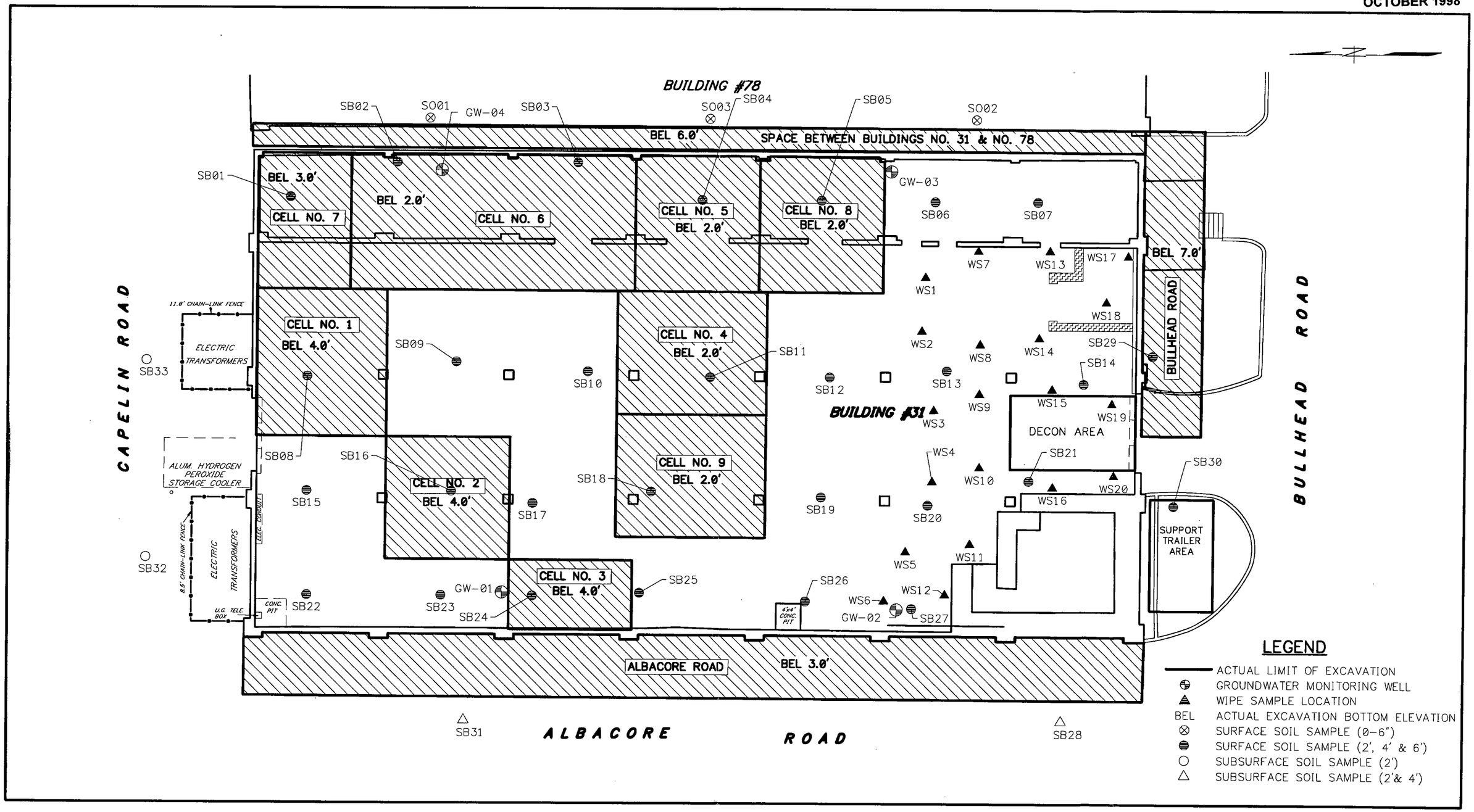
019809/P

CTO 0260



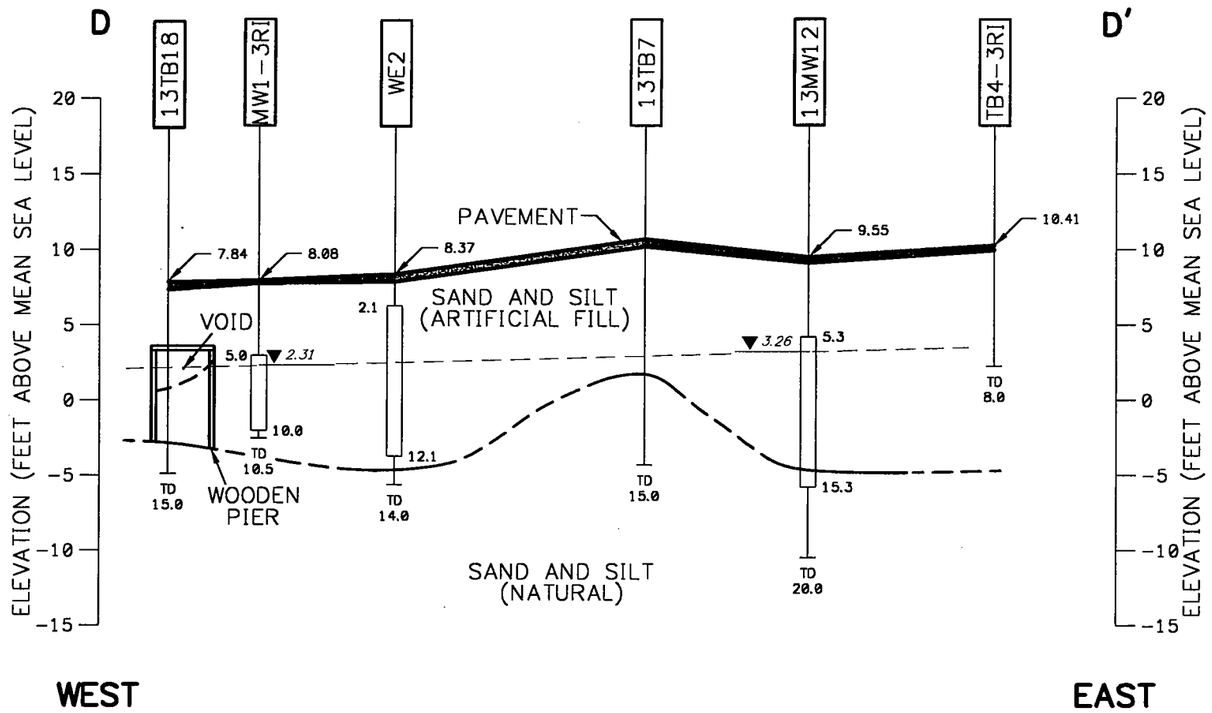
CONTAMINATED SOIL EXCAVATION PLAN
AND SAMPLING LOCATIONS
BUILDING 31 LEAD REMEDIATION
NSB-NLON, GROTON, CONNECTICUT

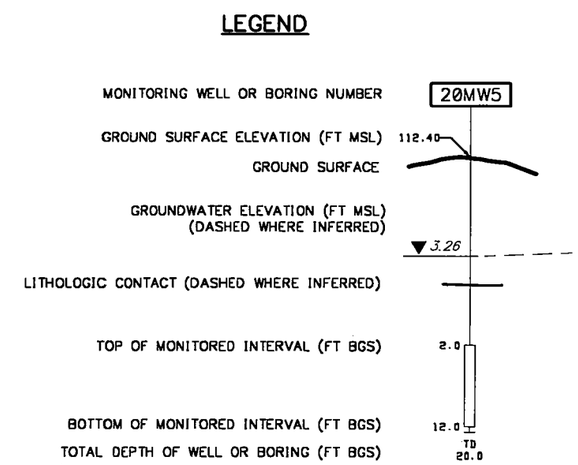
0 15 30
SCALE IN FEET

FIGURE 6-2

Brown & Root Environmental

ACAD: 7237gx04.dwg 09/30/98 HJP





0 40 80
HORIZONTAL SCALE IN FEET

0 10 20
VERTICAL SCALE IN FEET

NOTES

1.) ELEVATIONS BASED ON SUBASE VERTICAL DATUM (1982)

2.) POTENTIOMETRIC SURFACE FOR LOW TIDE OCTOBER 27, 1997

3.) WOODEN PIER SUPPORT LOCATIONS WERE ESTIMATED

4.) SEE DRAWING 5 FOR CROSS SECTION LOCATION

NO.	DATE	REVISIONS	BY	CHKD	APPD	REFERENCES

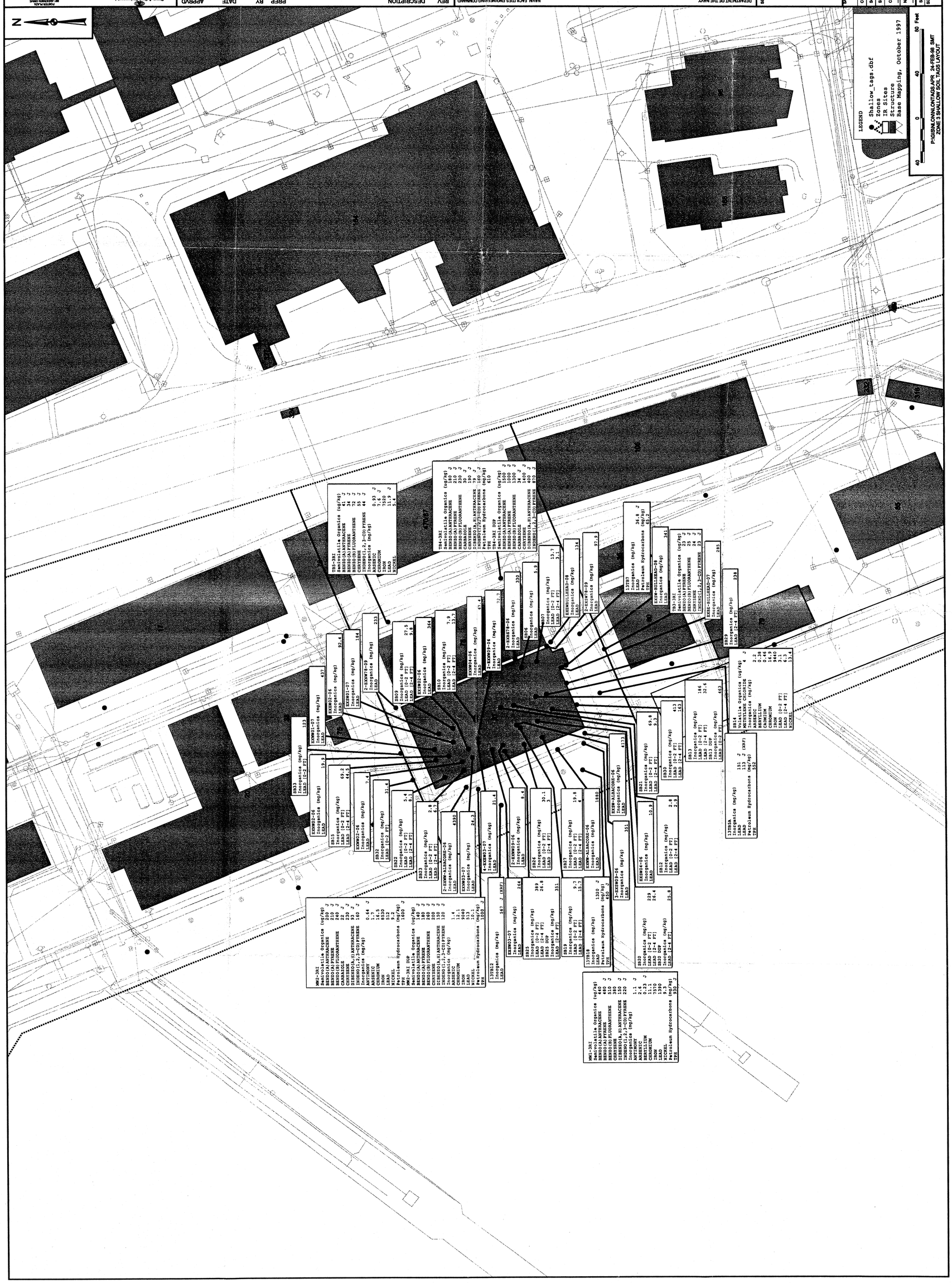
DRAWN BY MF DATE 2/15/98
CHECKED BY DATE
COST/SCHED-AREA
SCALE AS NOTED

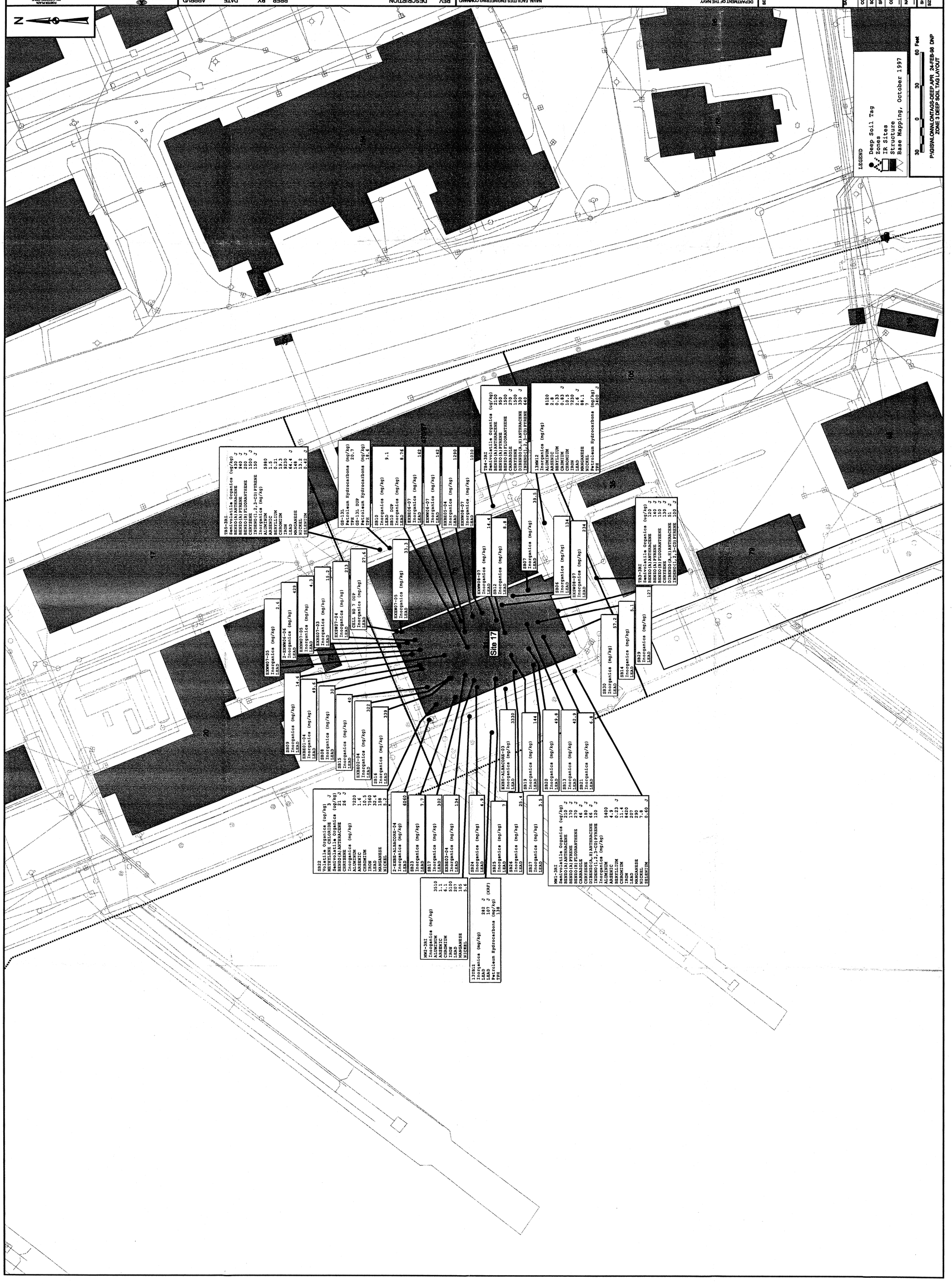
Brown & Root Environmental

GENERALIZED GEOLOGIC CROSS SECTION D – D'
ZONE 3
LOWER SUBASE RI
NSB-NLON, GROTON, CONNECTICUT

CONTRACT NO. 7237
OWNER NO. 0260
APPROVED BY Corey A. Pike DATE 10/7/98
APPROVED BY DATE
DRAWING NO. FIGURE 6-3
REV. 0

FORM CADD NO. SOUTH_BH.DGN - REV 0 - 02/11/97


ZONE 3 SHALLOW SOIL COPC POSITIVE DETECTS
LOWER SUBAER RI
NSB-NLON, GROTON, CONNECTICUT
NORTHERN DIVISION
NAVAL FACILITIES ENGINEERING COMMAND
PHILADELPHIA, PA
DEPARTMENT OF THE NAVY
NAVAL BASE
NORTHDIV FOR COMMANDER, NAVFAC
APPROVED
DATE
REV DESCRIPTION
PREP BY
DATE
APPRVD
Brown & Root Environmental
DSGN
DR
M. JANET LAWLEY
CHK
SURV
CH ENG
SUBMITTED BY:
CTR D
OFFICER IN CHARGE
APPROVED
DATE
SEAL AREA
CODE I.D. NO.
SCALE: AS SHOWN
SPEC. NO.
CONSTR. CONTR. NO.
NAVFAC DRAWING NO.
SHEET
OF
SIZE
D
DWG. SH. NO.
64
LEGEND
Shallow_tags.dbf
Zones
IR Sites
Structure
Base Mapping, October 1997
0
40
80 Feet
P:\GIS\NLON\NLONTAGS.APR 24-FEB-98 SMIT
ZONE 3 SHALLOW SOIL TAGS LAYOUT
N
MW2-3RI
Semivolatile Organics (ug/kg)
BENZO(A)ANTHRACENE 140 J
BENZO(A)PYRENE 210 J
BENZO(B)FLUORANTHENE 260 J
CHRYSENE 200 J
DIBENZO(A,H)ANTHRACENE 110 J
INDENO(1,2,3-CD)PYRENE 120 J
Inorganics (mg/kg)
ARSENIC 1.4
CHROMIUM 12.1
IRON 9140
LEAD 10.1
NICKEL 10.1
Petroleum Hydrocarbons (mg/kg) 1600 J
TPH 1600 J
MW1-3RI
Semivolatile Organics (ug/kg)
BENZO(A)ANTHRACENE 490 J
BENZO(A)PYRENE 450 J
BENZO(B)FLUORANTHENE 380 J
CHRYSENE 150 J
DIBENZO(A,H)ANTHRACENE 120 J
INDENO(1,2,3-CD)PYRENE 220 J
Inorganics (mg/kg)
ANTIMONY 1.1
ARSENIC 2.4
BERYLLIUM 0.23 J
CHROMIUM 7.1
IRON 7510
LEAD 13.9
NICKEL 9.3
Petroleum Hydrocarbons (mg/kg) 930 J
TPH 930 J
1379812
Inorganics (mg/kg)
LEAD 583 J (RKF)
EXNW01-07
Inorganics (mg/kg)
LEAD 264
SB25
Inorganics (mg/kg)
LEAD [0-2 FT] 389
LEAD [2-4 FT] 26.8
SB26
Inorganics (mg/kg)
LEAD [0-2 FT] 351
SB19
Inorganics (mg/kg)
LEAD [0-2 FT] 9.7
LEAD [2-4 FT] 35.7
1379814
Inorganics (mg/kg) 1320 J
LEAD 1320 J
Petroleum Hydrocarbons (mg/kg) 450 J
TPH 450 J
SB20
Inorganics (mg/kg)
LEAD [0-2 FT] 239
LEAD [2-4 FT] 26.4
SB20 DUP
Inorganics (mg/kg)
LEAD [2-4 FT] 25.8
3-EXNW03-06
Inorganics (mg/kg)
LEAD 351
EXNW02-06
Inorganics (mg/kg)
LEAD 4173
EXSN-ALBACORE-06
Inorganics (mg/kg)
LEAD 1886
EXNW02-06
Inorganics (mg/kg)
LEAD 10.3
SB12
Inorganics (mg/kg)
LEAD [0-2 FT] 2.8
LEAD [2-4 FT] 2.5
SB21
Inorganics (mg/kg)
LEAD [0-2 FT] 413
LEAD [2-4 FT] 153
SB35
Inorganics (mg/kg) 69.8
LEAD [0-2 FT] 9.3
SB13
Inorganics (mg/kg) 186
LEAD [0-2 FT] 32.6
LEAD [2-4 FT]
SB13 DUP
Inorganics (mg/kg) 463
LEAD [0-2 FT]
1379813
Inorganics (mg/kg) 151 J (RKF)
LEAD 151 J
Petroleum Hydrocarbons (mg/kg) 552
TPH
SB14
Volatile Organics (ug/kg) 4 J
METHYLENE CHLORIDE
Inorganics (mg/kg)
ARSENIC 2.2
BERYLLIUM 0.18
CADMIUM 0.45
CHROMIUM 16.9
IRON 3440
LEAD 11.1
LEAD [2-4 FT] 6.3
NICKEL 13.3
1379815
Inorganics (mg/kg)
LEAD 238
LEAD [2-4 FT]
SB29
Inorganics (mg/kg)
LEAD [2-4 FT]
TB3-3RI
Semivolatile Organics (ug/kg)
BENZO(A)PYRENE 23 J
BENZO(B)FLUORANTHENE 25 J
CHRYSENE 24 J
INDENO(1,2,3-CD)PYRENE 23 J
Inorganics (mg/kg)
LEAD 285
EXSN-BULHEAD-07
Inorganics (mg/kg)
LEAD 341
EXSN-BULHEAD-08
Inorganics (mg/kg)
LEAD 3
1379817
Inorganics (mg/kg)
LEAD 134
Petroleum Hydrocarbons (mg/kg) 36.8 J
TPH 36.8 J
2-EXNW02-09
Inorganics (mg/kg)
LEAD 97.2
EXNWBULHEAD-08
Inorganics (mg/kg)
LEAD [0-2 FT] 13.7
LEAD [2-4 FT] 3.1
SB07
Inorganics (mg/kg)
LEAD 5.5
SB06
Inorganics (mg/kg)
LEAD 330
2-EXNBT8-06
Inorganics (mg/kg)
LEAD 72.7
2-EXNW03-06
Inorganics (mg/kg)
LEAD 69.4
EXNW04-06
Inorganics (mg/kg)
LEAD 7.9
SB10
Inorganics (mg/kg)
LEAD [0-2 FT] 364
LEAD [2-4 FT] 33.1
EXSN02-06
Inorganics (mg/kg)
LEAD 27.5
SB09
Inorganics (mg/kg)
LEAD [0-2 FT] 9.6
LEAD [2-4 FT]
EXNW01-07
Inorganics (mg/kg)
LEAD 233
EXNW02-24
Inorganics (mg/kg)
LEAD 184
EXNW01-07
Inorganics (mg/kg)
LEAD 92.4
EXNW01-07
Inorganics (mg/kg)
LEAD 437
SB33
Inorganics (mg/kg)
LEAD [0-2 FT] 123
EXNW02-06
Inorganics (mg/kg)
LEAD 19.0
SB15
Inorganics (mg/kg)
LEAD [0-2 FT] 69.2
LEAD [2-4 FT] 44.5
EXNW02-06
Inorganics (mg/kg)
LEAD 7.4
SB32
Inorganics (mg/kg)
LEAD [0-2 FT] 31.4
SB22
Inorganics (mg/kg)
LEAD [0-2 FT] 5.4
LEAD [2-4 FT] 8.1
SB23
Inorganics (mg/kg)
LEAD [2-4 FT] 2.8
LEAD [2-4 FT] 6.7
2-EXNW-ALBACORE-06
Inorganics (mg/kg)
LEAD 4393
EXNW03-07
Inorganics (mg/kg)
LEAD 24.3
4-EXNW03-07
Inorganics (mg/kg)
LEAD 21.4
2-EXNW03-06
Inorganics (mg/kg)
LEAD 8.4
SB26
Inorganics (mg/kg)
LEAD [0-2 FT] 30.1
LEAD [2-4 FT] 3
SB27
Inorganics (mg/kg)
LEAD [0-2 FT] 19.6
LEAD [2-4 FT] 4
EXNW-ALBACORE-06
Inorganics (mg/kg)
LEAD 351
EXNW02-06
Inorganics (mg/kg)
LEAD 4173
EXSN-ALBACORE-06
Inorganics (mg/kg)
LEAD 1886
2-EXNW03-06
Inorganics (mg/kg)
LEAD 264
EXNW01-07
Inorganics (mg/kg)
LEAD 583 J (RKF)
1379812
Inorganics (mg/kg)
LEAD
TB3-3RI
Semivolatile Organics (ug/kg)
BENZO(A)ANTHRACENE 180 J
BENZO(A)PYRENE 210 J
BENZO(B)FLUORANTHENE 210 J
CHRYSENE 30 J
CARBAZOLE 30 J
DIBENZOFURAN 79 J
DIBENZO(A,H)ANTHRACENE 160 J
INDENO(1,2,3-CD)PYRENE 160 J
Petroleum Hydrocarbons (mg/kg) 610
TPH 610
TB4-3RI DUP
Semivolatile Organics (ug/kg)
BENZO(A)ANTHRACENE 1500 J
BENZO(A)PYRENE 1500 J
BENZO(B)FLUORANTHENE 1300 J
CARBAZOLE 34 J
CHRYSENE 140 J
DIBENZO(A,H)ANTHRACENE 400 J
INDENO(1,2,3-CD)PYRENE 970 J



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DEPARTMENT OF THE NAVY
NAVAL FACILITIES ENGINEERING COMMAND
NAVAL BASE PHILADELPHIA, PA

NORTHERN DIVISION

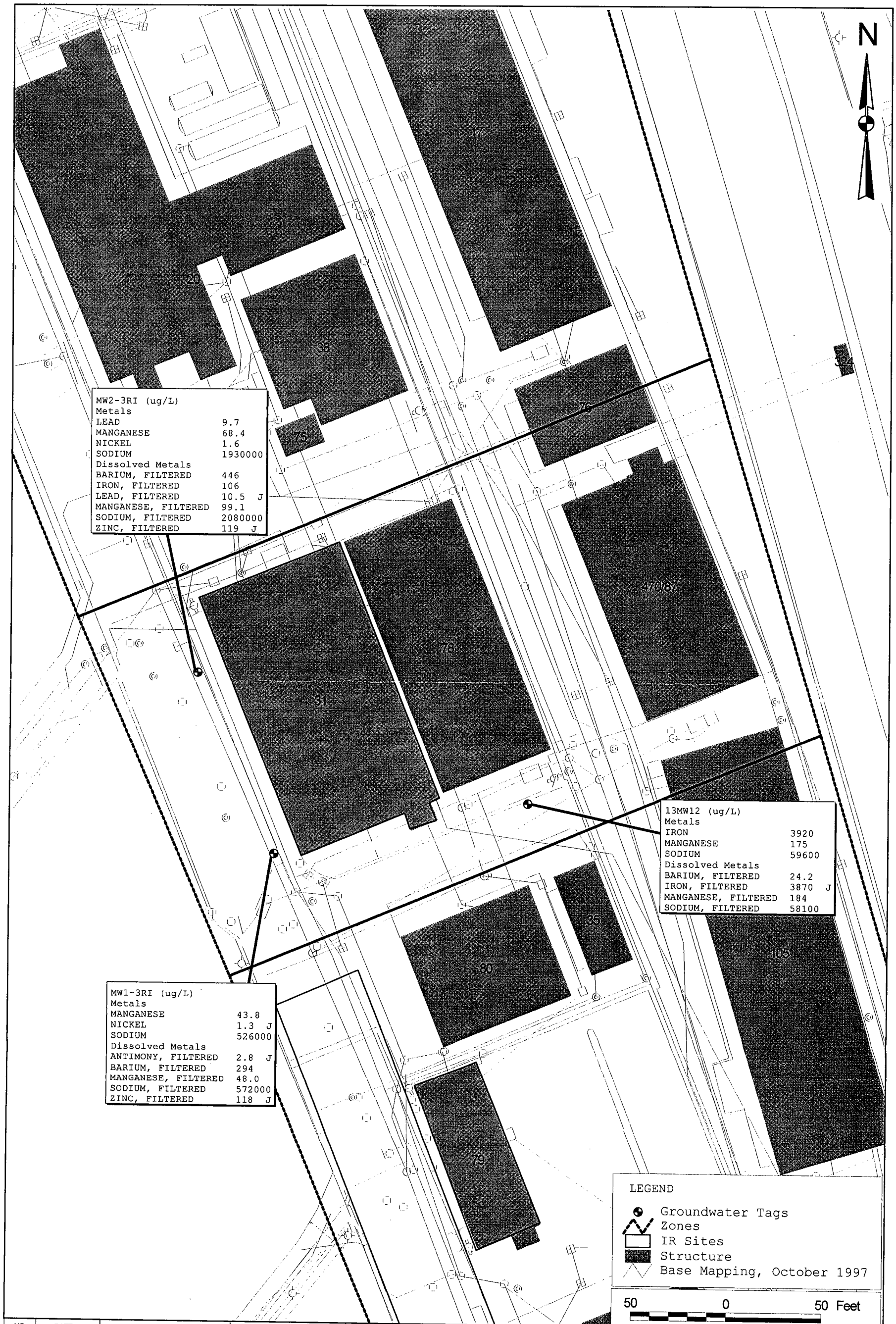
ZONE 3 DEEP SOIL COPC POSITIVE DETECTS
LOWER SUBASE RI
NSB-NLON, GROTON, CONNECTICUT

APPROVED DATE NORTHDIV FOR COMMANDER, NAVFAC

REV	DESCRIPTION	PREP BY	DATE	APPROVD

DSGN: Chris Cox CH ENG:
SUBMITTED BY: 4/15/98
DATE
OFFICER IN CHARGE
APPROVED DATE

P:\GIS\NLON\NLONTAGS.APR 25-FEB-98 SMT ZONE 3 GROUNDWATER TAG LAYOUT



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COST/SCHED-AREA
SCALE AS NOTED

Brown & Root Environmental

ZONE 3 GROUNDWATER
COPC POSITIVE DETECTS
LOWER SUBASE RI
NSB-NLON, GROTON, CONNECTICUT

CONTRACT NO. OWNER NO.
APPROVED BY Craig C. Rule DATE 4/16/98
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DRAWING NO. FIGURE 6-6 REV. 0

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7.0 ZONE 4

7.1 SITE DESCRIPTION

Zone 4 extends from the southern side of Bullhead Road to the southern boundary of the Lower Subase along the Thames River. Zone 4 includes Site 13 - Building 79 Waste Oil Pit; Site 19 - Solvent Storage Area (Building 316); and the Quay Wall Study Area. Utility trenches and fuel distribution lines run through Zone 4. The gate valve (Building 332) to the tank farms is also located in this zone. Figure 7-1 illustrates Zone 4 and the site boundaries. Fuel oil distribution lines, steam, condensate and electrical ducts, and sewer lines are also shown in Figure 7-1. Photographs of Zone 4 are provided in Appendix G.

7.1.1 Site 13 - Building 79 Waste Oil Pit

Building 79 is located adjacent to one of the oil contamination areas identified in the Navy Environmental Support Office (NESO) and Wehran Engineers reports (NESO, 1979 and Wehran, 1987) (see Sections 7.2.1 and 7.2.3, respectively). This area features a railroad spur. Diesel engines were serviced inside the building during World War II through the 1950s. The service area included a pit in the northwestern corner of the building 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 has been filled with concrete. Available building maps show a subsurface drain pipe extending from the pit to Albacore Road.

7.1.2 Site 19 - Solvent Storage Area (Building 316)

Building 316 is located south of the gate valve building (Building 332). Various solvents used for equipment cleaning are stored in Building 316. No major spills have been reported for this building.

7.1.3 The Quay Wall Study Area

The Quay Wall Study Area runs from approximately Pier 2 to Pier 6. A wooden platform and quay wall were constructed in 1940. The wooden platform is 4 inches thick and supported by 10- to 12-inch-square wooden joists and 8-inch timber pilings. A steel bulkhead along the Thames River was erected in 1952 and constructed of steel sheet piling and supports. During construction of the bulkhead, the quay wall and wooden platform were covered with approximately 6 to 7 feet of sand and gravel fill, and the area was paved for vehicular access along Albacore Road. The quay wall is located approximately 4 feet east of the steel bulkhead, immediately beneath the paved surface. Fill soil below the wooden platform and quay wall may periodically wash out. Void spaces of 3 to 8 feet exist discontinuously beneath the wooden platform. Sand and gravel fill separate the void spaces and can be replaced with sand poured into a

series of manholes along the length of the Albacore Road. Natural river deposits of silt and sand underlie the void spaces and sand fill.

Zones of visible petroleum contamination were present in the soil immediately above the wooden platform and in the fill below the wooden platform. The petroleum was found in the area around the storm sewer manhole northeast of Pier 4. Globules of floating product were also present in the standing water in the void spaces below the wooden platform. Releases of petroleum products and oily substances were observed in the Thames River in the vicinity of the storm sewer outfall just north of Pier 4 in November 1994. It was determined that the probable source of the releases was the storm sewer manhole near Pier 4 and Building 79. An expandable rubber plug was placed in the storm sewer outfall in November 1994, and the storm sewer pipe leading to the outfall was filled with sand in late December 1994. This measure appears to have eliminated migration of petroleum product from this outlet, because no visible release of petroleum product has been observed in the Thames River near the outlet.

7.1.4 Fuel Oil Distribution Lines and Utility Ducts

Fuel oil distribution lines and utility ducts and trenches run through Zone 4. A description of the fuel oil distribution system is provided in Section 1.4.1.3 and a description of the utility (steam, condensate, and electrical) ducts and trenches is provided in Section 1.4.1.4. The locations of the fuel distribution lines and the utility ducts are shown in Figure 7-1. In 1996, pressure leak testing was performed on the lines and valves in the fuel distribution system within Zone 4. The results of this testing program are presented in Section 7.2.6.

7.1.5 Storm Sewers

As can be seen on Figure 7-1, four storm sewers discharge to the Thames River from Zone 4. Invert elevations for the storm sewer outfalls to the Thames River and upgradient catch basins were not readily available, with the exception of Catch Basin No. 583 which is located on the northwest side of Building 85. The invert elevation for this catch basin is 6.18 feet msl. This elevation was taken from the Navy drawing, *Utility Map, Storm Drainage* (Drawing Number 1142295, Sheet 2 of 19, July 27, 1967). The elevation of the Thames River fluctuates daily and seasonally, but the elevation of the river typically ranges between approximately 0.00 feet msl to 4.00 feet msl. Based on this information, the storm sewer system upgradient of Catch Basin No. 583 is not typically submerged. Although unconfirmed by survey data, it is likely that some portions of the Zone 4 storm sewer system will be submerged to varying degrees depending on the time of day and time of year. A typical cross-section for Zones 1 through 4, showing the storm sewer system and the variation in the tides, is provided on Figure 1-4 in Section 1.0.

In accordance with the requirements of the basewide General NPDES Stormwater Permit, the storm sewer off the southwestern corner of Building 85 in the Quay Wall Study Area is monitored annually during a storm event. This storm sewer, referred to as BLDG 85, was last sampled during a storm event on June 13, 1997. Results of the chemical and toxicity testing performed on this storm water are presented in Section 7.2.10.

7.2 SITE INVESTIGATIONS

The following investigations were conducted at Zone 4 and are discussed in the following subsections:

- Oil Contamination of Groundwater at Subase New London (NESO, 1979)
- Final Initial Assessment Study (Envirodyne, 1983)
- Final Site Investigation - Subsurface Oil Contamination (Wehran, 1987)
- Phase I Remedial Investigation (Atlantic, 1992)
- Removal Site Evaluation for Quay Wall (HNUS, 1995b)
- Leak Testing Investigation for Fuel Oil Distribution System (Heitkamp, 1996)
- Existing Data Summary Report for Lower Subase Remedial Investigation (B&R Environmental, 1997a)
- Phase II Remedial Investigation (B&R Environmental, 1997b)
- Site Investigation Report for Tank Farm Investigation (B&R Environmental, 1997c)
- Annual NPDES Stormwater Monitoring Program (Navy, 1997)

7.2.1 Oil Contamination of Groundwater at Subase

In 1979, the NESO conducted a study to identify the source and extent of oil found in soils along the Thames River at three sites on the Lower Subase, including Building 79 Waste Oil Pit (Site 13). NESO drilled a total of 12 soil borings and installed piezometers in each soil boring. Soil samples collected from each boring were analyzed for oil content. Groundwater samples were collected from each piezometer to check for the presence of oil and, where oil was present, to measure product thickness.

Four borings/piezometers were installed during this study at Zone 4 (NESO9 through 12). Locations of these wells are shown in Figure 7-1. Oil and grease content in soils ranged from 500 ppm to 1,600 ppm. Oil content in groundwater ranged from 15 ppm (NESO10 and NESO11) essentially free product (more than 98 percent) at NESO9. Oil thickness in NESO9 was reported to range from 10 inches to over 5 feet. Oil, identified as lubricating oil, was found in the vicinity of Building 79 (Site 13). The NESO report recommended the abandonment of the Building 79 waste oil pit and the installation of a recovery well system.

The Building 79 waste oil pit was eventually filled with concrete, and a recovery well system was installed sometime around 1985. The system operated for a period of several months but was determined to be ineffective and later abandoned.

7.2.2 Final Initial Assessment Study

Envirodyne Engineers performed an Initial Assessment Study (IAS) at NSB-NLON as part of the NACIP program. The purpose of this study was to identify and evaluate past waste disposal practices and to assess the potential for environmental impacts. Envirodyne reviewed installation records, interviewed long-term and former employees, toured the installation, and photographed sites as part of the IAS.

Envirodyne identified 11 sites at NSB-NLON as having contained hazardous material; one site is located within Zone 4 (Site 13). The report recommended that no further actions be pursued at Building 79 (Site 13) because the pit was no longer in use, had been filled with concrete, and was closed to all drainage.

7.2.3 Final Site Investigation of Subsurface Oil Contamination

In 1987, Wehran Engineering Corporation completed an investigation to identify and delineate the sources of heavy oils in the subsurface of the Lower Subase (Sites 10, 11, and 13). Activities during the investigation included collecting soil samples from soil borings, oil samples from manholes and trenches, and groundwater samples from monitoring wells. These samples were tested to identify the type, degree of weathering, and general concentrations of oil contamination at the three sites.

Four borings, converted to monitoring wells, were installed in Zone 4 (WE1, WE3, WE4, and WE5). Six oil samples were collected from manholes and trenches (MH-1, MH-2, MH-3, MH-4, T-1, and T-2). In addition, one existing well (NESO10) was also sampled. One of the manhole samples (MH-3) was also analyzed for PCBs. Wehran identified two areas located within Zone 4 that were contaminated with heavy oil. Oil contamination (determined to be No. 6 fuel oil weathered less than a year) was observed in the trench that runs along Argonaut Road from approximately Building 85 (Zone 4) to near the northeastern corner of Building 78 (Zone 3). Manholes and the area underneath the supporting platform in the vicinity of Building 79 (Site 13) contained No. 6 fuel oil older than 1 year and trace levels of waste oil. PCBs were not detected.

Wehran recommended removal of the oil from the manholes near Building 79 by using absorption pads and/or excavation of oil-laden soil and inspection of fuel lines within the trench and subsequent cleaning of the trench.

7.2.4 Phase I Remedial Investigation

An investigation of 11 sites was completed at NSB-NLON by Atlantic Environmental Services. One site, identified as the Lower Subase - Site 13, included the area represented by Zones 1 through 4.

The Lower Subase Phase I field investigation consisted of a utility manhole inspection and waterfront bulkhead inspection for evidence of contamination sources. Also included were a soil gas survey, test boring completion, monitoring well installation, and soil and groundwater sampling.

During the utility manhole inspection, manhole covers were removed and inspected for visual evidence of oil. Four areas of significant petroleum accumulation were observed during the manhole inspection. Two of these areas are located within Zone 4. Thick black oil was identified in an area west of Building 80, on the boundary of Zones 3 and 4. The accumulation appeared to be from product release. There was no evidence of ongoing releases. In the other area, a brown milky oil was identified west of Building 79. The report indicated this oil potentially originated from the former waste pit in Building 79. An old drawing shows the outlet from the waste oil pit 29 feet south of the north side of Building 79.

The waterfront inspection was conducted by boat during low tide. Seeps or sheens have historically been observed at the waterfront near Pier 4; however, no oil seeps or sheens or evidence of such were observed anywhere along the waterfront at the Lower Subase during the inspection.

A shallow soil gas survey (depths of 12 to 18 inches) was conducted within Zones 1 through 4. The results for Zone 4 showed a large area of a low concentration of VOCs west of Buildings 79 and 80. This area was further characterized by subsurface investigations.

Four test borings (13TB1 through 13TB4) and four borings converted to monitoring wells (13MW13 through 13MW16) were installed within Zone 4 and are shown on Figure 7-1. The soils from the test borings were screened in the field for organic vapors and examined visually, but they were not chemically analyzed. Soil and groundwater samples collected from the monitoring wells were analyzed for VOCs, inorganics, TPH, and fluorescence. Existing monitoring wells (NESO10, NESO11, WE1, WE4, and WE5) were also sampled and analyzed during the Phase I RI.

Based on TPH and fluorescence, an area of subsurface soil west and adjacent to Building 79 contained a mixture of No. 6 fuel oil and waste oil. This mixture was also identified in groundwater; however, positive detections of TPH were only identified in one monitoring well (13MW16).

7.2.5 Removal Site Evaluation for the Quay Wall

Halliburton NUS prepared a Removal Site Evaluation for the quay wall to summarize removal actions performed in November and December 1994 to remedy petroleum product releases that occurred along the quay wall of the Lower Subase. A summary of the actions completed are as follows:

- From November 4, 1994 to November 6, 1994, a spill response and cleanup contractor retained by the Navy completed cleanup activities.

- Approximately 2,300 gallons of oily waste water and thirty-nine 55-gallon drums, two 30-gallon drums, and one 18-gallon drum of absorbent pads contaminated with product were generated during cleanup activities.

- Five product recovery wells (QW-1 through QW-5) were subsequently installed. Oil/water was pumped from the recovery wells 4 times between December 5 and 21, 1994. A total of approximately 16,000 gallons of oil/water was pumped and containerized. A small percentage of the liquid pumped (less than 5 percent) was petroleum product.

Five subsurface soil samples were collected from five of the six borings. Four of the soil samples (QW-2, QW-3, QW-4, and QW-5) were analyzed for BTEX and TPH. The fifth soil sample (QW-1) was analyzed for TCL organics, TAL inorganics plus boron, TPH, and TCLP metals. Lead was identified as the only chemical of concern. Based on current and anticipated land use of the area, direct exposures to lead were not considered likely to occur except during construction activities. Therefore, the Removal Site Evaluation recommended that no further removal action be performed at that time but that further site investigations need to focus on lead concentrations. It was estimated that no more than 800 gallons of petroleum were pumped from the void spaces.

7.2.6 Leak Testing Investigation for Fuel Oil Distribution System

In April and May 1996, Heitkamp performed pressure leak testing on the lines and valves in the fuel distribution system within Zone 4. The recommendations from this investigation indicated that Valve Numbers 19 and 20 on the Building 332 North Line and Valve Numbers 17 and 18 on the Building 332 South Line do not seal tight and should be replaced. All other sections of line and various valves tested in the portion of the distribution system within Zone 4 passed the pressure testing procedures. The Navy has subsequently replaced the appropriate valves.

7.2.7 Site Investigation Report for Tank Farm Investigation

B&R Environmental conducted an investigation in 1995 of the UST farm along Crystal Lake Road. The primary objectives of the investigation were to define the extent of soil and groundwater contamination from the UST farm, evaluate the impact of the UST farm on the stormwater discharge, and recommend remedial alternatives, if needed. As part of the tank farm investigation, underground pipelines from the fuel loading dock (Pier 1), throughout a portion of the Lower Subase (Zones 1 through 4) and from the gate valve (Building 332) to tanks within the tank farm were investigated. Soil samples were collected along the new and old diesel underground pipelines at approximately 100-foot intervals. The samples were analyzed for TPH. The No. 6 fuel oil lines were not included as part of the investigation because they were installed within concrete-lined trenches, which would prevent or minimize any potential soil and groundwater impact from leaks. Six samples were collected within Zone 4 (GS-6L through GS-11L). Except for one sample located near the southwestern corner of Building 105 (GS-9L), TPH concentrations were less than 50 mg/kg. The concentration near Building 105 was greater than 2,500 mg/kg. This contamination was apparently from a leak along the pipeline.

The report recommended that additional integrity inspections be performed to determine the locations of the previous line leaks on both active and inactive product lines throughout the Lower Subase. In addition, a records review was recommended to identify previous leaks based on the results of line inspections and tightness tests.

7.2.8 Phase II Remedial Investigation

B&R Environmental conducted a Phase II RI at 13 sites at NSB-NLON. The Lower Subase was included in this investigation. Soil boring installation and soil and groundwater sampling at Zone 4 were included in the investigation. Seven soil samples were collected from five borings (13TB2A, 13TB3A, 13TB4A, 13TB6, and WE4A) and analyzed for lead, TPH, and TCLP metals. Groundwater samples were collected from eight new and existing monitoring wells (13MW13 through 13MW16, WE1, WE5, NESO10, and NESO11) and analyzed for VOCs, SVOCs, metals (total and dissolved), and TPH.

Relatively high concentrations of TPHs (maximum - 11,800 mg/kg) were found in Zone 4 soil, particularly near the waste oil pit at Building 79 (Site 13) and the quay wall. In addition, lead was detected in the soil from the same areas at a maximum concentration of 10,600 mg/kg.

The Phase II RI recommended that further characterization of the Lower Subase be performed during a separate RI. This characterization effort should emphasize evaluation of the nature and extent of lead, TPH, and SVOCs in soil. Continuous groundwater sampling and analyses were also recommended to

monitor contamination levels. In addition, a focused data collection effort was recommended that would provide information relevant to an FS to evaluate potential remedial options for the site.

7.2.9 Existing Data Summary Investigation for Lower Subase

The Existing Data Summary Report for the Lower Subase RI was developed as part of the first tier of data collection to accumulate data from several studies, including the Phase II RI, and to identify potential data gaps that would then be filled in during the Lower Subase RI.

With respect to Zone 4, the Existing Data Summary Report recommended that TPH, lead, and SVOC concentrations in the soil be further characterized. In addition, the report recommended that lead levels continue to be monitored in the groundwater, the mobility of lead in shallow and deep soil be determined through sampling and analysis using the SPLP method, the amount of lead entering the Thames River be quantified, and ecological impacts in the Thames River be evaluated. Also, since sampling has not been conducted in the southeastern corner of Zone 4, a review of records and background information related to Building 316 was recommended, along with limited sampling to determine whether contaminated soils and/or groundwater have resulted from activities at this building. Finally, the report recommended that further characterization activities at Zone 4 be coordinated with sediment sampling of the Thames River in the vicinity of Zone 4 to aid in the identification of source areas and contaminants of concern.

With respect to the fuel oil distribution lines, utility ducts, and storm sewers located in Zone 4, the RI report recommended that fuel line leak detection systems be evaluated to ensure against leakage, past and present fuel line leaks be identified and repaired, utility ducts and trenches and storm sewers be inspected, and any contaminated material found be removed.

7.2.10 Annual NPDES Stormwater Monitoring Program

In accordance with the requirements of the basewide General NPDES Stormwater Permit, the storm sewer off the southwestern corner of Building 85 in the Quay Wall Study Area is monitored annually during a storm event. During a 0.27-inch storm of 27-minute duration on June 13, 1997, the Building 85 storm sewer, referred to as BLDG 85, was sampled and analyzed. The analyses indicated that the storm sewer contained 300 colonies per 100 ml of fecal coliform and 370 mg/L of suspended solids. Analytical results also indicated low concentrations of oil/grease (less than 1.0 mg/L), copper (less than 0.01 mg/L), lead (0.19 mg/L), and zinc (less than 0.01 mg/L). The pH was measured at 5.72. Toxicity tests run on the same sample indicated both a 24-hour and a 48-hour survival for *Daphnia Pulex* to be less than 6.25 percent.

7.2.11 Lower Subase Remedial Investigation

Five test borings (TB1-4RI through TB5-4RI) were installed to the water table in Zone 4. Borings TB2-4RI, TB3-4RI, and TB4-4RI were advanced using DPT. Borings TB1-4RI and TB5-4RI were advanced using HAS techniques and converted to monitoring wells MW1-4RI and MW2-4RI, respectively. Monitoring well screen intervals were installed across the water table. Boring and monitoring well locations are illustrated in Figure 7-1. Boring log sheets and monitoring well construction sheets are provided in Appendix A. Two soil samples were collected from each boring from shallow (0 to 5 feet) and deep (greater than 5 feet) depths. SVOC analysis was performed on both shallow and deep samples. TPH and TAL metals analyses were performed on shallow samples from locations TB1-4RI, TB3-4RI, and TB5-4RI. TAL metals analysis was performed on the deep soil samples from these same locations. SPLP lead analysis was performed on shallow and deep soil samples from locations TB1-4RI, TB3-4RI, and TB5-4RI. Soil sample log sheets are included in Appendix B.1.

Groundwater samples were collected from eight existing monitoring wells (WE1, NESO10, NESO11, 13MW13, 13MW14, 13MW15, 13MW16, and QW-4) and two installed monitoring wells (MW1-4RI and MW2-4RI). Existing monitoring wells WE4, WE5, and QW-5 were not sampled because they were destroyed or inaccessible. Groundwater samples were collected using low-flow purging and sampling techniques, as described in Section 2.3.2. Samples were analyzed for TPH, TCL SVOCs, filtered and unfiltered TAL metals, and natural attenuation parameters. Groundwater sample log sheets and purge data sheets are provided in Appendix B.2.

Three sediment samples (SD1-4RI through SD3-4RI) were collected from locations in the Thames River along Zone 4. Sediment sampling locations are illustrated on Figure 7-1. Surface water quality measurements were taken from each sediment sampling location at the surface and the bottom of the water column. Sediment samples were analyzed for TCL SVOCs, TAL metals, TOC, grain size, AVS/SEM, pH, and ammonia. Surface water quality parameters that were measured include temperature, salinity, turbidity, pH, specific conductance, and dissolved oxygen. Sediment sample log sheets with surface water measurements are provided in Appendix B.3.

7.3 PHYSICAL CHARACTERISTICS

General physical characteristics of the Lower Subase are discussed in Sections 1.3 and 1.4. Site-specific physical characteristics for Zone 4 are discussed in the subsections following.

7.3.1 Topography, Surface Features, and Surface Water Features

Zone 4 is entirely paved or covered with buildings. The Providence and Worcester Railroad runs along the eastern border of the zone, and the Thames River borders it to the west. The ground surface in Zone 4 slopes gently to the west toward the Thames River from an elevation of 9 to 10 feet along the eastern side to 8 feet along the river.

No significant surface water features are located within Zone 4. Surface water runoff in Zone 4 is collected in catch basins and drained through storm sewers to the Thames River. Catch basins and storm sewers in Zone 4 are shown in Figure 7-1. Four storm sewers discharge to the Thames River in Zone 4.

7.3.2 Soil Characteristics, Geology, and Hydrogeology

The soils of Zone 4 are mapped as Urban Land (USDA, 1983), and the surficial geology is mapped as artificial fill (USGS, 1960). A north-south cross-section of Zone 4 is illustrated in Drawing 7, and a west-east cross-section of Zone 4 is illustrated in Figure 7-2. Underlying Zone 4 is 5 to 15 feet of sand and gravel fill material with some debris (brick fragments and fly ash) in the eastern part of the site, underlain by a natural micaceous silt and sand unit, interpreted as a stratified drift deposit. The bottom of the silt and sand unit was not encountered and is unknown. The depth to the bottom of the sand and silt unit is also unknown.

In the western part of Zone 4, a wooden pier and quay wall, constructed in 1940, underlie Albacore Road. The wooden pier is approximately 4 inches thick and is supported by 10- to 12-inch-square wooden joists and 8-inch timber pilings. The quay wall is located immediately beneath the paved surface, approximately 4 feet east of the current steel bulkhead along the river. The current steel bulkhead along the Thames River was erected in 1952 and is constructed of steel sheet piling and supports. During construction of the current bulkhead, the quay wall and wooden pier were covered with sand and gravel fill, and the area was paved for vehicular access along Albacore Road. Fill material below the wooden pier and quay wall periodically washes out due to diurnal tides and leaves a void space of 3 to 4 feet directly below the wooden pier. The fill is replaced with sand via a series of manholes along Albacore Road. Additional information is contained in the Removal Site Evaluation for Quay Wall report (HNUS, 1995c)

Borings in Zone 4 were not advanced to bedrock, and the bedrock depth in Zone 4 is unknown. However, the USGS bedrock map (USGS, 1967) identifies the Mamacoke Formation underlying Zone 1, and the Phase II RI report (B&R Environmental, 1997b) estimates the bedrock to be approximately 60 feet below msl (70 feet bgs).

The unconfined water table in Zone 4 lies within the sand and gravel backfill, with depths ranging from approximately 4 to 6 feet, and groundwater flow is generally to the west-northwest toward the Thames River at low tide (Drawing 3). Monitoring wells along Albacore Road are influenced by diurnal tides. The influence of the tide extends approximately 50 to 60 feet east from the Thames River.

Based on a slug test conducted by Atlantic Environmental (Atlantic, 1992) in 13MW14, the hydraulic conductivity of the sand and gravel backfill is 576 feet per day. A slug test conducted by Atlantic in 13MW13 yielded a hydraulic conductivity of 40 feet per day; however, this monitoring well is screened across the sand and gravel fill and the sand and silt units and does not provide representative conductivity values for each formation, but rather a combined value. Based on water-level data during low tide on October 27, 1998, the hydraulic gradient across Zone 4 is 0.0039 from MW2-4RI to QW-4.

The volumetric rate of groundwater discharge through the sand and gravel fill material in Zone 4 to the Thames River was calculated to be 5,391 cubic feet per day, using Darcy's Law $Q = -KA(dh/dl)$, where Q = the volumetric discharge, K = the average hydraulic conductivity, A = the cross-sectional area (i.e., the saturated fill thickness by the width of the fill material along the Thames River), and dh/dl = the hydraulic gradient. An average saturated fill thickness of 12 feet and a width of 200 feet of fill along the Thames River in Zone 4 were assumed.

Generic contaminant loading rates for groundwater discharge into the Thames River from Zone 4 were generated using an estimated groundwater discharge rate (Q, discounting tidal effects) of 5,391 cubic feet/day; a 0.75 factor applied to this flux rate to account for the lack of groundwater discharge during periods of high tide (assumed to be about 6 hours/day over two tidal cycles); hypothetical solute concentrations (C) of 10, 100, and 1,000 µg/L; and, the following mass flux equation: Mass flux = $Q \times 0.75 \times C$. The corresponding daily discharge rates from Zone 4 into the Thames River are 0.00252, 0.0252, and 0.252 lbs/day for solute concentrations of 10, 100, and 1,000 µg/L, respectively. Actual discharge rates for individual dissolved constituents can be approximated by using these generic discharge rates and the average concentration of the constituent. For example, a compound present at an average concentration of 25 µg/L in groundwater would have a loading rate 2.5 times the generic rate calculated for a solute present at the 10 µg/L concentration. This loading estimate does not factor in retardation and degradation of solutes, which may be substantial in some cases and would reduce the loading rate.

7.4 NATURE AND EXTENT OF CONTAMINATION

This section is a discussion of the nature and extent of contamination of Zone 4 at the Lower Subase. The general site location of Zone 4 is shown on Figure 1-2, and a more detailed drawing of this zone is shown on Figure 7-1. Soil, groundwater, and storm sewer surface water sampling was conducted at Zone 4 during the Phase I, Phase II, and Lower Subase RIs, as well as during the other investigations discussed in Section 7.2. Tables 7-1 through 7-7 provide summaries of the sampling and analytical programs for each investigation. The complete database for Zone 4, including both chemical and physical parameters for all investigative samples, is contained in Appendix H of this report,.

7.4.1 Soil

Positive analytical results for Zone 4 soil samples collected during all investigations are presented in Table 7-8. Positive TCLP and SPLP results for all Zone 4 soil samples are presented in Tables 7-9 and 7-10, respectively. All positive Zone 4 soil analytical results are summarized in Table 7-11. In addition, observations made based on fluorescence spectroscopy of Zone 4 soil samples are summarized in Table 7-12; these observations were obtained from the text of the Final Site Investigation Subsurface Oil Contamination (Wehran, 1987) and the Phase I RI report (Atlantic, 1992). Background concentrations of inorganics in soil, used for comparison with Zone 4 soil sample concentrations, were taken from the Background Concentrations of Inorganics in Soil Report (Atlantic, 1995b). These background concentrations are listed in Table 1-4.

Figures 7-3 and 7-4 depict, for Zone 4 shallow and deep soil samples, respectively, the locations and concentrations of parameters that were detected in excess of COC selection criteria used in the risk assessment. Drawings 8 through 11, located in Volume III of this RI report, delineate TPH and lead concentrations in soil in all zones, including Zone 4, being investigated as part of the Lower Subase RI. Drawings 8 and 9 depict TPH isoconcentration contours for shallow soil and deep soil, respectively, whereas Drawings 10 and 11 show lead isoconcentration contours in shallow soil and deep soil, respectively. Data collected for lead analysis using field screening x-ray fluorescence were not included in Drawings 10 and 11.

7.4.1.1 Shallow Soil

Three Zone 4 shallow soil samples (0 to 5 feet bgs) were analyzed for the full list of TAL metals. Five additional Zone 4 shallow soil samples were analyzed by a fixed-based laboratory for lead only, and two additional Zone 4 shallow soil samples were analyzed for lead using field screening x-ray fluorescence. As shown in Table 7-11, 20 metals were detected in Zone 4 shallow soil samples. Arsenic, antimony, cadmium, calcium, copper, lead, mercury, nickel, sodium, and zinc were detected in Zone 4 shallow soils at maximum

concentrations exceeding NSB-NLON background levels (Table 1-4). However, calcium and sodium are naturally occurring abundant constituents of soil.

Lead was detected at concentrations exceeding background (17.5 mg/kg) in all Zone 4 shallow soil samples, with concentrations of lead ranging from 57.1 mg/kg (MW2-4RI) to 10,600 mg/kg (WE4A). Drawing 10 shows the distribution of lead in shallow soils within Zone 4. The contours indicate that there are significant levels of lead contamination in shallow soils in the northwestern corner of Zone 4 (west of Building 80) and in the north-central portion of Zone 4 (east of Building 79). The source(s) of lead contamination may be the waste oil pit at Building 79 or Building 31 (the site of a lead removal action that was conducted in Zone 3).

TCLP extraction followed by analysis for RCRA metals was performed for five Zone 4 shallow soil samples. Analyses for TCLP organics (volatiles, semivolatiles, pesticides, and herbicides) were also performed for one of the shallow soil TCLP leachates; no TCLP organics were detected. Arsenic, barium, cadmium, chromium, and lead were detected in the TCLP leachates. With the exception of lead, all TCLP metals concentrations were less than Federal toxicity characteristic regulatory levels and Connecticut remediation standard pollutant mobility criteria for a GB area. Concentrations of lead in the TCLP leachate of the shallow soil sample collected from location 13TB4A exceeded the Connecticut remediation standard pollutant mobility criterion for lead, and TCLP lead concentrations in the leachates of the shallow soil sample collected from location WE4A and from the two shallow soil samples collected from location 13TB3A exceeded both the Federal and state criteria. These sample locations coincide with the two areas of significant lead contamination noted in the previous paragraph.

SPLP extraction, followed by analysis for lead, was performed for three Zone 4 shallow soil samples collected during the Lower Subase RI. Lead was detected in the SPLP leachates of two of the shallow soil samples. The concentration of lead in the SPLP leachate of the shallow soil sample collected from boring TB3-4RI (0.104 mg/L) exceeded the Connecticut remediation pollutant mobility criterion for lead. However, the samples collected for SPLP extraction followed by analysis for lead were not collected from the same general area as the samples with results for TCLP lead at concentrations exceeding regulatory criteria. In addition, the concentrations of lead detected in the shallow soil samples collected from these three locations were not similar in magnitude to the concentrations of lead detected in the shallow soil samples from locations associated with high levels of TCLP lead. Therefore, concerning potential migration, the results of the recent SPLP analyses cannot be used to confirm the results of the historical TCLP analyses.

Analysis for VOCs was not performed for any of the Zone 4 shallow soil samples. As shown in Table 7-11, 20 SVOCs, primarily PAHs, were detected in the five shallow soil samples analyzed for this analytical fraction. Concentrations of PAHs in the shallow soil samples ranged from 19 µg/kg (acenaphthylene) to

15,000 µg/kg (pyrene). With the exception of phenol, which was detected in only one sample, the maximum concentrations of all SVOCs were detected in the shallow soil sample collected from location MW1-4RI, located south of Building 85 near the southern end of the quay wall.

TPH was detected in all nine Zone 4 shallow soil samples analyzed for this parameter, at concentrations ranging from 31.8 mg/kg to 3,440 mg/kg. The maximum TPH concentration was detected in the shallow soil sample from location 13TB4A, located just west of Building 80 and east of a sanitary sewer line. The isoconcentration contours for TPH on Drawing 8 indicate the presence of TPH contamination in shallow soils at the western edge of Zone 4 along the Thames River, with the greatest concentrations of TPH present west of Building 80.

7.4.1.2 Deep Soil

Ten Zone 4 deep soil samples (greater than 5 feet bgs) were analyzed for the full list of TAL metals. One additional Zone 4 deep soil sample was analyzed by a fixed-base laboratory for lead only, and another Zone 4 deep soil sample was analyzed for lead using field screening x-ray fluorescence. Table 7-11 indicates that 20 metals were detected in the deep soil samples collected from Zone 4. Maximum concentrations of arsenic, cadmium, calcium, chromium, copper, lead, magnesium, manganese, nickel, potassium, selenium, sodium, vanadium, and zinc in Zone 4 deep soil samples exceeded NSB-NLON background levels (Table 1-4). However, calcium, magnesium, potassium, and sodium are naturally occurring, abundant constituents of soil. A majority of the maximum concentrations of metals were detected in the sample collected from well 13MW16. Monitoring well 13MW16 is located west of Building 79, near the base of Pier 4. The metals contamination in the area of well 13MW16 is likely to be the result of activities at Building 79.

Lead was detected in 10 of 12 Zone 4 deep soil samples, at concentrations ranging from 25.2 mg/kg to 1,990 mg/kg. Drawing 11 shows the distribution of lead concentrations measured in Zone 4 deep soil samples based on fixed-base laboratory data. A high concentration of lead (1,470 mg/kg) is evident along Albacore Road at location QW-1. This lead contamination may be the result of activities at Building 79 (former location of pit) or of activities at Building 31, located in Zone 3. An area of lead contamination in Zone 4 deep soils is also evident north of Building 85. The maximum concentration of lead measured in Zone 4 deep soil samples (1,990 mg/kg measured using field screening x-ray fluorescence for the deep soil sample from boring 13TB3A, located in the northwestern corner of Zone 4 near boring QW-1) is roughly five times less than the maximum concentration of lead measured in Zone 4 shallow soil samples (10,600 mg/kg). A comparison of Drawings 10 and 11 indicates that lead contamination in deep soils within Zone 4 is less pervasive than lead contamination in Zone 4 shallow soils.

Nine Zone 4 deep soil samples were collected for TCLP extraction followed by RCRA metals analysis. Analyses for TCLP organics (volatiles, semivolatiles, pesticides, and herbicides) were also performed for one of the deep soil TCLP leachates; no TCLP organics were detected. Arsenic, barium, cadmium, chromium, lead, and selenium were detected in the TCLP leachates of these soil samples. Lead was detected in the TCLP leachates of six deep soil samples. All TCLP lead concentrations exceeded the Connecticut remediation standard pollutant mobility criterion for lead, and half of the TCLP lead concentrations exceeded the Federal toxicity characteristic regulatory level for lead. The maximum TCLP lead concentration (51.9 mg/L) was measured in the deep soil sample collected from location QW-1, located along Albacore Road west of Building 80.

Three Zone 4 deep soil samples were collected for SPLP extraction followed by analysis for lead during the Lower Subase RI. These samples were collected from locations MW1-4RI, MW2-4RI, and TB3-4RI, located in the southern half of Zone 4 near Buildings 85 and 316. Lead was detected in one of the three samples at a concentration less than both the Federal toxicity characteristic regulatory level for lead and the Connecticut remediation standard pollutant mobility criterion for lead. However, these samples were not collected from the same general area as the samples with results for TCLP lead at concentrations exceeding regulatory criteria. In addition, the concentrations of lead detected in the deep soil samples collected from these locations were not similar in magnitude to the concentrations of lead detected in the deep soil samples from locations associated with high levels of TCLP lead. Therefore, concerning potential migration, the results of the recent SPLP analyses cannot be used to confirm the results of the historical TCLP analyses.

Eight VOCs were detected at low concentrations (ranging from 0.7 µg/kg to 20.3 µg/kg) in Zone 4 deep soil samples. Carbon disulfide was detected in one sample (collected from well 13MW16) at a concentration of 5 µg/kg. Benzene, ethylbenzene, toluene, and total xylenes were each detected in from one to four of 11 Zone 4 shallow soil samples. Maximum concentrations of these four compounds, which are all constituents of fuel, were detected in deep soil samples collected from locations QW-2 and QW-3, located along the quay wall. Methylene chloride (a common laboratory contaminant), tetrachloroethene, and trichloroethene were detected in a majority of the Zone 4 deep soil samples at concentrations ranging from 1 µg/kg to 12 µg/kg. The maximum concentrations of these three halogenated aliphatic compounds were all detected in the deep soil sample collected from location 13MW13.

Six Zone 4 deep soil samples were analyzed for SVOCs. As shown in Table 7-11, 15 PAHs and butylbenzyl phthalate (a common laboratory contaminant) were detected in the deep soil samples. PAH concentrations ranged from 19 µg/kg to 830 µg/kg. The concentrations of PAHs detected in the deep soil samples collected from locations near Building 85 were much less than the PAH concentrations detected in the shallow soil

samples from these locations; PAH concentrations detected in the deep soil sample collected from well MW1-4RI, located south of Building 85, were generally from 50 to 100 times less than respective PAH concentrations detected in the shallow soil sample from this well, and PAH concentrations detected in the deep soil sample collected from boring TB3-4RI, located north of Building 85, were roughly five times less than respective PAH concentrations detected in the shallow soil sample from this location. Conversely, PAH concentrations detected in the deep soil sample collected from boring TB2-4RI, located west of Building 79, were roughly two times greater than PAH concentrations detected in the shallow soil sample collected from this location.

One deep soil sample, collected from boring QW-1, was analyzed for pesticides/PCBs. One pesticide (endrin at a concentration of 6.7 µg/kg) was detected in this sample.

TPH was detected in 17 of the 19 Zone 4 deep soil samples analyzed for this parameter. Concentrations ranged from 15.3 mg/kg to 11,800 mg/kg. Drawing 9 shows isoconcentration contours of TPH measured in deep soil samples, indicating that TPH contamination in Zone 4 deep soils is widespread. High levels of TPH contamination are evident in Zone 4 deep soils along Albacore Road and Bluefish Road. The source of TPH contamination at the intersection of Argonaut Road and Bluefish Road (location GS-9L) is likely to be a fuel line leak. Drawing 9 isoconcentration contours indicate that TPH contamination from this location may be migrating toward the Thames River. The source of the other significant area of TPH contamination in Zone 4 deep soils, located along Albacore Road west of Building 79, is likely to be the pit at Building 79. The area of TPH contamination evident along the boundary of Zones 3 and 4 is likely to be a result of TPH contamination originating from fuel pipeline leaks within Zone 3 and migrating toward the Thames River.

Based upon the results of fluorescence spectroscopy analyses (Table 7-12), Zone 4 deep soil samples collected from locations WE-3 and WE-4, located west and east of Building 79, respectively, contained low levels of No. 6 fuel oil. In addition, deep soil samples collected from wells 13MW14, 13MW15, and 13MW16 (all located west of Building 79) contained a mixture of waste oil and No. 6 fuel oil. Trace levels of petroleum hydrocarbons were also observed in deep soil samples collected from locations 13MW13 (located east of Building 79), WE-1 (located south of Building 35), and WE-5 (located west of Building 80), but concentrations were too low to identify the type of oil present. In addition, some evidence of oil was apparent during the drilling of four of the borings installed near Building 79 during the Phase I RI. The presence of oil globules was noted during the drilling of two of these borings, 13TB2 and 13TB3.

7.4.2 Groundwater

Positive analytical results for all groundwater samples collected from Zone 4 are presented in Table 7-13. Table 7-14 summarizes analytical results for groundwater samples collected from Zone 4 during historical investigations (i.e., the Phase I and Phase II RIs) and during the Lower Subase RI. In addition, observations made based on fluorescence spectroscopy of Zone 4 groundwater samples are summarized in Table 7-15; these observations were obtained verbatim from the text of the Final Site Investigation Subsurface Oil Contamination Report (Wehran, 1987) and the Phase I RI Report (Atlantic, 1992). Table 7-16 provides a summary of natural attenuation and water-quality parameters for Zone 4 groundwater samples; these parameters will be discussed in Section 7.5.3.

Figure 7-5 shows, for data collected during the Lower Subase RI only, the locations and concentrations of parameters that were detected in excess of COC selection criteria used in the risk assessment. Drawings 12 through 14 (Volume III) show the distribution of TPH and lead contamination in groundwater for all zones, including Zone 1, of the Lower Subase using data collected during the Lower Subase RI. Drawing 12 depicts isoconcentration contours of TPH in groundwater, whereas Drawings 13 and 14 show lead isoconcentration contours in unfiltered and filtered groundwater, respectively (i.e., for total and dissolved lead).

7.4.2.1 Historical Data

Three rounds of groundwater samples were collected from eight monitoring wells installed within Zone 4 (13MW13, 13MW14, 13MW15, 13MW16, NESO10, NESO11, WE1, and WE5) during the Phase I and Phase II RIs. An additional well, WE4, was sampled only during the Phase I RI. Unfiltered groundwater samples were analyzed for total metals during all three rounds, and filtered groundwater samples were analyzed for dissolved metals during the two sampling rounds of the Phase II RI only.

Sixteen metals were detected in both unfiltered and filtered historical groundwater samples. Beryllium, cadmium, chromium, cobalt, and mercury were each detected in from one to four unfiltered groundwater samples only, nickel was detected in 12 unfiltered groundwater samples, and antimony was detected in two filtered groundwater samples. In general, concentrations of metals in unfiltered and filtered historical groundwater samples were at the same order of magnitude.

A majority of the maximum concentrations of metals in unfiltered historical groundwater samples were detected in the groundwater sample collected from well NESO11, located near the northeastern corner of Building 85, during Round 1 of the Phase II RI. Concentrations of metals detected in this sample generally exceeded metals concentrations detected in historical groundwater samples collected from all other zones of the Lower Subase. Metals concentrations of note in this groundwater sample include cadmium (13.2 µg/L),

copper (649 µg/L), lead (2,760 µg/L), manganese (1,980 µg/L), nickel (80 µg/L), vanadium (105 µg/L), and zinc (924 µg/L). Concentrations of similar magnitude were not detected in the filtered groundwater sample collected from this well during Round 1 of the Phase II RI or in any of the filtered or unfiltered groundwater samples collected from this well during the Phase I, Phase II, or Lower Subase RIs. Lead concentrations measured in groundwater samples collected from well NESO11 during the three historical sampling rounds were 22.2 µg/L (Phase I RI), 2,760 µg/L (Phase II RI - Round 1), and 11.4 µg/L (Phase II RI - Round 2). Lead was detected at a concentration of 10.2 µg/L in the groundwater sample collected from this well during the Lower Subase RI. Therefore, it is likely that the groundwater sample collected from this well during Round 1 of the Phase II RI contained suspended solids exhibiting metals contamination.

Concentrations of lead detected in other Zone 4 historical groundwater samples ranged from 1.6 µg/L to 140 µg/L. Lead was detected at a concentration of 140 µg/L in the historical groundwater sample collected from well WE5, located along the western side of Building 80.

Eight VOCs, including five halogenated aliphatics (1,1,1-trichloroethane, 1,1-dichloroethane, 1,1-dichloroethene, methylene chloride, and vinyl chloride) and three monocyclic aromatics (ethylbenzene, toluene, and total xylenes), were detected in Zone 4 historical groundwater samples. These compounds, however, were infrequently detected (in from zero to three groundwater samples per sampling event, or in from one to seven samples per the total number of 26 groundwater samples). Concentrations of VOCs in groundwater ranged from 1 µg/L (1,1,1-trichloroethane and 1,1-dichloroethane) to 57 µg/L (1,1-dichloroethene). With the exception of ethylbenzene, methylene chloride, and total xylenes (for which maximum concentrations were detected during Round 2 of the Phase II RI), maximum concentrations of all VOCs were detected during the Phase I RI.

Fourteen SVOCs were detected in Zone 4 historical groundwater samples. Most of the SVOCs were detected only in the groundwater sample collected from well NESO11 during Round 1 of the Phase II RI; bis(2-ethylhexyl)phthalate (10 µg/L) and 10 PAHs (at concentrations ranging from 0.6 µg/L to 2 µg/L) were detected in this sample. SVOCs were not detected in the groundwater sample collected from well NESO11 during Round 2 of the Phase II RI. Concentrations of phthalates, which are common laboratory contaminants, and PAHs detected in groundwater samples collected from other Zone 4 wells during the Phase I and Phase II RIs (wells 13MW15, 13MW16, and WE1 only) ranged from 0.6 µg/L to 1 µg/L.

TPH was detected in all three historical groundwater samples collected from well 13MW16, located west of Building 79 along Albacore Road, at concentrations ranging from 700 µg/L (during Round 2 of the Phase II RI) to 5,400 µg/L (during the Phase I RI). TPH was also detected in the groundwater sample collected from well WE1, located south of Building 35 and west of a fuel pipeline, during Round 2 of the Phase II RI at a

concentration of 500 µg/L. TPH was not detected in historical groundwater samples collected from any of the other wells located within Zone 4. It should be noted, however, that reporting limits for TPH ranged from 2,000 µg/L to 3,000 µg/L for samples collected during the Phase I RI.

Based on fluorescence spectroscopy data (Table 7-15), spectra typical of No. 6 fuel oil were observed for groundwater samples collected from wells WE3 and NESO10, located west and southwest of Building 79, during the Final Site Investigation Subsurface Oil Contamination (Wehran 1987). Spectra typical of a heavy waste/fuel oil were observed for groundwater samples collected from wells WE1 (located south of Building 35), WE4 (located south of Building 80), and WE5 (located west of Building 80) during this 1987 investigation. However, spectra for groundwater samples collected from wells WE1, WE4, and WE5 during the Phase I RI (Table 7-15) did not indicate the presence of petroleum hydrocarbons. Trace levels of petroleum hydrocarbons were detected in groundwater samples collected from wells NESO10 and NESO11 during the Phase I RI, but concentrations were too low to identify the type of oils present in these samples. Fluorescence spectra for samples collected from wells 13MW14 and 13MW15 (both located west of Building 79) during the Phase I RI indicated the presence of a mixture of waste oil and heavy residual fuel oil (i.e., No. 6 fuel oil), and the spectra for the groundwater sample collected from well 13MW16 (also located west of Building 79) were typical of some type of heavy residual fuel oil. The spectrum for the groundwater sample collected from well 13MW13, located east of Building 79, during the Phase I RI did not indicate the presence of petroleum hydrocarbons.

7.4.2.2 Lower Subase RI

Groundwater samples were collected from eight existing groundwater monitoring wells and two newly installed groundwater monitoring wells (MW1-4RI and MW2-4RI) during the Lower Subase RI. Fifteen metals were detected in both filtered and unfiltered Zone 4 groundwater samples collected during the Lower Subase RI. In addition, chromium (4.7 µg/L) and vanadium (0.63 µg/L) were each detected in the unfiltered groundwater sample collected from well 13MW15. Barium, calcium, iron, lead, magnesium, manganese, potassium, sodium, and zinc were detected in at least half of the Zone 4 groundwater samples. In general, concentrations of metals detected in Zone 4 groundwater samples collected during the Lower Subase RI were at the same order of magnitude but lower than concentrations detected in historical Zone 4 groundwater samples.

Lead was detected in Zone 4 groundwater samples collected during the Lower Subase RI at concentrations ranging from 1.3 µg/L to 14.4 µg/L (unfiltered) and from 1.4 µg/L to 6.8 µg/L (filtered). The distribution of lead in unfiltered and filtered groundwater samples is shown on Drawings 13 and 14, respectively. The contours for total lead concentrations in unfiltered groundwater samples (Drawing 13) indicate the presence of three areas of lead contamination in Zone 4. These areas are along the quay wall northwest of Building 85, at the

northeastern corner of Building 85, and along the western side of Building 79. Drawing 14, based on data from Zone 4 filtered groundwater samples collected during the Lower Subase RI, indicates the presence of only one area of lead contamination. This area is located along the western side of Building 79.

Groundwater samples collected from Zone 4 during the Lower Subase RI were not analyzed for VOCs. Eight SVOCs (2,4-dimethylphenol, carbazole, dibenzofuran, and five PAHs) were detected in Zone 4 groundwater samples collected during the Lower Subase RI. SVOC concentrations ranged from 0.6 µg/L to 4 µg/L. With the exceptions of pyrene and acenaphthene, which were detected at concentrations of 1 µg/L and 0.9 µg/L, respectively, in the groundwater sample collected from well 13MW15, all the SVOCs were detected only in the groundwater sample collected from well 13MW16.

TPH was not detected in any of the Zone 4 groundwater samples collected during the Lower Subase RI. Based on the sensitivity of the method used for analysis, the reporting limits for TPH were greater than the Connecticut remediation criterion of 500 µg/L. The presence of TPH below the reporting limits could not be confirmed since TPH at concentrations less than the reporting limits would not have been reported. Based on convention, one-half the reporting limit is shown on Drawing 12 for each sample in which TPH was not detected. The values provided on Drawing 12 for Zone 4 groundwater samples (500 µg/L to 550 µg/L) are equal to or slightly greater than the Connecticut remediation criterion of 500 µg/L.

7.4.3 Surface Water/Sediment

Surface water and sediment samples were collected from the Thames River adjacent to Zone 4. The nature and extent of contamination in Thames River surface water and sediment samples, as well as the impact of the activities and contamination at the Lower Subase (including Zone 4) on Thames River surface water and sediments, are discussed in Section 11.4.

As part of the basewide General NPDES Stormwater Monitoring Program, three annual storm sewer surface water samples were collected from the storm sewer located adjacent to Building 85 (Figure 7-1). Table 7-17 presents the positive analytical results for these samples. All three samples were analyzed for copper, lead, and zinc. Maximum concentrations of copper and zinc (260 µg/L and 450 µg/L, respectively) were detected in the storm water sample collected in 1996; copper and zinc were not detected in the most recent storm water sample (collected in 1997). The maximum concentration of lead (190 µg/L) was detected in the 1997 storm water sample. Iron and sodium, for which analysis was not performed in 1995 and 1996, were detected at concentrations of 1,270 µg/L and 121,000 µg/L, respectively, in the 1997 storm water sample. Each of the samples was analyzed for oil and grease; however, oil and grease (2,500 µg/L) was only detected in the storm water sample collected in 1995. All three samples were also analyzed for a number of miscellaneous parameters. The results of the miscellaneous parameters, as shown in Table 7-17, will be discussed in Section 11.7.

7.5 CONTAMINANT FATE AND TRANSPORT

7.5.1 General Contaminant Fate and Transport Processes

The major area of concern for Zone 4 is impacted soil, as evidenced by detection of VOCs and SVOCs (mainly PAHs). In addition, several metals (antimony, arsenic, cadmium, chromium, copper, lead, manganese, mercury, nickel, selenium, and zinc) were detected at elevated concentrations in the samples from Zone 4 when compared to the concentrations in the background samples.

VOCs are typically considered to be fairly soluble and have a low capacity for retention by soil organic carbon. Therefore, VOCs are the organic compounds most frequently detected in groundwater. These types of chemicals may migrate through the soil column after being released by a spill event or by subsurface waste disposal as infiltrating precipitation solubilizes them. Some portion of these compounds will be retained by the soil, but most will continue migrating downward until they reach the water table. At Zone 4, VOCs were detected in the deep soil and groundwater and not in the shallow soil. Consequently, it appears that migration of VOCs has occurred at Zone 4 to a limited extent.

PAHs are generally considered to be fairly immobile in the environment. As noted in Section 3.3.2.4, PAHs have very low solubilities, vapor pressures, and Henry's Law constants, and high K_{oc}s and K_{ow}s. The low-molecular weight PAHs (e.g., acenaphthene, anthracene, fluorene, phenanthrene) are more mobile (higher solubilities, etc.) than the high-molecular-weight PAHs (e.g., benzo(a)pyrene, benzo(a)anthracene, chrysene, etc.). PAHs in soil are much more likely to bind to soil and be transported via mass transport mechanisms than go into solution. PAHs can be degraded via aerobic bacteria, but may be relatively persistent in the absence of microbial population or macronutrients such as phosphorous and nitrogen.

Within Zone 4, TPH, as well as the PAHs, were found in both shallow and deep soils. The PAHs were detected at higher concentrations in the shallow soils than they were in the deep soils, indicating that the PAHs have not migrated significantly. Although PAHs were detected in groundwater samples at Zone 4, low concentrations and infrequent detections indicate that PAHs have not migrated significantly to the groundwater.

Some of the highest concentrations of TPH detected in Zone 4 were detected in the northwest corner, near Building 80. TPH was detected in both the shallow soil samples and deep soil samples in this area, indicating that migration of contamination may have occurred, even though the PAH data does not show

this same trend. An elevated detection of TPH in deep soil at sample location GS-9L may be the result of leakage from the fuel pipe line that passes through that area.

As noted in Section 3.3.2.9, metals are highly persistent environmental contaminants. They do not biodegrade, photolyze, hydrolyze, etc. The major fate mechanisms for metals are adsorption to the soil matrix (as compared to being part of the soil structure) and bioaccumulation.

In addition, under normal conditions, metals are not very mobile in the environment. Because metals frequently remain bound to particulate matter, the major transport mechanism for metals is bulk movement processes (erosion). However, metals can become mobile in the environment under certain conditions. The mobility of metals is influenced primarily by their physical or chemical properties in conjunction with the physical and chemical properties of the soil matrix. Factors that assist in predicting the mobility of metals are the soil/pore water pH, REDOX potential, and cation exchange capacity. The mobility of metals generally increases with decreasing soil pH and cation exchange capacity. The effect of REDOX potential varies for each metal.

Within Zone 4, metals were detected in shallow soil samples and deep soil samples at elevated levels. The presence of metals in the soil samples may be indicative of the fill material used to construct the Lower Subase. However, the presence of lead in deep soil samples and groundwater samples is more likely the result of handling of lead batteries used in submarines for underwater propulsion until the 1950's. Because of the low pH acid present in the batteries, the lead in the batteries would have been extremely mobile, and if the batteries had been spilled on the ground surface, the lead would have migrated much farther than under normal conditions.

Because the use of the lead acid batteries was discontinued in the 1950's, it is likely that the pH of the media in the area of Zone 4 has increased to its present level (groundwater pH between 6.51 and 7.2 and soil pH unknown). In soil with a pH of 6 to 8, lead may form insoluble organic lead complexes, or if the soil has less organic matter at the same pH, hydrous lead oxide complexes may form or lead may precipitate out with carbonate or phosphate ions. As long as the pH in the soil remains above 6, the lead present in the soil may continue to be relatively immobile and the lead concentration in the groundwater may decrease over time as it is flushed out.

Generally, lead was detected within Zone 4 at higher concentrations in the shallow soil than in the deep soil, indicating that lead has not migrated significantly. In addition, the detection of lead at elevated concentrations in the groundwater appears to be more indicative of suspended soil particles in the groundwater samples than of contaminant migration. The highest levels of lead were detected in

unfiltered historical groundwater samples. Filtered groundwater samples collected at the same time did not contain lead at elevated concentrations. In addition, samples collected during the Lower Subase RI did not contain lead at elevated concentrations in either the unfiltered or filtered samples.

Another factor that may be limiting the concentration of contaminants in the groundwater is the presence of paving over most of the site. The paving serves to limit the amount of infiltration passing through the soil. With limited infiltration, the amount of contaminants that can be leached out of the soil and transported to the groundwater is minimized.

7.5.2 Effects of Cross Contamination on Other Zones and the Thames River

TPH is an indicator of petroleum hydrocarbon contamination. PAHs are the primary components of waste oils, which were used at Building 79 (Site 13), and fuel oils No. 2 and No. 6, which are used throughout the Lower Subase and are distributed through the fuel lines that run through Zone 4. Therefore, based on historical practices at the site, observed TPH contamination is assumed to be mainly comprised of PAHs and other SVOCs. TPH concentrations in shallow and deep soil are shown in Drawings 8 and 9, respectively (Volume III). TPH concentrations are elevated in shallow soil across the western portion of Zone 4; the highest concentrations are in the vicinity of Building 80. TPH concentrations are highest in the northwestern section of Zone 4 near the quay wall along the border near Zone 3. It appears that the elevated TPH concentrations near the quay wall along the boundary near Zone 3 may be the result of cross contamination from Zone 4.

Generally, the same constituents were detected in soil, groundwater, and sediment samples of Zone 4. SVOCs (mainly PAHs) were detected in shallow soil samples, while VOCs and SVOCs (mainly PAHs) were detected in deep soil samples at Zone 4. SVOCs (mainly PAHs) were detected at low frequencies and low concentrations (i.e., less than 1 µg/L) in Zone 4 groundwater samples. Although it was detected during historical sampling events, TPH was not detected in groundwater at Zone 4 during the latest sampling round. VOCs and SVOCs (mainly PAHs) were also detected in Zone 4 sediment samples. Concentrations of VOCs and SVOCs in sediments were on the same order of magnitude as those concentrations in soil; the concentrations in sediment were slightly lower than those concentrations in soil. Concentrations of inorganics were higher in sediment samples than those concentrations in soil samples. Also, concentrations of VOCS and SVOCs in Zone 4 sediment samples are generally higher than those detected in sediment samples collected from locations upstream and downstream of the Lower Subase. This suggests that migration of contaminants to the Thames River may have occurred. In addition, based on site visits, it has been concluded that soil behind the quay wall at Zone 4 may be subject to erosion as

a result of tidal action. This tidal erosion of soil may have contributed to the migration of contamination in Zone 4 to sediment and surface water in the Thames River.

Several inorganics (i.e., antimony, arsenic, cadmium, calcium, chromium, copper, lead, manganese, magnesium, mercury, nickel, potassium, selenium, sodium, vanadium, and zinc) have been detected in shallow and/or deep soil samples at concentrations exceeding background levels. These inorganics were also detected in groundwater samples and in Thames River sediment samples. Reported concentrations exceeded background, indicating that migration of inorganics to the Thames River may have occurred.

As shown in Drawing 10, concentrations of lead in shallow soil are elevated (i.e., in excess of background) across Zone 4. Drawing 11 indicates that, in deep soil, lead concentrations are highest in the northwest corner of Zone 4 near the quay wall. It does not appear that lead has migrated to other zones at the Lower Subase, but it does appear that lead has migrated to Thames River sediments.

A storm sewer that discharges to the Thames River in Zone 4 has been sampled and analyzed as part of the NPDES permit. Oil and grease, copper, lead, and zinc were detected at elevated levels in storm sewer surface water samples. This indicates that the storm sewer system may be a source of contamination to the Thames River.

There may be other off-Base sources contributing to the observed contamination detected in Thames River sediments. The Thames River is tidally influenced and contaminants may be migrating in the river from upstream and downstream sources. Also, the contamination may be a result of spillage that may have occurred during historical refueling of submarines and tugboats at the Lower Subase.

7.5.3 Evaluation of Natural Attenuation Data

Soil and groundwater samples were collected in Zone 4 and analyzed in the field or by a fixed-base laboratory. The resulting data provide the information necessary to answer the three following questions:

- Are contaminants present in either medium that could be remediated via natural attenuation or bioremediation?
- Is natural attenuation currently in progress in the groundwater?
- Are the conditions in the groundwater favorable for natural attenuation or bioremediation?

For Zone 4, TPH concentrations in soil and groundwater were contoured and the results are presented on Drawings 8, 9, and 12. Drawings 8 (shallow soil) and 9 (deep soil) show that high levels of TPH (i.e.,

indicative of petroleum hydrocarbons) are present in the soil of Zone 4. The maximum TPH concentrations were detected in 13TB4A (3,440 mg/kg, shallow soil) and 13TB2A (11,800 mg/kg, deep soil). As discussed in Section 7.4, PAHs were also frequently detected in the shallow and deep soil of Zone 1, which confirms the TPH concentrations. BTEX compounds were also detected in the deep soil. TPH was not detected in the groundwater of Zone 4 above the detection limit. VOCs and SVOCs were detected infrequently in the groundwater. These results indicate that petroleum hydrocarbons are present mainly in the soil and that limited migration of hydrocarbons to the groundwater has occurred. As discussed previously, petroleum hydrocarbons in either media can be treated successfully via natural attenuation or bioremediation.

The procedure for evaluating natural attenuation data for groundwater was previously outlined in Section 3.3.4 and is followed in this section. Table 7-16 summarizes the parameters that were measured to determine if natural attenuation is occurring in the groundwater of Zone 4. Other information in the table includes parameter-specific concentration ranges and frequency of detections. Drawings showing the distribution of key parameters were also prepared to aid in the interpretation of the data. The drawings that were prepared include the following:

- Drawing 1 - High Tide Potentiometric Surface Map
- Drawing 3 - Low Tide Potentiometric Surface Map
- Drawing 15 - Dissolved Oxygen
- Drawing 16 - REDOX potential
- Drawing 17 - Divalent Iron
- Drawing 18 - Specific Conductivity

The following conclusions were reached after review and evaluation of the data presented in Table 7-16 and Drawings 1, 3, and 15 through 18.

- Dissolved oxygen levels varied in the groundwater of Zone 4 indicating that both aerobic and anaerobic regions are present. Concentrations of dissolved oxygen greater than 1 mg/L were detected in 13MW16, MW1-4RI, MW2-4RI, and QW-4 and concentrations less than 1 mg/L were detected in 13MW13, 13MW14, 13MW15, NESO11 and WE1. As discussed below the dissolved oxygen data did not correlate well with REDOX potential measurements and therefore the data is considered to be suspect.

- REDOX potential measurements generally did not correlate well with the measured dissolved oxygen concentrations. The wells with negative REDOX potential were 13MW13, 13MW16, NESO10, QW-4,

and WE1. The wells with positive REDOX potential were 13MW14, MW1-4RI, MW2-4RI, and NESO11. As discussed in Section 4, REDOX potential is easier to measure in the field and it is likely that the REDOX potential measurements are more representative of the actual Zone 4 groundwater conditions than are the dissolved oxygen concentrations. This statement is further collaborated by the information provided below.

- A range of nitrate concentrations (0.057 to 7.9 mg/L) was measured in Zone 4 groundwater. Concentrations of nitrate at or in excess of 1 mg/L were detected in MW1-4RI, MW2-4RI, and WE1. Low concentrations of nitrate were detected in the remaining Zone 4 monitoring wells. These results are not conclusive regarding denitrification, but it is likely that denitrification is occurring in certain regions of Zone 4.

- Concentrations of divalent iron close to or greater than 1 mg/L were detected in 13MW13, 13MW16, NESO10, QW-4, and WE1. These are the same wells that had negative REDOX potential levels. This information suggests that iron reduction is occurring in the central portion of Zone 4.

- Concentrations of sulfate below 20 mg/L were detected in 13MW13, NESO11, and WE1. High concentrations of sulfate (i.e., greater than 20 mg/L) were detected in remaining monitoring wells. A sulfate concentration of 25 mg/L was detected in MW1-6RI. These results indicate that sulfate reduction may be occurring in the central portion of Zone 4.

- Methane was detected in three out of ten monitoring wells (13MW13, 13MW15, and NESO10) at significant concentrations (i.e., greater than 1 mg/L). Methane was not detected in MW1-6RI. The detections indicate that methanogenesis is occurring in the central portion of Zone 4.

- Concentrations of alkalinity detected in the groundwater were normal compared to other zones; however, the maximum detection of hardness (4,000 mg/L) was higher than concentrations in other zones. All concentrations of alkalinity and hardness detected in Zone 4 groundwater were higher than the concentrations detected in MW1-6RI.

- Overall the temperature of the Zone 4 groundwater was comparable to other zones, with the exception being WE1. The temperature of the groundwater in this well was approximately 4°C to 7°C higher than the temperature in the other Zone 4 wells. The pH of the groundwater was consistent throughout Zone 4 and ranged from 6.51 to 7.20.

- Ammonia was detected in six of 10 wells. Ammonia is an intermediate product of denitrification and the detection of ammonia in these wells in conjunction with the low concentrations of nitrate detected in the Zone 4 wells suggests that denitrification is occurring.

- Phosphorous was detected in the groundwater and is available as a nutrient.

- As expected, salinity and chloride concentrations were high along the western side of Zone 4, adjacent to the Thames River. The groundwater sampled in 13MW15 had a salinity level (21.88 ppt) very similar to the Thames River (26 to 29 ppt). Monitoring wells 13MW14 (11.9 ppt), 13MW16 (11.59 ppt), and QW-4 (12.22 ppt) also had significant levels of salinity. This data indicates that this area of Zone 4 has a direct connection with the Thames River. This data is also confirmed by the information provided on Drawings 1 and 3, which show that under high tide conditions, the northwestern portion of Zone 4 is tidally influenced. The groundwater in all of the other Zone 4 wells had much lower salinity levels (0.26 ppt to 0.86 ppt), but the levels were in excess of the level detected in MW1-6RI (0.08 ppt).

The information provided above indicates that natural attenuation is probably occurring in the groundwater of the central portion of Zone 4 (i.e., near 13MW13 and WE1). The fact that TPH, VOCs, and SVOCs were either not detected or were detected very infrequently in the groundwater is most likely the result of a variety of factors (i.e., condition, type, and age of source, natural attenuation, mobility of contaminants, unique hydrogeologic conditions, and tidal flushing). Due to the variety of factors influencing Zone 4 and the limited contaminant plume, it is unlikely that bioremediation or other more active remedial technologies are practical or necessary for the groundwater of this zone. It is likely that a combination of monitored natural attenuation or a tiered groundwater monitoring program and source control would be a viable remedial strategy for this zone. If monitored natural attenuation is selected as part of the remedial strategy for Zone 4, additional investigations would need to be completed to provide the preliminary data required for the remedial alternative and to monitor the progress of the alternative. Monitoring of the non-tidally influenced areas of Zone 4 would provide the best indication that natural attenuation processes are working in the groundwater.

7.6 BASELINE HUMAN HEALTH RISK ASSESSMENT

This section contains the baseline risk assessment performed for soil and groundwater exposures at Zone 4 of the Lower Subase. Section 7.6.1 contains a discussion on the selection of Chemicals of Concern (COCs), Section 7.6.2 contains information on the potential receptors considered and the routes

by which they might be exposed, Section 7.6.3 contains the numerical results of the risk assessment, and Section 7.6.4 presents site-specific uncertainties associated with the risk assessment.

7.6.1 Data Evaluation

COCs were identified for Zone 4 of the Lower Subase using risk-based COC screening levels, as described in Section 3.4.3. All validated data collected during the Phase I and II RIs, the Lower Subase RI, and the additional investigations, except soil data collected from depths greater than 10 feet, were used to identify COCs. Table 7-18 presents a summary of COCs for Zone 4. Appendix I.8 contains the COC summary screening tables for the site.

A medium-specific discussion of COCs is presented in the following subsections. Within a given medium, discussions of direct exposure COCs (i.e., those chemicals detected at concentrations in excess of federal and state direct exposure criteria) and additional COCs are provided. Additional COCs are identified based on contaminant migration tendencies: migration from soil to groundwater and from groundwater to the Thames River. These additional COCs are not quantitatively addressed in the human health risk assessment (i.e., numerical risk estimates are not developed) because they are not considered to be significant contributors to the direct exposure pathways identified for potential human receptors.

7.6.1.1 Soil Chemicals of Concern

The following chemicals were identified as direct exposure COCs for soil based on a comparison of maximum detected concentrations to USEPA Region III COC screening levels for residential land use and Connecticut RSRs for direct exposure (residential and industrial land use):

- PAHs [benzo(a)anthracene, benzo(a)pyrene, benzo(b)fluoranthene, dibenzo(a,h)anthracene, and indeno(1,2,3-cd)pyrene].
- Inorganics (antimony, arsenic, beryllium, iron, and lead).
- TPH.

TPH was qualitatively identified as a COC for shallow soil and "all soils" (soil from depths of 0 to 10 feet) because maximum detected concentrations exceeded the Connecticut RSRs for residential and industrial direct exposure.

Maximum detections in soil were also compared to generic USEPA SSLs for migration from soil to groundwater and Connecticut RSRs for pollutant mobility in a GB classified area. Maximum

concentrations of the following chemicals exceeded the generic soil pollutant mobility criteria, indicating the potential for these chemicals to migrate to groundwater and potentially impact water quality:

- PAHs [benzo(a)anthracene, benzo(a)pyrene, benzo(b)fluoranthene, benzo(k)fluoranthene, carbazole, chrysene, dibenzo(a,h)anthracene, and indeno(1,2,3-cd)pyrene].
- Inorganics (antimony, arsenic, cadmium, chromium, lead, and nickel).
- TPH.

Under the Connecticut RSR (CTDEP, 1996), concerns regarding the mobility of inorganics in soil are addressed using TCLP and SPLP data. A comparison of site-specific TCLP and SPLP data and state RSRs for pollutant mobility is provided in Tables 7-9 and 7-10. Lead concentrations in the TCLP extracts from several shallow and subsurface soil samples exceeded the state GB pollutant mobility criteria. However, detected concentrations of lead in the SPLP extracts associated with recent sample collection efforts were less than the state criteria.

Although the use of generic mobility criteria (rather than site-specific criteria) results in a conservative identification of additional COCs for soil, the mobility of TPH and inorganics (including lead) is supported by the groundwater data available for the site. Of the chemicals previously identified as migration COCs for soil, several PAHs [benzo(a)anthracene, benzo(a)pyrene, benzo(b)fluoranthene, benzo(k)fluoranthene, carbazole, chrysene, and indeno(1,2,3-cd)pyrene], several inorganics (antimony, arsenic, cadmium, chromium, and nickel) and TPH were detected infrequently in groundwater samples collected from the site. Although they were frequently detected in the Zone 4 soil samples, the migration of PAHs may not be as significant as the qualitative comparison indicates since exceedances of the generic mobility criteria are limited to only a few samples at a few locations (i.e., in less than 28 percent of the samples at primarily two locations). In most cases, the COCs were only detected in historical groundwater samples. The results of the TCLP and confirmatory SPLP analyses indicate that inorganic constituents are not mobile. However, TCLP/SPLP analyses were not performed for all soil samples collected at the site; therefore, there is still some uncertainty regarding the mobility of inorganics. A discussion of COCs for groundwater is provided in the following subsection.

7.6.1.2 Groundwater Chemicals of Concern

COCs for groundwater were selected using unfiltered and filtered data. Although groundwater at the site is not currently used or expected to be used in the future as a drinking water supply because of saline conditions, a conservative list of direct exposure COCs was developed for this medium based on a comparison of maximum detected concentrations to USEPA Region III COC screening levels for tap

water, Federal and state MCLs, and Connecticut RSRs for the protection of groundwater. Chemicals retained as direct exposure COCs include

- VOCs (1,1-dichloroethene, methylene chloride, and vinyl chloride).
- PAHs [benzo(a)anthracene, benzo(a)pyrene, benzo(b)fluoranthene, benzo(k)fluoranthene, and indeno(1,2,3-cd)pyrene].
- Bis(2-ethylhexyl)phthalate.
- Inorganics (aluminum, antimony, arsenic, barium, beryllium, boron, cadmium, chromium, copper, iron, lead, manganese, nickel, sodium, thallium, and vanadium).
- TPH.

Aluminum, beryllium, cadmium, chromium, copper, lead, nickel, and vanadium were identified as direct exposure COCs for the unfiltered sample matrix only. Beryllium, cadmium, and chromium were not detected in filtered groundwater samples. Reported concentrations of aluminum, copper, lead, nickel, and vanadium in the filtered groundwater samples were less than the direct exposure criteria. Sodium was retained as a COC because the maximum detections for this chemical in unfiltered and filtered groundwater samples were in excess of the State Notification Level. However, elevated levels of sodium in groundwater are anticipated because of nearby saltwater intrusion from the Thames River.

Since Zone 4 borders the Thames River, maximum concentrations in groundwater were also compared to the Connecticut WQSs for aquatic life (chronic saltwater criteria) and for the protection of human health (water and organisms). These criteria were used to evaluate the potential for contaminant migration to the water body. The following chemicals were detected at maximum concentrations in excess of the state WQSs:

- VOCs (1,1-dichloroethene, methylene chloride, and vinyl chloride).
- PAHs [benzo(a)anthracene, benzo(a)pyrene, benzo(b)fluoranthene, benzo(g,h,i)perylene, benzo(k)fluoranthene, chrysene, indeno(1,2,3-cd)pryene, and phenanthrene].
- Bis(2-ethylhexyl)phthalate.
- Inorganics (antimony, arsenic, beryllium, cadmium, chromium, copper, lead, mercury, nickel, thallium, and zinc).

Beryllium, cadmium, chromium, mercury, and nickel were identified as additional COCs for the unfiltered sample matrix only. Beryllium, cadmium, chromium, and mercury were not detected in the filtered groundwater samples. Antimony was identified as an additional COC for the filtered sample matrix only.

Reported concentrations of antimony in the unfiltered groundwater samples were less than Connecticut WQSs.

The actual impact on the water quality in the Thames River is not expected to be as significant as the qualitative comparison implies since significant dilution and tidal mixing are anticipated, thereby reducing contaminant concentrations. For example, the maximum detected concentrations of some of the chemicals previously identified as migration COCs (1,1-dichloroethene, methylene chloride, vinyl chloride, bis(2-ethylhexyl)phthalate, antimony, cadmium, chromium, nickel, and thallium) are within one order of magnitude of the Connecticut WQSs. Appropriate alternative surface water protection criteria can be calculated by multiplying the lower of the human health or aquatic life criterion in the latest Connecticut WQSs by a site-specific dilution factor. Recently calculated site-specific dilution factors for the DRMO (Site 6) and Goss Cove Landfill (Site 8), other NSB-NLON IRP sites located along the Thames River, were 226 and 118, respectively. Consequently, these chemicals are not considered to be problematic since the maximum concentration of these chemicals would be less than the alternative SWPC. In addition most organic migration COCs were only detected in historical groundwater samples and at a low frequency of occurrence (i.e., less than eight percent of the samples). A separate evaluation of the water and sediment quality in the Thames River is provided in Section 11.0.

7.6.1.3 Exposure Point Concentrations

Exposure point concentrations were developed for direct exposure COCs only using the methodologies presented in Section 3.4.1. The average and maximum detected concentrations for soil and groundwater were typically used for the RME and CTE, respectively. The 95 percent UCL was not used for soil because of the limited amount of validated data available for a given data set or because the distribution of the data set could not be defined. Groundwater exposure concentrations were developed using USEPA Region I guidance (USEPA, 1994f). A summary of the exposure point concentrations used to estimate potential risks associated with direct exposure COCs for Zone 4 is provided in Table 7-19.

Because of a lack of published dose-response parameters, some essential human nutrients (calcium, magnesium, potassium, and sodium) detected in the site media were not identified as COCs or quantitatively evaluated in the risk assessment. TPH was identified as a direct exposure COC based on a qualitative analysis. However, exposure to this chemical could not be quantitatively evaluated because of the lack of dose-response parameters. In addition, although aluminum, copper, and iron may be identified as COCs, USEPA Region I does not advocate a quantitative evaluation of exposure to these metals because the only available toxicity criteria for these chemicals are provisional reference doses based on

daily allowable intakes rather than adverse effect levels. Exposure to these chemicals is addressed in the general uncertainty section of the baseline human health risk assessment, Section 3.4.5.

7.6.2 Exposure Assessment

This section presents a summary of the persons potentially exposed to soil and groundwater at Zone 4 of the Lower Subase and describes the routes by which they might be exposed. Details on the exposure parameters used in the quantitative risk assessment were provided in Section 3.4.3.

The most likely receptors at this site include any full-time adult employees or military personnel assigned to the various buildings. These persons could be exposed to shallow soil via direct contact (incidental ingestion or dermal contact). They are assumed to be exposed 150 days/year for 6 years for the CTE and for 25 years for the RME.

A construction worker scenario was also evaluated for the Lower Subase. A construction project is assumed to take between 80 (CTE) and 120 (RME) days in a 1-year period. These persons could come into contact "all soil" (soil from depths of 0 to 10 feet) via dermal contact and incidental ingestion. These receptors may also be dermally exposed to groundwater during ground-intrusive activities.

Since the site is located along the Thames River and waterfront property is typically regarded as an attractive location for residential development, future residents were evaluated as potential receptors. This exposure scenario is dependent upon Base closure, which is considered to be highly unlikely because of the critical nature of the facility with respect to support of the submarine fleet and national defense. Therefore, this scenario is primarily evaluated for informational purposes only (i.e., to aid in decision making, and risk management decisions). Future potential residents are not assumed to come in contact with groundwater at the site because saline conditions that exist near the Thames River would preclude domestic use of groundwater. Receptors are assumed to be exposed to "all soil" (soil from depths of 0 to 10 feet) via incidental ingestion and dermal contact. Soil exposures were assumed to occur 150 days/year for a total of 7 years under the CTE and 30 years for the RME.

There are no dermal absorption factors available for antimony and beryllium. As requested by EPA Region I, dermal exposures to these COCs will be evaluated using a generic absorption factor of 0.01 and the results will be discussed in the uncertainty analysis presented in Section 7.6.4.

The identified potential receptors could also be exposed to chemicals in soil via inhalation of fugitive dust and volatile emissions. This exposure pathway is evaluated in a qualitative fashion by a comparison of

maximum soil concentrations to generic USEPA SSLs for the inhalation pathway, as summarized in the site-specific COC summary screening tables in Appendix I.8. Maximum detections for all soil chemicals were below the inhalation SSLs, indicating that the inhalation pathway is not expected to be a significant exposure route. Consequently, this exposure route was eliminated from further quantitative risk evaluation.

7.6.3 Risk Characterization

A summary of the quantitative risk assessment for Zone 4 is provided in this section. Total noncarcinogenic and carcinogenic risks for each exposure route, as well as the cumulative risks for the RME and CTE scenarios, are outlined in Table 7-20 for the construction worker, full-time employee, and future resident. Sample calculations are provided in Appendix I.3. Appendix I.8 contains the chemical-specific risks for Zone 4.

7.6.3.1 Noncarcinogenic Risks

Cumulative Hazard Indices (HIs) for all receptors are less than unity, indicating that no averse effects are anticipated for these receptors under both RME and CTE scenarios.

7.6.3.2 Carcinogenic Risks

Cumulative incremental cancer risks for Zone 4 ranged from 5.0E-7 for the construction worker (CTE) to 1.1E-4 for the future resident (RME). The cumulative incremental cancer risk for the future resident under the RME scenario (1.1E-4) slightly exceeded the upper limit of the USEPA target risk range (1E-4 to 1E-6), as well as the CTDEP target cancer risk of 1E-5. Although the cumulative incremental cancer risk for the full-time employee (7.4E-5) under the RME scenario is within the USEPA target risk range, the cancer risk exceeds the CTDEP cumulative target risk level of 1E-5. Cumulative incremental cancer risks for all other receptor scenarios were either less than 1E-6 or less than 1E-5 and within the USEPA target risk range.

The exposure routes of concern for the full-time employee and future resident under the RME scenario is incidental ingestion and dermal contact with soil. As summarized in Table 7-21, PAHs and arsenic are the major contributors to the elevated cancer risks. For the RME future resident and full-time employee, the chemical-specific incremental cancer risks for benzo(a)pyrene and dibenzo(a,h)anthracene exceed 1E-5.

7.6.3.3 Exposure to Lead

Lead was identified as a potential COC for soil and groundwater at the Lower Subase. Maximum detections of the chemical in site media exceeded the associated screening criteria (i.e., the 400 mg/kg OSWER soil screening level for residential land use, the state RSR of 500 mg/kg for residential soil exposures and 1,000 mg/kg for industrial soil exposures; and the 15 µg/L Federal Drinking Water Action Level and Connecticut RSR for the protection of groundwater). Exposure by children to lead in soil at Zone 4 was addressed using the USEPA IEUBK Model, as discussed in Section 3.4.3. CTE and RME exposure concentrations for soil (presented in Table 7-19) were used, as well as several default parameters, to calculate estimated blood-lead levels for children in a residential setting. The estimated geometric mean blood-lead level for children exposed to lead in soil at Zone 4 was 15 µg/dL and 47 µg/dL for CTE and RME scenarios, respectively. The IEUBK model estimates that 76 percent (CTE) and 100 percent (RME) of children are expected to have blood-lead levels greater than 10 µg/dL. These values are greater than the established level of "concern," 10 µg/dL, and the acceptable level of 5 percent. This indicates that adverse effects are anticipated for small children exposed to shallow and subsurface soil at Zone 4.

As discussed in Section 3.4.3, exposures to lead by nonresidential adults were evaluated by the use of a slope-factor approach developed by the USEPA Technical Review Workgroup for Lead (USEPA, 1996f; USEPA, 1996g). The estimated 95th percentile fetal blood-lead level in women exposed to lead in site soil was 13 µg/dL (CTE) and 72 µg/dL (RME) for full-time employees and 100 µg/dL (RME) for construction workers. A CTE scenario was not evaluated for a construction worker since the exposure frequency of 80 days a year is less than the model minimum acceptable value of 90 days per year. The aforementioned calculated blood-lead levels are greater than the established level of "concern," 10 µg/dL, indicating that adverse effects are anticipated for fetuses of pregnant women workers exposed to lead in shallow soil at Zone 4. The estimated 95th percentile blood-lead level for women exposed to lead in site soil was 14 µg/dL (CTE) and 80 µg/dL (RME) for full-time employees and 111 µg/dL (RME) for construction workers. With the exception of the CTE value for full-time employees, these values are greater than the OSHA permissible blood-lead level of 40 µg/dL, indicating that adverse effects are anticipated for adults exposed to lead in shallow and subsurface soil at Zone 4.

The USEPA IEUBK Model was not used to assess exposure to lead in groundwater at Zone 4 since this medium is not expected to be used as a potable water supply because of saline conditions.

7.6.4 Uncertainties

A detailed discussion of uncertainties associated with the various aspects of risk assessment, in general, was provided in Section 3.4.5. Site-specific uncertainties for the Zone 4 risk evaluation are presented below.

Dermal exposure to antimony and beryllium in soil could not be quantitatively evaluated in the risk assessment since there are no dermal absorption factors available for these compounds. Therefore, as requested by EPA Region I, a screening analysis was performed for dermal exposures to antimony and beryllium in soil using a generic absorption factor for inorganics of 0.01. Cancer risks could not be calculated for antimony and beryllium since no oral cancer slope factors are available for these compounds. Hazard indices are as follows:

	Scenario	
Receptor	**RME**	**CTE**
Construction Worker	0.02	0.0008
Full-time Employee	0.003	0.0002
Future Resident	0.003	0.0002

All cumulative hazard indices for the RME and CTE scenarios are more than an order of magnitude less the acceptable level of 1.0. Consequently, no adverse health effects are anticipated as a result of dermal exposure to beryllium and manganese in soil under the conditions evaluated in the risk assessment.

Some inorganic chemicals detected in site soil samples may be attributable to naturally occurring background levels. Background levels for metals in soil at NSB-NLON, developed by Atlantic Environmental Services were presented in Table 1-4. All reported concentrations of aluminum, barium, beryllium, cobalt, and iron in the site soils were less than the established background levels.

The calculated risks for exposure to soil under current site conditions are to some degree overestimated. Most of the soil samples collected at the site were obtained from locations beneath pavement. All soil samples (currently exposed and beneath pavement) were used to conservatively evaluate potential risks for the site. Therefore, actual exposure under current site conditions is less than exposure that is assumed for this risk assessment.

7.7 SUMMARY AND RECOMMENDATIONS

This section presents a summary of major findings for Zone 4 of the Lower Subase. A summary of the nature and extent of contamination is provided in Section 7.7.1. Section 7.7.2 includes a summary of contaminant fate and transport information and Section 7.7.3 provides a synopsis of the baseline human health risk assessment for Zone 4. Section 7.7.4 provides recommendations regarding additional action and investigatory efforts for the soil and groundwater of Zone 4. A summary of the ecological risks for the Thames River adjacent to Zone 4 and the corresponding recommendations for the river are provided in Section 11.0.

7.7.1 Nature and Extent of Contamination

Two general areas of lead contamination in shallow soils were identified within Zone 4. These areas are in the northwestern corner of Zone 4 (west of Building 80) and in the north central portion of Zone 4 (east of Building 79). Concentrations of lead detected in the TCLP leachates of shallow soils collected from these two areas exceeded both the Federal toxicity characteristic regulatory level and the Connecticut remediation standard pollutant mobility criterion for lead. Lead contamination in deep soil samples within Zone 4 is less pervasive than lead contamination in Zone 4 shallow soils. Lead contamination is evident in Zone 4 deep soils in the northwestern corner of Zone 4 and north of Building 85. The maximum concentration of lead detected in Zone 4 deep soils is roughly five times less than the maximum concentration of lead detected in Zone 4 shallow soils. The source(s) of lead contamination in Zone 4 may be the former waste oil pit at Building 79, Building 31 (the site of a lead removal action that was conducted in Zone 3), or historical waste disposal practices.

Little VOC contamination is evident in Zone 4 soils. An area of PAH contamination in the shallow soils south of Building 85 near the southern end of the quay wall is evident based on the results of the shallow soil sample collected from well MW1-4RI. However, concentrations of PAHs detected in the deep soil sample collected from well MW1-4RI are from 50 to 100 times less than respective PAH concentrations detected in the shallow soil sample from this well.

TPH contamination is evident in the shallow soils at the western edge of Zone 4 along the Thames River, with the greatest concentrations of TPH present in the shallow soils west of Building 80. TPH contamination in Zone 4 deep soils is more widespread, with high levels of TPH contamination in Zone 4 deep soils along Albacore Road and Bluefish Road. Sources of TPH contamination are likely to be fuel pipeline leaks and the pit at Building 79.

Three small areas of lead contamination were noted in the groundwater system beneath Zone 4, based on groundwater data collected during the Lower Subase RI. These areas are along the quay wall northwest of Building 85, at the northeastern corner of Building 85, and along the western side of Building 79. Very little VOC or SVOC contamination was noted in the groundwater samples collected from Zone 4. TPH was detected in historic groundwater samples collected from well 13MW16 (at concentrations decreasing from 5,400 µg/L to 700 µg/L over time) and in the groundwater sample collected from well WE1 at a concentration of 500 µg/L during Round 2 of the Phase II RI. A time-critical removal action was completed by the Navy in this zone in 1994. It was estimated that 800-gallons of petroleum product were removed from zone 4 during the action. TPH was not detected in any of the groundwater samples collected during the Lower Subase RI.

7.7.2 Contaminant Fate and Transport

High concentrations of petroleum hydrocarbons and SVOCs, as well as inorganic concentrations in excess of background, have been detected in the soil of Zone 4. Analytical results from the groundwater sampling activities indicate that the petroleum hydrocarbons and inorganics (mainly lead) in the soil may be migrating to the groundwater and to downgradient locations. The analytical results for the storm sewer near Building 85 also indicate that lead is migrating via the storm sewer from Zone 4. Lead data from Zones 3 and 4 suggest that historical waste disposal practices at Building 31 in Zone 3 have contaminated the soil in both zones and that cross-contamination is probably not occurring. It is possible that Zone 4 may be contributing petroleum contamination to the southern end of Zone 3. The Thames River, which is downgradient of Zone 4, showed some potential evidence of cross-contamination with some detections of inorganics and PAHs. An evaluation of natural attenuation indicated that this process is feasible for the soil because of the presence of biodegradable contaminants (i.e., petroleum hydrocarbons and SVOCs). Key parameters indicate that natural attenuation is occurring in a limited portion of the groundwater of Zone 4; however, petroleum-related compounds were generally not detected in the groundwater. Therefore, a tiered groundwater monitoring program versus monitored natural attenuation may be an option that could be evaluated further as part of the remedial strategy for Zone 4.

7.7.3 Baseline Human Health Risk Assessment

The baseline human health risk assessment for Zone 4 focused on three potential receptor groups: construction workers, full-time employees, and future residents. Noncarcinogenic risks for all receptor groups were less than the USEPA and CTDEP acceptable limit of one. Carcinogenic risks for all receptors were either less than or within the USEPA's acceptable target risk range of 1E-4 to 1E-6 except for the future resident under the RME scenario. The cancer risk for the full-time employee and future resident under the RME scenario exceeded the CTDEP acceptable cumulative cancer risk level of 1E-5.

PAHs and arsenic (via incidental ingestion and dermal contact with soil) are the main contributors to the cancer risk for these receptors.

Lead was identified as a COC for soil and groundwater at Zone 4. Evaluation of lead using the IEUBK model for children and the interim slope-factor approach for full-time employees indicates that adverse health effects are anticipated for these receptors from exposure to lead in Zone 4 soil.

The calculated risks for Zone 4 under current site conditions (full-time employees) are to some degree overestimated. Most of the soil samples collected from the site and used in the risk assessment were collected from locations beneath pavement. Currently, these soils are not exposed and available for human contact.

Maximum detected concentrations of PAHs, metals, and TPH in soil exceeded their respective generic mobility criteria which indicates the potential exists for these chemicals to migrate from soil to groundwater. Although the maximum detected concentrations of PAHs exceeded the generic mobility criteria, these chemicals were detected infrequently in groundwater samples (i.e., in less than 8 percent of the samples) collected at Zone 4. The mobility of lead may be supported by the groundwater data and TCLP soil data.

Maximum chemical concentrations in groundwater were compared to Connecticut salt water WQSs since Zone 4 borders the Thames River. Several migration COCs in groundwater were identified as exceeding the Connecticut salt water WQSs. Use of the Connecticut salt water WQSs to determine groundwater impacts on the Thames River is very conservative since the WQSs do not account for the dilutional effects of the groundwater mixing with the river. Appropriate alternative surface water protection criteria can be calculated by multiplying the lower of the human health or aquatic life criterion in the latest Connecticut WQSs by a site-specific dilution factor. Recently calculated site-specific dilution factors for the DRMO (Site 6) and Goss cove Landfill (Site 8), other NSB-NLON IRP sites located along the Thames River, were 226 and 118, respectively. The maximum detected concentrations of most migration COCs [1,1-dichloroethene, methylene chloride, vinyl chloride, bis(2-ethylhexyl)phthalate, antimony, cadmium, chromium, nickel, and thallium] are within one order of magnitude of the Connecticut WQSs. Therefore, the actual impact on water quality in the Thames River is expected to be minimal because significant dilution is anticipated, thereby reducing chemical concentrations in the Thames River.

7.7.4 Recommendations

It is recommended that this zone, which includes Site 13 - Building 79 Waste Oil Pit, Site 19 - Solvent Storage Area (Building 316), the Quay Wall Study Area, and the fuel distribution pipeline, proceed to a feasibility study to evaluate appropriate remedial alternatives. Because of the extensive amount of underground utilities in Zone 4 and the nature of the activities conducted at this location (i.e., national security), the feasibility study for this zone should evaluate to the extent possible alternatives that include institutional controls to limit exposure to contaminated soil and passive and/or in-situ remedial alternatives. In addition, "hot spot" removal actions, in lieu of full-scale excavation, should be considered in the Zone 4 feasibility study. A tiered groundwater monitoring program and cleaning and repair of the Zone 4 storm sewer system should also be evaluated during the feasibility study. These recommendations are based on the following information:

- The nature and extent of organic and inorganic contamination in the soil and groundwater are well defined to the extent practical considering infrastructure limitations.

- The baseline human health risk assessment indicates that there are carcinogenic risks associated with Zone 4 that exceed the USEPA acceptable risk range (i.e., the hypothetical future resident RME scenario) and CTDEP target risk level (i.e., the full-time employee and hypothetical future resident RME scenarios). In addition, modeling performed to evaluate exposures to lead showed that sensitive receptors for lead exposure (i.e., small children and fetuses of pregnant working women) are at risk in Zone 4. All the elevated risks (for lead and other chemicals) were calculated for a future exposure scenario where soils currently covered by pavement or buildings are available for human contact. Institutional controls and/or "hot spot" removal actions could be used to eliminate this exposure route.

- Evidence suggests that limited organic and inorganic contamination is migrating from the site. Natural attenuation seems to be occurring in the groundwater of Zone 4 and is most likely reducing the concentration and magnitude of petroleum hydrocarbons migrating from the site. Groundwater monitoring will confirm natural attenuation and potential inorganic migration.

- Natural attenuation or bioremediation could be feasible alternatives for the petroleum contamination in the soil.

- A tiered groundwater monitoring program will allow for further actions to be completed if the results show significant impacts.

- The ecological risk assessment for the Thames River adjacent to Zone 4 (see Section 11.0) shows that the risks to ecological receptors in this area are relatively low.

- The Thames River provides significant dilution and mixing which minimizes the impact of contaminant migration from Zone 4.

- The Navy removed the waste oil pit at Building 79 and filled the area in with concrete. A recovery well system was installed and operated for a short time in this area. In addition, approximately 800 gallons of petroleum product was removed via pumping from the quay wall area during a removal action in 1994.

- The Navy currently conducts regular pressure testing and repairs on the fuel distribution lines; therefore, the historical source of petroleum contamination has most likely been eliminated.

- The zone is covered with pavement or buildings, which minimizes the potential for direct exposure to the contaminated soil by human receptors.

- The groundwater at Zone 4 is not currently or anticipated to be used in the future as a potable water source because it is brackish; therefore, there is no imminent threat to human health.

- The storm sewer system in Zone 4 may be acting as a migration pathway for contaminants present in the groundwater. Analytical results from one catch basin sampled as part of the NPDES permit indicate that lead has been detected at low concentrations in the surface water discharged from Zone 4 and lead was identified as a groundwater COC for Zone 4. A limited evaluation of the invert elevations of the storm sewer system indicate that portions of the system are submerged by varying amounts during a given day or time of year. Because of the age of parts of the system (i.e., greater than 40 years) and the material that it was constructed with (i.e., vitrified clay), it is likely that the system is cracked and groundwater will infiltrate into the storm sewers.

TABLE 7-1

SUMMARY OF SAMPLING AND ANALYTICAL PROGRAM - ZONE 4
FINAL SITE INVESTIGATION SUBSURFACE OIL CONTAMINATION
LOWER SUBASE
NSB-NLON, GROTON, CONNECTICUT

Sample ID	Sample Depth (feet below ground)	Analysis								
		Target Compound List (TCL)			TAL Metals		RCRA Metals[1]	Lead	TPH	Fluorescence
		Volatiles	Semivolatiles	Pesticides/PCBs	Total	Dissolved				
SOIL										
NSB-WE1-13-15	13-15									●
NSB-WE1-5-7	5-7									●
NSB-WE3-7-9	7-9									●
NSB-WE3-9-11	9-11									●
NSB-WE4-11-13	11-13									●
NSB-WE4-7-9	7-9									●
NSB-WE5-11-13	11-13									●
NSB-WE5-7-9	7-9									●
GROUNDWATER										
NSB-WS-WE4-001	NA									●
NSB-WS-WE1-002	NA									●
NSB-WS-WE5-004	NA									●
NSB-WE3-006	NA									●
NSB-WS-WE3-007	NA									●
NSB-WS-MW10-008	NA									●

1 Toxicity Characteristic Leaching Procedure (TCLP) extraction followed by analysis for RCRA metals.
NA = Not applicable.
● = Sample was analyzed for this parameter.
Blank cell indicates that this analysis was not performed for this sample.

TABLE 7-2

SUMMARY OF SAMPLING AND ANALYTICAL PROGRAM - ZONE 4
PHASE I REMEDIAL INVESTIGATION
LOWER SUBASE
NSB-NLON, GROTON, CONNECTICUT

Sample ID	Sample Depth (feet below ground)	Analysis								
		Target Compound List (TCL)			TAL Metals[1] + Cyanide		RCRA Metals[2]	Lead	TPH	Misc
		Volatiles	Semivolatiles	Pesticides/PCBs	Total	Dissolved				
SOIL										
13MW13(8-10)	8-10	●			●		●		●	
13MW23(8-10)[3]	8-10	●			●		●		●	
13MW14(12-14)	12-14	●			●		●		●	
13MW24(12-14)[4]	12-14	●			●		●		●	
13MW15(12-14)	12-14	●			●		●		●	
13MW16(10-12)	10-12	●			●		●		●	
GROUNDWATER										
011591-13MW14S	NA	●			●				●	
012191-13MW13S	NA	●			●				●	
012191-NESO11	NA	●			●				●	
012191-NESOMW10S	NA	●			●				●	
012291-13MW15S	NA	●			●				●	
012291-13MW19S[5]	NA	●			●				●	
012291-WEMW1S	NA	●			●				●	
012291-WEMW4S	NA	●			●				●	
012391-13MW16S	NA	●			●				●	
012391-WEMW5S	NA	●			●				●	

1 Analysis for boron was also performed.
2 Toxicity Characteristic Leaching Procedure (TCLP) extraction followed by analysis for RCRA metals.
3 13MW23(8-10) is a field duplicate of 13MW13(8-10).
4 13MW24(12-14) is a field duplicate of 13MW14(12-14).
5 012291-13MW19S is a field duplicate of 012291-13MW15S.
NA = Not applicable.
● = Sample was analyzed for this parameter.
Blank cell indicates that this analysis was not performed for this sample.

TABLE 7-3

SUMMARY OF SAMPLING AND ANALYTICAL PROGRAM - ZONE 4
QUAY WALL REMOVAL SITE EVALUATION
LOWER SUBASE
NSB-NLON, GROTON, CONNECTICUT

Sample ID	Sample Depth (feet below ground)	Analysis								
		Target Compound List (TCL)			TAL Metals[1]		RCRA Metals[2]	Lead	TPH	Misc
		Volatiles	Semivolatiles	Pesticides/PCBs	Total	Dissolved				
SOIL										
QW-1	5-6	●	●	●	●		●		●	
QW-2	5-6	●[3]							●	
QW-3	5-6	●[3]							●	
QW-4	7-7.3	●[3]							●	
QW-5	6-7	●[3]							●	

1 Analysis for boron was also performed.
2 Toxicity Characteristic Leaching Procedure (TCLP) extraction followed by analysis for RCRA metals.
3 Benzene, toluene, ethyl benzene, and xylenes (BTEX) only.
● = Sample was analyzed for this parameter.
Blank cell indicates that this analysis was not performed for this sample.

TABLE 7-4
SUMMARY OF SAMPLING AND ANALYTICAL PROGRAM - ZONE 4
TANK FARM INVESTIGATION
LOWER SUBASE
NSB-NLON, GROTON, CONNECTICUT

Sample ID	Sample Depth (feet below ground)	Analysis								
		Target Compound List (TCL)			TAL Metals		RCRA Metals[1]	Lead	TPH	Misc
		Volatiles	Semivolatiles	Pesticides/PCBs	Total	Dissolved				
SOIL										
FPTB10L-03	3-3								●	
FPTB11L-07	7-7								●	
FPTB06L-07	7-8								●	
FPTB07L-08	8-8								●	
FPTB08L-07	7-7								●	
FPTB09L-08	8-8								●	
DUP-16-111695[2]	8-8								●	

1 Toxicity Characteristic Leaching Procedure (TCLP) extraction followed by analysis for RCRA metals.
2 DUP-16-111695 is a field duplicate of FPTB09L-08.
● = Sample was analyzed for this parameter.
Blank cell indicates that this analysis was not performed for this sample.

TABLE 7-5

SUMMARY OF SAMPLING AND ANALYTICAL PROGRAM - ZONE 4
PHASE II REMEDIAL INVESTIGATION
LOWER SUBASE
NSB-NLON, GROTON, CONNECTICUT
PAGE 1 OF 2

Sample ID	Sample Depth (feet below ground)	Analysis								
		Target Compound List (TCL)			TAL Metals[1]		RCRA Metals[2]	Lead	TPH	Misc[3]
		Volatiles	Semivolatiles	Pesticides/PCBs	Total	Dissolved				
SOIL										
13TB2A-0406	4-6						●	●	●	
13TB2A-0406-X	4-6							O		
13TB2A-0608	6-8								●	
13TB3A-0608	6-8						●[4]			
13TB3A-0608-X	6-8							O		
13TB3A-2.5-4.5	2.5-4.5						●[4]	●	●	
13TB3A-2.5-4.5D[5]	2.5-4.5						●	●	●	
13TB4A-0002	0-2						●	●	●	
13TB4A-0002-X	0-2							O		
13TB6-0507	5-7						●	●	●	
13WE4A-0002	0-2						●	●	●	
GROUNDWATER - ROUND 1										
13GW13	NA	●	●		●	●			●	●
13GW15	NA	●	●		●	●			●	●
13GW14	NA	●	●		●	●			●	●
13GW16	NA	●	●		●	●			●	●
NESO10	NA	●	●		●	●			●	●
NESO11	NA	●	●		●	●			●	●
WE-1	NA	●	●		●	●			●	●
WE-5	NA	●	●		●	●			●	●
GROUNDWATER - ROUND 2										
13GW13-2	NA	●	●		●	●			●	●
13GW14-2	NA	●	●		●	●			●	●
13GW15-2	NA	●	●		●	●			●	●
13GW16-2	NA	●	●		●	●			●	●

TABLE 7-5

SUMMARY OF SAMPLING AND ANALYTICAL PROGRAM - ZONE 4
PHASE II REMEDIAL INVESTIGATION
LOWER SUBASE
NSB-NLON, GROTON, CONNECTICUT
PAGE 2 OF 2

Sample ID	Sample Depth (feet below ground)	Analysis								
		Target Compound List (TCL)			TAL Metals[1]		RCRA Metals[2]	Lead	TPH	Misc[3]
		Volatiles	Semivolatiles	Pesticides/PCBs	Total	Dissolved				
NES010-2	NA	●	●		●	●			●	●
NES011-2	NA	●	●		●	●			●	●
WE1-2	NA	●	●		●	●			●	●
WE5-2	NA	●	●		●	●			●	●

1 Analysis for boron was also performed.
2 Toxicity Characteristic Leaching Procedure (TCLP) extraction followed by analysis for RCRA metals.
3 Miscellaneous parameter for these samples includes: Hardness (as $CaCO^3$).
4 Analysis for TCLP organics (volatiles, semivolatiles, pesticides, herbicides) was also performed on the TCLP leachate of this sample.
5 13TB3A-2.5-4.5D is a field duplicate of 13TB3A-2.5-4.5.
NA = Not applicable.
● = Sample was analyzed for this parameter.
O = Sample was analyzed for this parameter using field screening x-ray fluorescence.
Blank cell indicates that this analysis was not performed for this sample.

TABLE 7-6

SUMMARY OF SAMPLING AND ANALYTICAL PROGRAM - ZONE 4
ANNUAL NPDES STORMWATER MONITORING PROGRAM
LOWER SUBASE
NSB-NLON, GROTON, CONNECTICUT

Sample ID	Date of Collection	Analysis						
		Target Compound List (TCL)		TAL Metals		TPH [1]	Fluorescence	Misc
		Volatiles	Semivolatiles	Total	Dissolved			
SURFACE WATER								
BLDG 85	02/28/95			● [2]		●	●	● [4]
BLDG 85	10/08/96			● [2]		●	●	● [4]
BLDG 85	06/19/97			● [3]		●	●	● [5]

1 Oil and grease analysis was performed.
2 Analysis for copper, lead, and zinc only.
3 Analysis for copper, iron, lead, mercury, nickel, silver, sodium, and zinc only.
4 Miscellaneous parameters for this sample include: COD, Fecal Coliform, Nitrate (as Nitrogen), pH, TKN, Total Phosphorous, and TSS.
5 Miscellaneous parameters for this sample include: Reactive Cyanide, Ammonia (as Nitrogen), COD, Chloride, Fecal Coliform, MBAS (Surfactants), Nitrate (as Nitrogen), pH, Sulfate, TDS, TKN, Total Phosphorous, and TSS.
● = Sample was analyzed for this parameter.
Blank cell indicates that this analysis was not performed for this sample.

TABLE 7-7

SUMMARY OF SAMPLING AND ANALYTICAL PROGRAM - ZONE 4
LOWER SUBASE REMEDIAL INVESTIGATION
LOWER SUBASE
NSB-NLON, GROTON, CONNECTICUT

Sample ID	Sample Depth (feet below ground)	Analysis							
		Target Compound List (TCL)			TAL Metals		SPLP Lead [1]	TPH	Misc[2]
		Volatiles	Semivolatiles	Pesticides/PCBs	Total	Dissolved			
SOIL									
LS4SB0010101	0.5-2		●		●		●	●	
LS4SB0010301	5-6		●		●		●		
LS4SB0050101	1-3		●		●		●	●	
LS4SB0050301	5-7		●		●		●		
LS4SB0020101	2-4		●						
LS4SB0020201	6.5-7		●						
LS4SB0030101	2-4		●		●		●	●	
LS4SB0030201	7-8		●		●		●		
LS4SB0040101	2-4		●						
LS4SB0040201	6-7		●						
GROUNDWATER									
LS4GW00101	NA		●		●	●		●	●
LS4GW00201	NA		●		●	●		●	●
LS4GW13MW1301	NA		●		●	●		●	●
LS4GW13MW1401	NA		●		●	●		●	●
LS4GW13MW1501	NA		●		●	●		●	●
LS4GW13MW1601	NA		●		●	●		●	●
LS4GWNES01001	NA		●		●	●		●	●
LS4GWNES01101	NA		●		●	●		●	●
LS4GWQW401	NA		●		●	●		●	●
LS4GWWE101	NA		●		●	●		●	●

1 Synthetic Precipitation Leaching Procedure (SPLP) extraction followed by analysis for lead.

2 Miscellaneous parameters include: Alkalinity (as $CaCO_3$), Ammonia (as Nitrogen), Chloride, Dissolved Oxygen, Divalent Iron, Hardness (as $CaCO_3$), Nitrate as Nitrogen, pH, Phosphorous, Redox Potential, Salinity, Specific Conductivity, Sulfate, Temperature, Total Organic Carbon, Turbidity, and Dissolved Methane.

NA = Not applicable.

● = Sample was analyzed for this parameter.

Blank cell indicates that this analysis was not performed for this sample.

TABLE 7-8 (PAGE 1 OF 15)
SUMMARY OF POSITIVE SOIL ANALYTICAL RESULTS FOR ZONE 4
LOWER SUBASE; NSB-NLON; GROTON, CONNECTICUT

SAMPLE NUMBER:	13MW13(8-10)	13MW23(8-10)	13MW14(12-14)	13MW24(12-14)	13MW15(12-14)	13MW16(10-12)
DEPTH (feet):	8 - 10'	8 - 10'	12 - 14'	12 - 14'	12 - 14'	10 - 12'
INVESTIGATION:	PH1	PH1	PH1	PH1	PH1	PH1
SAMPLE DATE:	11/13/90	11/13/90	11/13/90	11/13/90	11/12/90	11/12/90
LOCATION:	13MW13	13MW13	13MW14	13MW14	13MW15	13MW16
VALIDATED:					VALIDATED	VALIDATED
SAMPLE TYPE:	GRAB	GRAB	GRAB	GRAB	GRAB	GRAB
STATUS:						
FIELD DUPLICATE OF:		111390-13MW13(8-10)		111390-13MW14(12-14		
VOLATILES (µg/kg)						
BENZENE	6 U	6 U	6 U	6 U	6 U	8 U
CARBON DISULFIDE	6 U	6 U	6 U	6 U	6 U	5 J
ETHYLBENZENE	6 U	6 U	6 U	6 U	6 U	6 J
METHYLENE CHLORIDE	12	10	1 J	1 J	2 J	3 J
TETRACHLOROETHENE	6	8 J	4 J	6 UJ	3 J	5 J
TOLUENE	6 U	6 U	6 U	6 U	6 U	8 U
TRICHLOROETHENE	5 J	5 J	4 J	2 J	2 J	4 J
XYLENES, TOTAL	6 U	6 U	6 U	6 U	6 U	20 J
METALS (mg/kg)						
ALUMINUM	6510	4850	6280	6460	5510	10600
ANTIMONY	2.3 UJ	2.3 UJ	2.4 UJ	2.4 UJ	2.4 UJ	3.4 UJ
ARSENIC	1.9	2.2	0.71 U	0.72 U	0.77	4
BARIUM	48.3 J	27.9 J	26.4	23.2	42.7	30.7
BERYLLIUM	0.23 U	0.23 U	0.24 U	0.24 U	0.24 U	0.34 J
CADMIUM	1 J	0.79 J	1.5 J	1 J	1.7 J	2.5 J
CALCIUM	867 J	738 J	783 J	851 J	603 J	2710
CHROMIUM	17.5 J	7.8 J	20.3	21.1	13.5	27.8
COBALT	4.1 J	3.5 J	4 J	4.2 J	4.1 J	6.7 J
COPPER	14	9.7 J	32.5	23.9	12.7	15.1
IRON	8560	5880 J	9940	9830	9140	16900
LEAD	50.2 J	25.2 J	68.7	76.2	34.4	41.3

TABLE 7-8 (PAGE 2 OF 15)
SUMMARY OF POSITIVE SOIL ANALYTICAL RESULTS FOR ZONE 4
LOWER SUBASE; NSB-NLON; GROTON, CONNECTICUT

SAMPLE NUMBER:	13MW13(8-10)	13MW23(8-10)	13MW14(12-14)	13MW24(12-14)	13MW15(12-14)	13MW16(10-12)
DEPTH (feet):	8 - 10'	8 - 10'	12 - 14'	12 - 14'	12 - 14'	10 - 12'
INVESTIGATION:	PH1	PH1	PH1	PH1	PH1	PH1
SAMPLE DATE:	11/13/90	11/13/90	11/13/90	11/13/90	11/12/90	11/12/90
LOCATION:	13MW13	13MW13	13MW14	13MW14	13MW15	13MW16
VALIDATED:					VALIDATED	VALIDATED
SAMPLE TYPE:	GRAB	GRAB	GRAB	GRAB	GRAB	GRAB
STATUS:						
FIELD DUPLICATE OF:		111390-13MW13(8-10)		111390-13MW14(12-14		
METALS (mg/kg)						
MAGNESIUM	2660	1870 J	3670	3590 J	3100	5510
MANGANESE	155 J	100 J	147 J	144 J	139 J	191 J
MERCURY	0.12 UJ	0.1 UJ	0.11 UJ	0.11 UJ	0.11 UJ	0.16 UJ
NICKEL	9.5	5.8	9.9	11.5	7.9	16.3
POTASSIUM	1890	1280	1850	1860	2660	2780
SELENIUM	0.23 U	0.23 U	0.24 U	0.24 U	0.28 J	1 J
SODIUM	124	126	306	345	1360	5890
VANADIUM	16.1	10.6	16.7	15.1	15.9	35.9
ZINC	62.4 J	28.1 J	38.7 J	38 J	48.9 J	43.1 J
TOTAL PETROLEUM HYDROCARBONS (mg/kg)						
TPH	310	440	110	80	170	960

TABLE 7-8 (PAGE 3 OF 15)

SUMMARY OF POSITIVE SOIL ANALYTICAL RESULTS FOR ZONE 4
LOWER SUBASE; NSB-NLON; GROTON, CONNECTICUT

SAMPLE NUMBER:	13TB2A-0406	13TB2A-0406-X	13TB2A-0608	13TB3A-0608-X	13TB3A-2.5-4.5	13TB3A-2.5-4.5D
DEPTH (feet):	4 - 6'	4 - 6'	6 - 8'	6 - 8'	2.5 - 4.5'	2.5 - 4.5'
INVESTIGATION:	PH2-1	PH2-1	PH2-1	PH2-1	PH2-1	PH2-1
SAMPLE DATE:	01/22/94	01/22/94	01/22/94	02/01/94	01/22/94	01/22/94
LOCATION:	13TB2A	13TB2A	13TB2A	13TB3A	13TB3A	13TB3A
VALIDATED:	VALIDATED	VALIDATED	VALIDATED	VALIDATED		
SAMPLE TYPE:	GRAB	GRAB	GRAB	GRAB	GRAB	GRAB
STATUS:						
FIELD DUPLICATE OF:						13TB3A-2.5-4.5
METALS (mg/kg)						
LEAD	1880 J	2080 J		1990 J	8240 J	4770 J
TOTAL PETROLEUM HYDROCARBONS (mg/kg)						
TPH	383		11800		321 J	69.2 J

TABLE 7-8 (PAGE 4 OF 15)

SUMMARY OF POSITIVE SOIL ANALYTICAL RESULTS FOR ZONE 4 LOWER SUBASE; NSB-NLON; GROTON, CONNECTICUT

SAMPLE NUMBER:	13TB4A-0002	13TB4A-0002-X	13TB6-0507	FPTB10L-03	FPTB11L-07	FPTB06L-07
DEPTH (feet):	0 - 2'	0 - 2'	5 - 7'	3 - 3'	7 - 7'	7 - 8'
INVESTIGATION:	PH2-1	PH2-1	PH2-1	TFI96	TFI96	TFI96
SAMPLE DATE:	01/22/94	01/22/94	01/23/94	11/16/95	11/16/95	11/18/95
LOCATION:	13TB4A	13TB4A	13TB6	GS-10L	GS-11L	GS-6L
VALIDATED:	VALIDATED	VALIDATED	VALIDATED	VALIDATED	VALIDATED	VALIDATED
SAMPLE TYPE:	GRAB	GRAB	GRAB	GRAB	GRAB	GRAB
STATUS:						
FIELD DUPLICATE OF:						
METALS (mg/kg)						
LEAD	280 J	1810 J	98.9 J			
TOTAL PETROLEUM HYDROCARBONS (mg/kg)						
TPH	3440		970	31.8	15.3	41.3

TABLE 7-8 (PAGE 5 OF 15)
SUMMARY OF POSITIVE SOIL ANALYTICAL RESULTS FOR ZONE 4
LOWER SUBASE; NSB-NLON; GROTON, CONNECTICUT

SAMPLE NUMBER:	FPTB07L-08	FPTB08L-07	FPTB09L-08	DUP-16-111695	LS4SB0010101	LS4SB0010301
DEPTH (feet):	8 - 8'	7 - 7'	8 - 8'	8 - 8'	0.5 - 2'	5 - 6'
INVESTIGATION:	TFI96	TFI96	TFI96	TFI96	1997RI	1997RI
SAMPLE DATE:	11/18/95	11/16/95	11/16/95	11/16/95	09/26/97	09/26/97
LOCATION:	GS-7L	GS-8L	GS-9L	GS-9L	MW1-4RI	MW1-4RI
VALIDATED:	VALIDATED	VALIDATED	VALIDATED	VALIDATED	VALIDATED	VALIDATED
SAMPLE TYPE:	GRAB	GRAB	GRAB	GRAB	GRAB	GRAB
STATUS:						
FIELD DUPLICATE OF:				FPTB09L-08		
SEMIVOLATILES (µg/kg)						
2-METHYLNAPHTHALENE					2000	400 U
ACENAPHTHENE					900	400 U
ACENAPHTHYLENE					1200	400 U
ANTHRACENE					2700	74 J
BENZO(A)ANTHRACENE					5300	53 J
BENZO(A)PYRENE					4300	73 J
BENZO(B)FLUORANTHENE					4300	92 J
BENZO(G,H,I)PERYLENE					3100 J	64 J
BENZO(K)FLUORANTHENE					1400	400 U
BUTYLBENZYL PHTHALATE					360 UJ	400 U
CARBAZOLE					1100	400 U
CHRYSENE					5500	67 J
DIBENZO(A,H)ANTHRACENE					1500	57 J
DIBENZOFURAN					1300	400 U
FLUORANTHENE					11000	120 J
FLUORENE					2900	28 J
INDENO(1,2,3-CD)PYRENE					3400	69 J
NAPHTHALENE					1700	400 U
PHENANTHRENE					14000	100 J
PHENOL					360 U	400 UR
PYRENE					15000	120 J

TABLE 7-8 (PAGE 6 OF 15)
SUMMARY OF POSITIVE SOIL ANALYTICAL RESULTS FOR ZONE 4
LOWER SUBASE; NSB-NLON; GROTON, CONNECTICUT

SAMPLE NUMBER:	FPTB07L-08	FPTB08L-07	FPTB09L-08	DUP-16-111695	LS4SB0010101	LS4SB0010301
DEPTH (feet):	8 - 8'	7 - 7'	8 - 8'	8 - 8'	0.5 - 2'	5 - 6'
INVESTIGATION:	TFI96	TFI96	TFI96	TFI96	1997RI	1997RI
SAMPLE DATE:	11/18/95	11/16/95	11/16/95	11/16/95	09/26/97	09/26/97
LOCATION:	GS-7L	GS-8L	GS-9L	GS-9L	MW1-4RI	MW1-4RI
VALIDATED:	VALIDATED	VALIDATED	VALIDATED	VALIDATED	VALIDATED	VALIDATED
SAMPLE TYPE:	GRAB	GRAB	GRAB	GRAB	GRAB	GRAB
STATUS:						
FIELD DUPLICATE OF:				FPTB09L-08		
METALS (mg/kg)						
ALUMINUM					4690	2670
ANTIMONY					3.3	0.49 U
ARSENIC					4.2	1.2
BARIUM					46.8	17.8
BERYLLIUM					0.28	0.11 U
CADMIUM					0.53	0.04 U
CALCIUM					1250	810
CHROMIUM					10.5	5.6
COBALT					2.8	1.8
COPPER					147	4.5
IRON					7860	4720
LEAD					444	2.7 U
MAGNESIUM					1640	1160
MANGANESE					130	99.5
MERCURY					0.31 J	0.01 UJ
NICKEL					8.7	5.0
POTASSIUM					878	614
SELENIUM					0.33 U	0.47 U
SODIUM					141	107
VANADIUM					14.1	7.3
ZINC					128	15.3

TABLE 7-8 (PAGE 7 OF 15)
SUMMARY OF POSITIVE SOIL ANALYTICAL RESULTS FOR ZONE 4
LOWER SUBASE; NSB-NLON; GROTON, CONNECTICUT

SAMPLE NUMBER:	FPTB07L-08	FPTB08L-07	FPTB09L-08	DUP-16-111695	LS4SB0010101	LS4SB0010301
DEPTH (feet):	8 - 8'	7 - 7'	8 - 8'	8 - 8'	0.5 - 2'	5 - 6'
INVESTIGATION:	TFI96	TFI96	TFI96	TFI96	1997RI	1997RI
SAMPLE DATE:	11/18/95	11/16/95	11/16/95	11/16/95	09/26/97	09/26/97
LOCATION:	GS-7L	GS-8L	GS-9L	GS-9L	MW1-4RI	MW1-4RI
VALIDATED:	VALIDATED	VALIDATED	VALIDATED	VALIDATED	VALIDATED	VALIDATED
SAMPLE TYPE:	GRAB	GRAB	GRAB	GRAB	GRAB	GRAB
STATUS:						
FIELD DUPLICATE OF:				FPTB09L-08		
TOTAL PETROLEUM HYDROCARBONS (mg/kg)						
TPH	10.4 U	13.1 U	3720	9360	500 J	

TABLE 7-8 (PAGE 8 OF 15)
SUMMARY OF POSITIVE SOIL ANALYTICAL RESULTS FOR ZONE 4
LOWER SUBASE; NSB-NLON; GROTON, CONNECTICUT

SAMPLE NUMBER:	LS4SB0050101	LS4SB0050301	QW-1	QW-2	QW-3	QW-4
DEPTH (feet):	1 - 3'	5 - 7'	5 - 6'	5 - 6'	5 - 6'	7 - 7.3'
INVESTIGATION:	1997RI	1997RI	RSE95	RSE95	RSE95	RSE95
SAMPLE DATE:	09/26/97	09/26/97	11/30/94	11/30/94	12/01/94	12/05/94
LOCATION:	MW2-4RI	MW2-4RI	QW-1	QW-2	QW-3	QW-4
VALIDATED:	VALIDATED	VALIDATED	VALIDATED	VALIDATED	VALIDATED	VALIDATED
SAMPLE TYPE:	GRAB	GRAB	GRAB	GRAB	GRAB	GRAB
STATUS:						
FIELD DUPLICATE OF:						
VOLATILES (µg/kg)						
BENZENE			13 U	1.15 U	1.4	1.23 UJ
CARBON DISULFIDE			13 U			
ETHYLBENZENE			13 U	18 J	0.7 J	1.23 UJ
METHYLENE CHLORIDE			13 U			
TETRACHLOROETHENE			13 U			
TOLUENE			3 J	1.15 U	3.2	1.23 UJ
TRICHLOROETHENE			13 U			
XYLENES, TOTAL			13 U	20.3 J	5.4	0.616 J
SEMIVOLATILES (µg/kg)						
2-METHYLNAPHTHALENE	360 U	430 U	420 U			
ACENAPHTHENE	360 U	430 U	420 U			
ACENAPHTHYLENE	19 J	430 U	420 U			
ANTHRACENE	360 U	430 U	59 J			
BENZO(A)ANTHRACENE	44 J	430 U	400 J			
BENZO(A)PYRENE	59 J	41 J	410 J			
BENZO(B)FLUORANTHENE	58 J	22 J	260 J			
BENZO(G,H,I)PERYLENE	92 J	54 J	290 J			
BENZO(K)FLUORANTHENE	56 J	430 U	390 J			
BUTYLBENZYL PHTHALATE	360 UJ	430 UJ	420 U			
CARBAZOLE	360 U	430 U	420 U			
CHRYSENE	55 J	430 U	430			
DIBENZO(A,H)ANTHRACENE	360 U	59 J	420 U			

TABLE 7-8 (PAGE 9 OF 15)
SUMMARY OF POSITIVE SOIL ANALYTICAL RESULTS FOR ZONE 4
LOWER SUBASE; NSB-NLON; GROTON, CONNECTICUT

SAMPLE NUMBER:	LS4SB0050101	LS4SB0050301	QW-1	QW-2	QW-3	QW-4
DEPTH (feet):	1 - 3'	5 - 7'	5 - 6'	5 - 6'	5 - 6'	7 - 7.3'
INVESTIGATION:	1997RI	1997RI	RSE95	RSE95	RSE95	RSE95
SAMPLE DATE:	09/26/97	09/26/97	11/30/94	11/30/94	12/01/94	12/05/94
LOCATION:	MW2-4RI	MW2-4RI	QW-1	QW-2	QW-3	QW-4
VALIDATED:	VALIDATED	VALIDATED	VALIDATED	VALIDATED	VALIDATED	VALIDATED
SAMPLE TYPE:	GRAB	GRAB	GRAB	GRAB	GRAB	GRAB
STATUS:						
FIELD DUPLICATE OF:						
SEMIVOLATILES (µg/kg)						
DIBENZOFURAN	360 U	430 U	420 U			
FLUORANTHENE	45 J	430 U	620			
FLUORENE	360 U	430 U	420 U			
INDENO(1,2,3-CD)PYRENE	65 J	56 J	290 J			
NAPHTHALENE	360 U	430 U	39 J			
PHENANTHRENE	24 J	430 U	190 J			
PHENOL	24 J	430 UR	420 U			
PYRENE	61 J	430 U	830			
PESTICIDES/PCBs (µg/kg)						
ENDRIN			6.7			
METALS (mg/kg)						
ALUMINUM	3300	3770	4060			
ANTIMONY	0.45 U	0.56 U	1.3			
ARSENIC	1.9	3.8	2.1			
BARIUM	19.5	24.5	22.2			
BERYLLIUM	0.13 U	0.11 U	0.15 J			
CADMIUM	0.07 J	0.05 U	0.11 J			
CALCIUM	672	1380	742			
CHROMIUM	5.9	6.8	9.1			
COBALT	2.1	2.1	2.8			
COPPER	7.3	5.4	20.5			
IRON	5200	5220	6700			

TABLE 7-8 (PAGE 10 OF 15)
SUMMARY OF POSITIVE SOIL ANALYTICAL RESULTS FOR ZONE 4
LOWER SUBASE; NSB-NLON; GROTON, CONNECTICUT

SAMPLE NUMBER:	LS4SB0050101	LS4SB0050301	QW-1	QW-2	QW-3	QW-4
DEPTH (feet):	1 - 3'	5 - 7'	5 - 6'	5 - 6'	5 - 6'	7 - 7.3'
INVESTIGATION:	1997RI	1997RI	RSE95	RSE95	RSE95	RSE95
SAMPLE DATE:	09/26/97	09/26/97	11/30/94	11/30/94	12/01/94	12/05/94
LOCATION:	MW2-4RI	MW2-4RI	QW-1	QW-2	QW-3	QW-4
VALIDATED:	VALIDATED	VALIDATED	VALIDATED	VALIDATED	VALIDATED	VALIDATED
SAMPLE TYPE:	GRAB	GRAB	GRAB	GRAB	GRAB	GRAB
STATUS:						
FIELD DUPLICATE OF:						
METALS (mg/kg)						
LEAD	57.1	2.2 U	1470			
MAGNESIUM	1070	1590	1890			
MANGANESE	75.1	76.4	101			
MERCURY	0.01 UJ	0.01 UJ	0.13 U			
NICKEL	4.6	4.6	6.5			
POTASSIUM	567	1280	1330 J			
SELENIUM	0.34 U	0.63 U	0.56 U			
SODIUM	78.4	157	403			
VANADIUM	8.7	8.7	9.6			
ZINC	29.2	12.3	38.6 J			
TOTAL PETROLEUM HYDROCARBONS (mg/kg)						
TPH	210 J		2450 J	1730	642	1360

TABLE 7-8 (PAGE 11 OF 15)

SUMMARY OF POSITIVE SOIL ANALYTICAL RESULTS FOR ZONE 4 LOWER SUBASE; NSB-NLON; GROTON, CONNECTICUT

SAMPLE NUMBER:	QW-5	LS4SB0020101	LS4SB0020201	LS4SB0030101	LS4SB0030201	LS4SB0040101
DEPTH (feet):	6 - 7'	2 - 4'	6.5 - 7'	2 - 4'	7 - 8'	2 - 4'
INVESTIGATION:	RSE95	1997RI	1997RI	1997RI	1997RI	1997RI
SAMPLE DATE:	12/12/94	09/26/97	09/26/97	09/23/97	09/23/97	09/23/97
LOCATION:	QW-5	TB2-4RI	TB2-4RI	TB3-4RI	TB3-4RI	TB4-4RI
VALIDATED:	VALIDATED	VALIDATED	VALIDATED	VALIDATED	VALIDATED	VALIDATED
SAMPLE TYPE:	GRAB	GRAB	GRAB	GRAB	GRAB	GRAB
STATUS:						
FIELD DUPLICATE OF:						
VOLATILES (µg/kg)						
BENZENE	1.17 U					
ETHYLBENZENE	1.17 U					
TOLUENE	1.17 U					
XYLENES, TOTAL	1.17 U					
SEMIVOLATILES (µg/kg)						
2-METHYLNAPHTHALENE		360 U	23 J	24 J	360 U	360 U
ACENAPHTHENE		360 U	360 U	360 U	360 U	360 U
ACENAPHTHYLENE		360 U	360 U	72 J	360 U	360 U
ANTHRACENE		360 U	28 J	66 J	360 U	360 U
BENZO(A)ANTHRACENE		110 J	180 J	620	110 J	47 J
BENZO(A)PYRENE		64 J	120 J	680	110 J	59 J
BENZO(B)FLUORANTHENE		84 J	180 J	680	100 J	57 J
BENZO(G,H,I)PERYLENE		55 J	110 J	650	71 J	55 J
BENZO(K)FLUORANTHENE		62 J	130 J	580	92 J	81 J
BUTYLBENZYL PHTHALATE		360 U	23 J	360 U	360 U	360 U
CARBAZOLE		360 U	360 U	25 J	360 U	360 U
CHRYSENE		110 J	200 J	660	120 J	83 J
DIBENZO(A,H)ANTHRACENE		34 J	80 J	360 U	360 U	360 UJ
DIBENZOFURAN		360 U	360 U	360 U	360 U	360 U
FLUORANTHENE		210 J	400 J	770	160 J	100 J
FLUORENE		360 U	360 U	360 U	360 U	360 U
INDENO(1,2,3-CD)PYRENE		64 J	120 J	560	67 J	46 J

TABLE 7-8 (PAGE 12 OF 15)
SUMMARY OF POSITIVE SOIL ANALYTICAL RESULTS FOR ZONE 4
LOWER SUBASE; NSB-NLON; GROTON, CONNECTICUT

SAMPLE NUMBER:	QW-5	LS4SB0020101	LS4SB0020201	LS4SB0030101	LS4SB0030201	LS4SB0040101
DEPTH (feet):	6 - 7'	2 - 4'	6.5 - 7'	2 - 4'	7 - 8'	2 - 4'
INVESTIGATION:	RSE95	1997RI	1997RI	1997RI	1997RI	1997RI
SAMPLE DATE:	12/12/94	09/26/97	09/26/97	09/23/97	09/23/97	09/23/97
LOCATION:	QW-5	TB2-4RI	TB2-4RI	TB3-4RI	TB3-4RI	TB4-4RI
VALIDATED:	VALIDATED	VALIDATED	VALIDATED	VALIDATED	VALIDATED	VALIDATED
SAMPLE TYPE:	GRAB	GRAB	GRAB	GRAB	GRAB	GRAB
STATUS:						
FIELD DUPLICATE OF:						
SEMIVOLATILES (µg/kg)						
NAPHTHALENE		360 U	360 U	34 J	360 U	360 U
PHENANTHRENE		63 J	160 J	210 J	41 J	52 J
PHENOL		360 U	360 U	360 U	360 U	360 U
PYRENE		120 J	230 J	830	170 J	120 J
METALS (mg/kg)						
ALUMINUM				5450	5520	
ANTIMONY				0.49 J	0.44 UJ	
ARSENIC				4.5 J	2.9 J	
BARIUM				34.5 U	38.6 U	
BERYLLIUM				0.19 U	0.21 J	
CADMIUM				0.10 U	0.15 U	
CALCIUM				1310 J	1460 J	
CHROMIUM				11.4	9.9	
COBALT				2.9	3.3	
COPPER				14.0	14.1	
IRON				6890	6630	
LEAD				237	214	
MAGNESIUM				1850 J	1860 J	
MANGANESE				122	121	
MERCURY				0.50	0.02 U	
NICKEL				7.5	7.7	
POTASSIUM				1060 J	984 J	

TABLE 7-8 (PAGE 13 OF 15)

SUMMARY OF POSITIVE SOIL ANALYTICAL RESULTS FOR ZONE 4 LOWER SUBASE; NSB-NLON; GROTON, CONNECTICUT

SAMPLE NUMBER:	QW-5	LS4SB0020101	LS4SB0020201	LS4SB0030101	LS4SB0030201	LS4SB0040101
DEPTH (feet):	6 - 7'	2 - 4'	6.5 - 7'	2 - 4'	7 - 8'	2 - 4'
INVESTIGATION:	RSE95	1997RI	1997RI	1997RI	1997RI	1997RI
SAMPLE DATE:	12/12/94	09/26/97	09/26/97	09/23/97	09/23/97	09/23/97
LOCATION:	QW-5	TB2-4RI	TB2-4RI	TB3-4RI	TB3-4RI	TB4-4RI
VALIDATED:	VALIDATED	VALIDATED	VALIDATED	VALIDATED	VALIDATED	VALIDATED
SAMPLE TYPE:	GRAB	GRAB	GRAB	GRAB	GRAB	GRAB
STATUS:						
FIELD DUPLICATE OF:						
METALS (mg/kg)						
SELENIUM				0.35 U	0.33 U	
SODIUM				104	122	
VANADIUM				12.7	12.4	
ZINC				59.9 J	63.6 J	
TOTAL PETROLEUM HYDROCARBONS (mg/kg)						
TPH	25.7			150		

TABLE 7-8 (PAGE 14 OF 15)
SUMMARY OF POSITIVE SOIL ANALYTICAL RESULTS FOR ZONE 4
LOWER SUBASE; NSB-NLON; GROTON, CONNECTICUT

SAMPLE NUMBER:	LS4SB0040201	13WE4A-0002				
DEPTH (feet):	6 - 7'	0 - 2'				
INVESTIGATION:	1997RI	PH2-1				
SAMPLE DATE:	09/23/97	01/23/94	/ /	/ /	/ /	/ /
LOCATION:	TB4-4RI	WE4A				
VALIDATED:	VALIDATED	VALIDATED				
SAMPLE TYPE:	GRAB	GRAB				
STATUS:						
FIELD DUPLICATE OF:						
SEMIVOLATILES (µg/kg)						
2-METHYLNAPHTHALENE	360 U					
ACENAPHTHENE	360 U					
ACENAPHTHYLENE	360 U					
ANTHRACENE	360 U					
BENZO(A)ANTHRACENE	360 U					
BENZO(A)PYRENE	360 U					
BENZO(B)FLUORANTHENE	360 U					
BENZO(G,H,I)PERYLENE	360 U					
BENZO(K)FLUORANTHENE	360 U					
BUTYLBENZYL PHTHALATE	360 U					
CARBAZOLE	360 U					
CHRYSENE	360 U					
DIBENZO(A,H)ANTHRACENE	360 U					
DIBENZOFURAN	360 U					
FLUORANTHENE	360 U					
FLUORENE	360 U					
INDENO(1,2,3-CD)PYRENE	360 U					
NAPHTHALENE	360 U					
PHENANTHRENE	360 U					
PHENOL	360 U					
PYRENE	19 J					

TABLE 7-8 (PAGE 15 OF 15)

SUMMARY OF POSITIVE SOIL ANALYTICAL RESULTS FOR ZONE 4
LOWER SUBASE; NSB-NLON; GROTON, CONNECTICUT

SAMPLE NUMBER:	LS4SB0040201	13WE4A-0002				
DEPTH (feet):	6 - 7'	0 - 2'				
INVESTIGATION:	1997RI	PH2-1				
SAMPLE DATE:	09/23/97	01/23/94	/ /	/ /	/ /	/ /
LOCATION:	TB4-4RI	WE4A				
VALIDATED:	VALIDATED	VALIDATED				
SAMPLE TYPE:	GRAB	GRAB				
STATUS:						
FIELD DUPLICATE OF:						
METALS (mg/kg)						
LEAD		10600 J				
TOTAL PETROLEUM HYDROCARBONS (mg/kg)						
TPH		925				

TABLE 7-9 (PAGE 1 OF 3)
SUMMARY OF POSITIVE TCLP ANALYTICAL RESULTS FOR ZONE 4
LOWER SUBASE; NSB-NLON; GROTON, CONNECTICUT

SAMPLE NUMBER:	13MW23(8-10)	13MW13(8-10)	13MW24(12-14)	13MW14(12-14)	13MW15(12-14)	13MW16(10-12)
DEPTH (feet):	8 - 10'	8 - 10'	12 - 14'	12 - 14'	12 - 14'	10 - 12'
INVESTIGATION:	PH1	PH1	PH1	PH1	PH1	PH1
SAMPLE DATE:	11/13/90	11/13/90	11/13/90	11/13/90	11/12/90	11/12/90
LOCATION:	13MW13	13MW13	13MW14	13MW14	13MW15	13MW16
VALIDATED:	VALIDATED	VALIDATED	VALIDATED	VALIDATED	VALIDATED	VALIDATED
SAMPLE TYPE:	GRAB	GRAB	GRAB	GRAB	GRAB	GRAB
STATUS:						
FIELD DUPLICATE OF:						
TCLP METALS (mg/L)*						
ARSENIC (5.0/0.5)	0.3 U	0.3 U	0.32 J	0.3 UJ	0.3 U	0.36
BARIUM (100.0/10.0)	0.31	0.24	0.086	0.072	0.07	0.035
CADMIUM (1.0/0.05)	0.005 U	0.005 U	0.005 U	0.005 U	0.005 U	0.005 U
CHROMIUM (5.0/0.5)	0.05 U	0.05 U	0.05 U	0.05 U	0.05 U	0.05 U
LEAD (5.0/0.15)	0.43 J	0.3 UJ	0.92 J	0.56 J	0.3 U	7.4
SELENIUM (1.0/0.5)	0.3 U	0.3 U	0.3 U	0.3 U	0.3 U	0.3 U

*Federal Toxicity Characteristic Regulatory Level (58 FR 46049)/Connecticut Remediation Standard Pollutant Mobility Criteria for GB Waters

TABLE 7-9 (PAGE 2 OF 3)

SUMMARY OF POSITIVE TCLP ANALYTICAL RESULTS FOR ZONE 4 LOWER SUBASE; NSB-NLON; GROTON, CONNECTICUT

SAMPLE NUMBER:	13TB2A-0406	13TB3A-0608	13TB3A-2.5-4.5D	13TB3A-2.5-4.5	13TB4A-0002	13TB6-0507
DEPTH (feet):	4 - 6'	6 - 8'	2.5 - 4.5'	2.5 - 4.5'	0 - 2'	5 - 7'
INVESTIGATION:	PH2-1	PH2-1	PH2-1	PH2-1	PH2-1	PH2-1
SAMPLE DATE:	01/22/94	01/23/94	01/22/94	01/22/94	01/22/94	01/23/94
LOCATION:	13TB2A	13TB3A	13TB3A	13TB3A	13TB4A	13TB6
VALIDATED:	VALIDATED	VALIDATED	VALIDATED	VALIDATED	VALIDATED	VALIDATED
SAMPLE TYPE:	GRAB	GRAB	GRAB	GRAB	GRAB	GRAB
STATUS:						
FIELD DUPLICATE OF:						
TCLP METALS (mg/L)*						
ARSENIC (5.0/0.5)	0.026 U	0.026 U	0.0354 J	0.0375 J	0.026 U	0.026 U
BARIUM (100.0/10.0)	0.125	0.246	0.379	0.408	0.291	0.0246
CADMIUM (1.0/0.05)	0.002 U	0.0022 J	0.002 U	0.002 U	0.0024 J	0.002 U
CHROMIUM (5.0/0.5)	0.0112	0.003 UJ	0.003 U	0.003 U	0.0087	0.003 U
LEAD (5.0/0.15)	0.014 UJ	21.3	109 J	150 J	0.909 J	0.0578 U
SELENIUM (1.0/0.5)	0.024 U	0.0453 J	0.024 U	0.024 U	0.024 U	0.024 U

*Federal Toxicity Characteristic Regulatory Level (58 FR 46049)/Connecticut Remediation Standard Pollutant Mobility Criteria for GB Waters

TABLE 7-9 (PAGE 3 OF 3)
SUMMARY OF POSITIVE TCLP ANALYTICAL RESULTS FOR ZONE 4
LOWER SUBASE; NSB-NLON; GROTON, CONNECTICUT

SAMPLE NUMBER:	QW-1	13WE4A-0002				
DEPTH (feet):	5 - 6'	0 - 2'				
INVESTIGATION:	RSC95	PH2-1				
SAMPLE DATE:	11/30/94	01/23/94	/ /	/ /	/ /	/ /
LOCATION:	QW-1	WE4A				
VALIDATED:	VALIDATED	VALIDATED				
SAMPLE TYPE:	GRAB	GRAB				
STATUS:						
FIELD DUPLICATE OF:						
TCLP METALS (mg/L)*						
ARSENIC (5.0/0.5)	0.003 U	0.0309 J				
BARIUM (100.0/10.0)	0.253	0.166				
CADMIUM (1.0/0.05)	0.0022	0.0106				
CHROMIUM (5.0/0.5)	0.0081	0.0086				
LEAD (5.0/0.15)	51.9	143 J				
SELENIUM (1.0/0.5)	0.0146 U	0.024 U				

*Federal Toxicity Characteristic Regulatory Level (58 FR 46049)/Connecticut Remediation Standard Pollutant Mobility Criteria for GB Waters

TABLE 7-10

SUMMARY OF POSITIVE SPLP ANALYTICAL RESULTS FOR ZONE 4 LOWER SUBASE; NSB-NLON; GROTON, CONNECTICUT

SAMPLE NUMBER:	LS4SB0010101	LS4SB0010301	LS4SB0050101	LS4SB0050301	LS4SB0030101	LS4SB0030201
DEPTH (feet):	0.5 - 2'	5 - 6'	1 - 3'	5 - 7'	2 - 4'	7 - 8'
INVESTIGATION:	1997RI	1997RI	1997RI	1997RI	1997RI	1997RI
SAMPLE DATE:	09/26/97	09/26/97	09/26/97	09/26/97	09/23/97	09/23/97
LOCATION:	MW1-4RI	MW1-4RI	MW2-4RI	MW2-4RI	TB3-4RI	TB3-4RI
VALIDATED:	VALIDATED	VALIDATED	VALIDATED	VALIDATED	VALIDATED	VALIDATED
SAMPLE TYPE:	GRAB	GRAB	GRAB	GRAB	GRAB	GRAB
STATUS:						
FIELD DUPLICATE OF:						
SPLP METALS (mg/L)*						
LEAD (5.0/0.15)	0.0766	0.002 U	0.0132 U	0.0013 U	0.104	0.0872

*Federal Toxicity Characteristic Regulatory Level (58 FR 46049)/Connecticut Remediation Standard Pollutant Mobility Criteria for GB Waters

TABLE 7-11

SUMMARY OF SOIL ANALYTICAL RESULTS - ZONE 4
LOWER SUBASE
NSB-NLON, GROTON, CONNECTICUT
PAGE 1 OF 3

Analyte	SHALLOW SOILS (<5 FEET)[1]			DEEP SOILS (>5 FEET)[2]		
	Frequency of Detection	Concentration Range	Location of Maximum Detection	Frequency of Detection	Concentration Range	Location of Maximum Detection
VOLATILE ORGANICS (ug/kg)						
Benzene	NA	NA	ND	1/11	1.4	QW-3
Carbon disulfide	NA	NA	ND	1/7	5	13MW16
Ethylbenzene	NA	NA	ND	3/11	0.7 - 18	QW-2
Methylene chloride	NA	NA	ND	6/7	1 - 12	13MW13
Tetrachloroethene	NA	NA	ND	5/7	3 - 8	13MW13
Toluene	NA	NA	ND	2/11	3 - 3.2	QW-3
Trichloroethene	NA	NA	ND	6/7	2 - 5	13MW13
Xylenes, total	NA	NA	ND	4/11	0.616 - 20.3	QW-2
SEMIVOLATILE ORGANICS (ug/kg)						
2-Methylnaphthalene	2/5	24 - 2000	MW1-4RI	1/6	23	TB2-4RI
Acenaphthene	1/5	900	MW1-4RI	0/6	ND	ND
Acenaphthylene	3/5	19 - 1200	MW1-4RI	0/6	ND	ND
Anthracene	2/5	66 - 2700	MW1-4RI	3/6	28 - 74	MW1-4RI
Benzo(a)anthracene	5/5	44 - 5300	MW1-4RI	4/6	53 - 400	QW-1
Benzo(a)pyrene	5/5	59 - 4300	MW1-4RI	5/6	41 - 410	QW-1
Benzo(b)fluoranthene	5/5	57 - 4300	MW1-4RI	5/6	22 - 260	QW-1
Benzo(g,h,i)perylene	5/5	55 - 3100	MW1-4RI	5/6	54 - 290	QW-1
Benzo(k)fluoranthene	5/5	56 - 1400	MW1-4RI	3/6	92 - 390	QW-1
Butylbenzyl phthalate	0/5	ND	ND	1/6	23	TB2-4RI
Carbazole	2/5	25 - 1100	MW1-4RI	0/6	ND	ND
Chrysene	5/5	55 - 5500	MW1-4RI	4/6	67 - 430	QW-1
Dibenzo(a,h)anthracene	2/5	34 - 1500	MW1-4RI	3/6	57 - 80	TB2-4RI
Dibenzofuran	1/5	1300	MW1-4RI	0/6	ND	ND
Fluoranthene	5/5	45 - 11000	MW1-4RI	4/6	120 - 620	QW-1
Fluorene	1/5	2900	MW1-4RI	1/6	28	MW1-4RI

TABLE 7-11

SUMMARY OF SOIL ANALYTICAL RESULTS - ZONE 4
LOWER SUBASE
NSB-NLON, GROTON, CONNECTICUT
PAGE 2 OF 3

Analyte	SHALLOW SOILS (<5 FEET)[1]			DEEP SOILS (>5 FEET)[2]		
	Frequency of Detection	Concentration Range	Location of Maximum Detection	Frequency of Detection	Concentration Range	Location of Maximum Detection
Indeno(1,2,3-Cd)pyrene	5/5	46 - 3400	MW1-4RI	5/6	56 - 290	QW-1
Naphthalene	2/5	34 - 1700	MW1-4RI	1/6	39	QW-1
Phenanthrene	5/5	24 - 14000	MW1-4RI	4/6	41 - 190	QW-1
Phenol	1/5	24	MW2-4RI	0/4	ND	ND
Pyrene	5/5	61 - 15000	MW1-4RI	5/6	19 - 830	QW-1
PESTICIDES/PCBs (ug/kg)						
Endrin	NA	NA	ND	1/1	6.7	QW-1
INORGANICS (mg/kg)						
Aluminum	3/3	3300 - 5450	TB3-4RI	10/10	2670 - 10600	13MW16
Antimony	2/3	0.49 - 3.3	MW1-4RI	1/10	1.3	QW-1
Arsenic	3/3	1.9 - 4.5	TB3-4RI	8/10	0.77 - 4	13MW16
Barium	2/3	19.5 - 46.8	MW1-4RI	9/10	17.8 - 48.3	13MW13
Beryllium	1/3	0.28	MW1-4RI	3/10	0.15 - 0.34	13MW16
Cadmium	2/3	0.07 - 0.53	MW1-4RI	7/10	0.11 - 2.5	13MW16
Calcium	3/3	672 - 1310	TB3-4RI	10/10	603 - 2710	13MW16
Chromium	3/3	5.9 - 11.4	TB3-4RI	10/10	5.6 - 27.8	13MW16
Cobalt	3/3	2.1 - 2.9	TB3-4RI	10/10	1.8 - 6.7	13MW16
Copper	3/3	7.3 - 147	MW1-4RI	10/10	4.5 - 32.5	13MW14
Iron	3/3	5200 - 7860	MW1-4RI	10/10	4720 - 16900	13MW16
Lead	10/10	57.1 - 10600	WE4A	10/12	25.2 - 1990	13TB3A
Magnesium	3/3	1070 - 1850	TB3-4RI	10/10	1160 - 5510	13MW16
Manganese	3/3	75.1 - 130	MW1-4RI	10/10	76.4 - 191	13MW16
Mercury	2/3	0.31 - 0.5	TB3-4RI	0/10	ND	ND
Nickel	3/3	4.6 - 8.7	MW1-4RI	10/10	4.6 - 16.3	13MW16
Potassium	3/3	567 - 1060	TB3-4RI	10/10	614 - 2780	13MW16
Selenium	0/3	ND	ND	2/10	0.28 - 1	13MW16

TABLE 7-11

SUMMARY OF SOIL ANALYTICAL RESULTS - ZONE 4
LOWER SUBASE
NSB-NLON, GROTON, CONNECTICUT
PAGE 3 OF 3

Analyte	SHALLOW SOILS (<5 FEET)[1]			DEEP SOILS (>5 FEET)[2]		
	Frequency of Detection	Concentration Range	Location of Maximum Detection	Frequency of Detection	Concentration Range	Location of Maximum Detection
Sodium	3/3	78.4 - 141	MW1-4RI	10/10	107 - 5890	13MW16
Vanadium	3/3	8.7 - 14.1	MW1-4RI	10/10	7.3 - 35.9	13MW16
Zinc	3/3	29.2 - 128	MW1-4RI	10/10	12.3 - 63.6	TB3-4RI
TOXICITY CHARACTERISTIC LEACHING PROCEDURE (mg/L)						
Arsenic	3/5	0.0309 - 0.0375	13TB3A	2/9	0.32 - 0.36	13MW16
Barium	5/5	0.125 - 0.408	13TB3A	9/9	0.0246 - 0.31	13MW13
Cadmium	2/5	0.0024 - 0.0106	WE4A	2/9	0.0022	13TB3A/QW-1
Chromium	3/5	0.0086 - 0.0112	13TB2A	1/9	0.0081	QW-1
Lead	4/5	0.909 - 150	13TB3A	6/9	0.43 - 51.9	QW-1
Selenium	0/5	ND	ND	1/9	0.0453	13TB3A
SYNTHETIC PRECIPITATION LEACHING PROCEDURE (mg/L)						
Lead	2/3	0.0766 - 0.104	TB3-4RI	1/3	0.0872	MW2-3RI
TOTAL PETROLEUM HYDROCARBONS (mg/kg)						
TPH	9/9	31.8 - 3440	13TB4A	17/19	15.3 - 11800	13TB2A

1 Includes samples 13TB2A-0406, 13TB2A-0406-X, 13TB3A-2.5-4.5, 13TB3A-2.5-4.5D (field duplicate of 13TB3A-2.5-4.5), 13TB4A-0002, 13TB4A-0002-X, 13WE4A-0002, FPTB10L-03, LS4SB0010101, LS4SB0020101, LS4SB0030101, LS4SB0040101, LS4SB0050101.

2 Includes samples 13MW13(8-10), 13MW14(12-14), 13MW15(12-14), 13MW16(10-12), 13MW23(8-10) (field duplicate of 13MW13(8-10)), 13MW24(12-14) (field duplicate of 13MW14(12-14)), 13TB2A-0608, 13TB3A-0608-X, 13TB6-0507, DUP-16-111695 (field duplicate of FPTB09L-08), FPTB06L-07, FPTB07L-08, FPTB08L-07, FPTB09L-08, FPTB11L-07, LS4SB0010301, LS4SB0020201, LS4SB0030201, LS4SB0040201, LS4SB0050301, NSB-WE1-13-15, NSB-WE1-5-7, NSB-WE3-7-9, NSB-WE3-9-11, NSB-WE4-11-13, NSB-WE4-7-9, NSB-WE5-11-13, NSB-WE5-7-9, QW-1, QW-2, QW-3, QW-4, QW-5.

ND - Not Detected

NA - Not Analyzed

TABLE 7-12

SUMMARY OF SOIL FLUORESCENCE SPECTROSCOPY DATA - ZONE 4
LOWER SUBASE
NSB-NLON, GROTON, CONNECTICUT

Sample	Sample Depth (ft)	Observations
13MW13[1]	8-10	Spectra is unresolved. Trace concentrations of petroleum hydrocarbons make oil identification impractical.
13MW14[1]	12-14	Spectra is similar to waste oil/heavy residual fuel oil (i.e., No. 6 fuel oil) mixture.
13MW15[1]	12-14	Spectra is similar to waste oil/heavy residual fuel oil (i.e., No. 6 fuel oil) mixture.
13MW16[1]	10-12	Spectra is similar to waste oil/heavy residual fuel oil (i.e., No. 6 fuel oil) mixture.
WE1[2]	5-7	Trace levels of petroleum hydrocarbons resulted in poor resolution spectra. No usable data obtained.
WE1[2]	13-15	Trace levels of petroleum hydrocarbons resulted in poor resolution spectra. No usable data obtained.
WE3[2]	7-9	Low levels of a heavy fuel oil (No. 6 fuel oil) detected.
WE3[2]	9-11	Low levels of a heavy fuel oil (No. 6 fuel oil) detected.
WE4[2]	7-9	Low levels of a heavy fuel oil (No. 6 fuel oil) detected.
WE4[2]	11-13	Trace levels of petroleum hydrocarbons resulted in poor resolution spectra. No usable data obtained.
WE5[2]	7-9	Trace levels of petroleum hydrocarbons resulted in poor resolution spectra. No usable data obtained.
WE5[2]	11-13	Trace levels of petroleum hydrocarbons resulted in poor resolution spectra. No usable data obtained.

1 Data obtained from Phase I Remedial Investigation Report (Atlantic, 1992).
2 Data obtained from Final Site Investigation Subsurface Oil Contamination (Wehran, 1987).

TABLE 7-13 (PAGE 1 OF 41)
SUMMARY OF POSITIVE GROUNDWATER ANALYTICAL RESULTS FOR ZONE 4
LOWER SUBASE; NSB-NLON; GROTON, CONNECTICUT

SAMPLE NUMBER:	012191-13MW13S	13GW13	13GW13	13GW13-2	13GW132	LS4GW13MW1301
INVESTIGATION:	PH1	PH2-1	PH2-1	PH2-2	PH2-2	1997RI
SAMPLE DATE:	01/21/91	03/07/94	03/07/94	06/24/94	06/24/94	10/29/97
LOCATION:	13MW13	13MW13	13MW13	13MW13	13MW13	13MW13
VALIDATED:	VALIDATED	VALIDATED	VALIDATED	VALIDATED	VALIDATED	VALIDATED
FILTERING:	Unfiltered	Unfiltered	Filtered	Unfiltered	Filtered	Unfiltered
FIELD DUPLICATE OF:						
VOLATILES (µg/L)						
1,1,1-TRICHLOROETHANE	5 U	10 U		10 U		
1,1-DICHLOROETHANE	15	10 U		10 U		
1,1-DICHLOROETHENE	57	4 J		21		
ETHYLBENZENE	5 U	10 U		10 U		
METHYLENE CHLORIDE	5 U	10 U		11 U		
TOLUENE	5 U	10 U		10 U		
VINYL CHLORIDE	12	10 U		5 J		
XYLENES, TOTAL	5 U	10 U		10 U		
SEMIVOLATILES (µg/L)						
2,4-DIMETHYLPHENOL		10 U		10 U		11 U
ACENAPHTHENE		10 U		10 U		11 U
BENZO(A)ANTHRACENE		10 U		10 U		11 U
BENZO(A)PYRENE		10 U		10 U		11 U
BENZO(B)FLUORANTHENE		10 U		10 U		11 U
BENZO(G,H,I)PERYLENE		10 U		10 U		11 U
BENZO(K)FLUORANTHENE		10 U		10 U		11 U
BIS(2-ETHYLHEXYL)PHTHALATE		10 U		10 U		11 U
CARBAZOLE		10 U		10 U		11 U
CHRYSENE		10 U		10 U		11 U
DI-N-BUTYL PHTHALATE		10 U		10 U		11 U
DIBENZOFURAN		10 U		10 U		11 U
FLUORANTHENE		10 U		10 U		11 UJ
FLUORENE		10 U		10 U		11 U
INDENO(1,2,3-CD)PYRENE		10 U		10 U		11 U

TABLE 7-13 (PAGE 2 OF 41)
SUMMARY OF POSITIVE GROUNDWATER ANALYTICAL RESULTS FOR ZONE 4
LOWER SUBASE; NSB-NLON; GROTON, CONNECTICUT

SAMPLE NUMBER:	012191-13MW13S	13GW13	13GW13	13GW13-2	13GW132	LS4GW13MW1301
INVESTIGATION:	PH1	PH2-1	PH2-1	PH2-2	PH2-2	1997RI
SAMPLE DATE:	01/21/91	03/07/94	03/07/94	06/24/94	06/24/94	10/29/97
LOCATION:	13MW13	13MW13	13MW13	13MW13	13MW13	13MW13
VALIDATED:	VALIDATED	VALIDATED	VALIDATED	VALIDATED	VALIDATED	VALIDATED
FILTERING:	Unfiltered	Unfiltered	Filtered	Unfiltered	Filtered	Unfiltered
FIELD DUPLICATE OF:						
SEMIVOLATILES (µg/L)						
NAPHTHALENE		10 U		10 U		11 U
PHENANTHRENE		10 U		10 U		11 U
PYRENE		10 U		10 U		11 U
METALS (µg/L)						
ALUMINUM	30 U	18.2 J	14 U	34.5	12.3 U	96.5 U
ANTIMONY	25 U	15 U	15 U	5 U	8.1 J	2.5 U
ARSENIC	4.5	9.3 J	2 UJ	13.6	11.6 U	21.4
BARIUM	15 U	10.8 J	11.4 J	6	6 J	3.6
BERYLLIUM	1 U	1 U	1 U	1 U	1 U	0.11 UJ
BORON	0.6 R	99.4	99.7	108	110 J	
CADMIUM	2 UJ	2 U	2 U	1.5 J	1 U	0.22 U
CALCIUM	35800	39500	40400	30300	30900	36500
CHROMIUM	5 U	3 UJ	3 UJ	1 U	1 U	1.8 U
COBALT	5 U	4 U	4 U	1 U	1 U	0.80 U
COPPER	5 U	2 U	2 U	3 U	3 U	1.2 U
IRON	3390 J	3210	694	8860	8460	12000
LEAD	2.8 J	2 UJ	2 UJ	2 UJ	2 UR	1.3 U
MAGNESIUM	7100	6350	6450	7570	7650	10300
MANGANESE	113	122	123	63.7	64.5	74.8
MERCURY	0.2 UJ	0.2 UJ	0.2 UJ	0.2 UJ	0.2 UJ	0.04 U
NICKEL	17.4 J	10 U	10 U	3 U	3 U	0.83 J
POTASSIUM	6160	6930	7080	7250	7470	8130
SELENIUM	1 UJ	3 UJ	3 UJ	2 U	2 UR	1.9 U
SILVER	7 UJ	2 UJ	2 UJ	2 U	2 U	1.5 J

TABLE 7-13 (PAGE 3 OF 41)
SUMMARY OF POSITIVE GROUNDWATER ANALYTICAL RESULTS FOR ZONE 4
LOWER SUBASE; NSB-NLON; GROTON, CONNECTICUT

SAMPLE NUMBER:	012191-13MW13S	13GW13	13GW13	13GW13-2	13GW132	LS4GW13MW1301
INVESTIGATION:	PH1	PH2-1	PH2-1	PH2-2	PH2-2	1997RI
SAMPLE DATE:	01/21/91	03/07/94	03/07/94	06/24/94	06/24/94	10/29/97
LOCATION:	13MW13	13MW13	13MW13	13MW13	13MW13	13MW13
VALIDATED:	VALIDATED	VALIDATED	VALIDATED	VALIDATED	VALIDATED	VALIDATED
FILTERING:	Unfiltered	Unfiltered	Filtered	Unfiltered	Filtered	Unfiltered
FIELD DUPLICATE OF:						
METALS (µg/L)						
SODIUM	58100 J	81500	85700	81000 J	79100 J	86600
THALLIUM	2 UR	10 UJ	10 UJ	2 UJ	2 UR	4.8 U
VANADIUM	20 U	5 U	5 U	1 U	1 U	0.55 U
ZINC	20.3 J	7 U	12 J	5.8 U	4.1 U	5.0 U
PETROLEUM HYDROCARBONS (µg/L)						
TPH	2000 U	500 U		1000 U		1000 U
WATER QUALITY PARAMETERS						
DISSOLVED OXYGEN (MG/L)						0.57
REDOX POTENTIAL (MV)						-140.4
SALINITY (PPT)						0.34
SPECIFIC CONDUCTIVITY (MS/CM)						0.69
TEMPERATURE (C)						19.49
MISCELLANEOUS PARAMETERS						
ALKALINITY AS CACO3 (MG/L)						100
AMMONIA, AS NITROGEN (MG/L)						0.38
CHLORIDE (MG/L)						160
DIVALENT IRON (MG/L)						4.60
HARDNESS AS CaCO3 (MG/L)		128		107		130
METHANE (UG/L)						2100
NITRATE, AS NITROGEN (MG/L)						0.17
PHOSPHORUS (MG/L)						1.4 J
SULFATE (MG/L)						18
TOTAL ORGANIC CARBON (MG/L)						4.2 J
TURBIDITY (NTU)						18

TABLE 7-13 (PAGE 4 OF 41)
SUMMARY OF POSITIVE GROUNDWATER ANALYTICAL RESULTS FOR ZONE 4
LOWER SUBASE; NSB-NLON; GROTON, CONNECTICUT

SAMPLE NUMBER:	012191-13MW13S	13GW13	13GW13	13GW13-2	13GW132	LS4GW13MW1301
INVESTIGATION:	PH1	PH2-1	PH2-1	PH2-2	PH2-2	1997RI
SAMPLE DATE:	01/21/91	03/07/94	03/07/94	06/24/94	06/24/94	10/29/97
LOCATION:	13MW13	13MW13	13MW13	13MW13	13MW13	13MW13
VALIDATED:	VALIDATED	VALIDATED	VALIDATED	VALIDATED	VALIDATED	VALIDATED
FILTERING:	Unfiltered	Unfiltered	Filtered	Unfiltered	Filtered	Unfiltered
FIELD DUPLICATE OF:						
GENERAL CHEMISTRY						
PH						6.61

TABLE 7-13 (PAGE 5 OF 41)
SUMMARY OF POSITIVE GROUNDWATER ANALYTICAL RESULTS FOR ZONE 4
LOWER SUBASE; NSB-NLON; GROTON, CONNECTICUT

SAMPLE NUMBER:	LS4GW13MW1301-F	011591-13MW14S	13GW14	13GW14	13GW14-2	13GW142
INVESTIGATION:	1997RI	PH1	PH2-1	PH2-1	PH2-2	PH2-2
SAMPLE DATE:	10/29/97	01/15/91	03/07/94	03/07/94	06/25/94	06/25/94
LOCATION:	13MW13	13MW14	13MW14	13MW14	13MW14	13MW14
VALIDATED:	VALIDATED	VALIDATED	VALIDATED	VALIDATED	VALIDATED	VALIDATED
FILTERING:	Filtered	Unfiltered	Unfiltered	Filtered	Unfiltered	Filtered
FIELD DUPLICATE OF:						
VOLATILES (µg/L)						
1,1,1-TRICHLOROETHANE		5 U	10 U		10 U	
1,1-DICHLOROETHANE		5 U	10 U		10 U	
1,1-DICHLOROETHENE		5 U	10 U		10 U	
ETHYLBENZENE		5 U	10 U		10 U	
METHYLENE CHLORIDE		5 U	10 U		10 U	
TOLUENE		5 U	10 U		10 U	
VINYL CHLORIDE		10 U	10 U		10 U	
XYLENES, TOTAL		5 U	10 U		10 U	
SEMIVOLATILES (µg/L)						
2,4-DIMETHYLPHENOL			10 U		10 U	
ACENAPHTHENE			10 U		10 U	
BENZO(A)ANTHRACENE			10 U		10 U	
BENZO(A)PYRENE			10 U		10 U	
BENZO(B)FLUORANTHENE			10 U		10 U	
BENZO(G,H,I)PERYLENE			10 U		10 U	
BENZO(K)FLUORANTHENE			10 U		10 U	
BIS(2-ETHYLHEXYL)PHTHALATE			10 U		10 U	
CARBAZOLE			10 U		10 U	
CHRYSENE			10 U		10 U	
DI-N-BUTYL PHTHALATE			10 U		10 U	
DIBENZOFURAN			10 U		10 U	
FLUORANTHENE			10 U		10 U	
FLUORENE			10 U		10 U	
INDENO(1,2,3-CD)PYRENE			10 U		10 U	

TABLE 7-13 (PAGE 6 OF 41)
SUMMARY OF POSITIVE GROUNDWATER ANALYTICAL RESULTS FOR ZONE 4
LOWER SUBASE; NSB-NLON; GROTON, CONNECTICUT

SAMPLE NUMBER:	LS4GW13MW1301-F	011591-13MW14S	13GW14	13GW14	13GW14-2	13GW142
INVESTIGATION:	1997RI	PH1	PH2-1	PH2-1	PH2-2	PH2-2
SAMPLE DATE:	10/29/97	01/15/91	03/07/94	03/07/94	06/25/94	06/25/94
LOCATION:	13MW13	13MW14	13MW14	13MW14	13MW14	13MW14
VALIDATED:	VALIDATED	VALIDATED	VALIDATED	VALIDATED	VALIDATED	VALIDATED
FILTERING:	Filtered	Unfiltered	Unfiltered	Filtered	Unfiltered	Filtered
FIELD DUPLICATE OF:						
SEMIVOLATILES (µg/L)						
NAPHTHALENE			10 U		10 U	
PHENANTHRENE			10 U		10 U	
PYRENE			10 U		10 U	
METALS (µg/L)						
ALUMINUM	10.0 UJ	30 U	14 U	14 U	42 U	10 U
ANTIMONY	2.5 U	25 U	15 U	15 U	3 UR	14.8
ARSENIC	14.7	3 U	2 U	2 U	10 U	20 U
BARIUM	272	25	29.7 U	29.9 U	49.4 J	62.9
BERYLLIUM	0.11 UJ	1 U	1 U	1 U	1 U	1 U
BORON		37 R	1110 J	1080	1730 J	1850
CADMIUM	0.22 U	2 U	2 UJ	2 UJ	1 U	2 U
CALCIUM	36300	75300	110000	107000	168000	208000
CHROMIUM	0.68 U	5 U	3 U	3 U	1 U	3 U
COBALT	0.80 U	5 U	4 U	4 U	1 U	3 U
COPPER	2.3 U	9.4	8.1 J	9.5 J	4.3 U	11.7
IRON	9280	258 J	95.2 J	28.8 U	16 U	56.2
LEAD	1.3 U	2.6 J	11.3	5.2 UJ	26.5 J	20 U
MAGNESIUM	10300	204000	305000	295000	663000	575000
MANGANESE	72.1	51.6	11.9 U	10.9 U	3.4	6.1
MERCURY	0.05 U	0.2 U	0.2 U	0.2 U	0.2 U	0.2 U
NICKEL	9.0 U	17.8 J	10 U	10 U	12 U	7 U
POTASSIUM	8210	67500	123000 J	118000 J	214000	202000
SELENIUM	1.9 U	7.7	30 UJ	3 UJ	4 UR	10 U
SILVER	1.1 U	7 U	2 U	2 U	1 U	2 U

TABLE 7-13 (PAGE 7 OF 41)
SUMMARY OF POSITIVE GROUNDWATER ANALYTICAL RESULTS FOR ZONE 4
LOWER SUBASE; NSB-NLON; GROTON, CONNECTICUT

SAMPLE NUMBER:	LS4GW13MW1301-F	011591-13MW14S	13GW14	13GW14	13GW14-2	13GW142
INVESTIGATION:	1997RI	PH1	PH2-1	PH2-1	PH2-2	PH2-2
SAMPLE DATE:	10/29/97	01/15/91	03/07/94	03/07/94	06/25/94	06/25/94
LOCATION:	13MW13	13MW14	13MW14	13MW14	13MW14	13MW14
VALIDATED:	VALIDATED	VALIDATED	VALIDATED	VALIDATED	VALIDATED	VALIDATED
FILTERING:	Filtered	Unfiltered	Unfiltered	Filtered	Unfiltered	Filtered
FIELD DUPLICATE OF:						
METALS (µg/L)						
SODIUM	93600	1790000	3090000	2850000	5430000	142 U
THALLIUM	4.8 U	10 U	10 UJ	10 UJ	20 UR	20 U
VANADIUM	0.55 U	20 U	5 UJ	5 U	1 U	3 U
ZINC	109 J	31.6 J	23.7	17.1 U	27.8	8.5
PETROLEUM HYDROCARBONS (µg/L)						
TPH		3000 U	500 U		500 U	
MISCELLANEOUS PARAMETERS						
HARDNESS AS CaCO3 (MG/L)			1690		3200	

TABLE 7-13 (PAGE 8 OF 41)
SUMMARY OF POSITIVE GROUNDWATER ANALYTICAL RESULTS FOR ZONE 4
LOWER SUBASE; NSB-NLON; GROTON, CONNECTICUT

SAMPLE NUMBER:	LS4GW13MW1401	LS4GW13MW1401-F	012291-13MW15S	012291-13MW19S	13GW15	13GW15
INVESTIGATION:	1997RI	1997RI	PH1	PH1	PH2-1	PH2-1
SAMPLE DATE:	10/28/97	10/28/97	01/22/91	01/22/91	03/07/94	03/07/94
LOCATION:	13MW14	13MW14	13MW15	13MW15	13MW15	13MW15
VALIDATED:	VALIDATED	VALIDATED	VALIDATED	VALIDATED	VALIDATED	VALIDATED
FILTERING:	Unfiltered	Filtered	Unfiltered	Unfiltered	Unfiltered	Filtered
FIELD DUPLICATE OF:				012291-13MW15S		
VOLATILES (µg/L)						
1,1,1-TRICHLOROETHANE			5 U	5 U	10 U	
1,1-DICHLOROETHANE			5 U	5 U	10 U	
1,1-DICHLOROETHENE			5 U	5 U	10 U	
ETHYLBENZENE			5 U	5 U	10 U	
METHYLENE CHLORIDE			5 U	5 U	10 U	
TOLUENE			5 U	5 U	10 U	
VINYL CHLORIDE			10 U	10 U	10 U	
XYLENES, TOTAL			5 U	5 U	10 U	
SEMIVOLATILES (µg/L)						
2,4-DIMETHYLPHENOL	11 U				10 U	
ACENAPHTHENE	11 U				10 U	
BENZO(A)ANTHRACENE	11 U				10 U	
BENZO(A)PYRENE	11 U				10 U	
BENZO(B)FLUORANTHENE	11 U				10 U	
BENZO(G,H,I)PERYLENE	11 U				10 U	
BENZO(K)FLUORANTHENE	11 UJ				10 U	
BIS(2-ETHYLHEXYL)PHTHALATE	12 U				10 U	
CARBAZOLE	11 U				10 U	
CHRYSENE	11 U				10 U	
DI-N-BUTYL PHTHALATE	11 U				10 U	
DIBENZOFURAN	11 U				10 U	
FLUORANTHENE	11 UJ				10 U	
FLUORENE	11 U				10 U	
INDENO(1,2,3-CD)PYRENE	11 U				10 U	

TABLE 7-13 (PAGE 9 OF 41)
SUMMARY OF POSITIVE GROUNDWATER ANALYTICAL RESULTS FOR ZONE 4
LOWER SUBASE; NSB-NLON; GROTON, CONNECTICUT

SAMPLE NUMBER:	LS4GW13MW1401	LS4GW13MW1401-F	012291-13MW15S	012291-13MW19S	13GW15	13GW15
INVESTIGATION:	1997RI	1997RI	PH1	PH1	PH2-1	PH2-1
SAMPLE DATE:	10/28/97	10/28/97	01/22/91	01/22/91	03/07/94	03/07/94
LOCATION:	13MW14	13MW14	13MW15	13MW15	13MW15	13MW15
VALIDATED:	VALIDATED	VALIDATED	VALIDATED	VALIDATED	VALIDATED	VALIDATED
FILTERING:	Unfiltered	Filtered	Unfiltered	Unfiltered	Unfiltered	Filtered
FIELD DUPLICATE OF:				012291-13MW15S		
SEMIVOLATILES (µg/L)						
NAPHTHALENE	11 U				0.8 J	
PHENANTHRENE	11 U				10 U	
PYRENE	11 U				1 J	
METALS (µg/L)						
ALUMINUM	16.1 U	22.2 U	30 U	30 U	244	14 U
ANTIMONY	2.5 U	2.5 U	25 U	25 U	15 UJ	15 U
ARSENIC	2.5 U	2.5 U	3 U	3 U	20 UJ	20 UJ
BARIUM	47.3	234	49.8	49.9	33.7 J	32.5 J
BERYLLIUM	0.19 U	0.28 U	1 U	1 U	1 U	1 U
BORON			9.9 R	9.3 R	1890	1900
CADMIUM	0.22 U	0.22 U	2 UJ	2 UJ	2 U	2 U
CALCIUM	188000	188000	157000	156000	181000	180000
CHROMIUM	3.1 U	3.1 U	5 U	5 U	3 UJ	3 UJ
COBALT	2.9 U	2.9 U	5 U	5 U	4 U	4 U
COPPER	8.7	8.5	6.4	5 U	6.9 R	3.5 R
IRON	150 U	97.0 U	283 J	288 J	1520	999
LEAD	10.3 J	6.8 J	10 UR	10 UR	20 UJ	20 UJ
MAGNESIUM	469000	473000	604000	591000	567000	574000
MANGANESE	13.1	12.9	56.5	56.1	44.9	40.1
MERCURY	0.03 U	0.03 U	0.2 UJ	0.2 UJ	0.2 UJ	0.2 UJ
NICKEL	9.0 U	9.0 U	16 J	11.8 J	10 U	10 U
POTASSIUM	155000	157000	175000	170000	259000	263000
SELENIUM	1.9 U	1.9 U	1 UJ	1 UJ	3 UJ	3 UJ
SILVER	2.8 U	2.8 U	7 UJ	7 UJ	2 UJ	2 UJ

TABLE 7-13 (PAGE 10 OF 41)
SUMMARY OF POSITIVE GROUNDWATER ANALYTICAL RESULTS FOR ZONE 4
LOWER SUBASE; NSB-NLON; GROTON, CONNECTICUT

SAMPLE NUMBER:	LS4GW13MW1401	LS4GW13MW1401-F	012291-13MW15S	012291-13MW19S	13GW15	13GW15
INVESTIGATION:	1997RI	1997RI	PH1	PH1	PH2-1	PH2-1
SAMPLE DATE:	10/28/97	10/28/97	01/22/91	01/22/91	03/07/94	03/07/94
LOCATION:	13MW14	13MW14	13MW15	13MW15	13MW15	13MW15
VALIDATED:	VALIDATED	VALIDATED	VALIDATED	VALIDATED	VALIDATED	VALIDATED
FILTERING:	Unfiltered	Filtered	Unfiltered	Unfiltered	Unfiltered	Filtered
FIELD DUPLICATE OF:				012291-13MW15S		
METALS (µg/L)						
SODIUM	3910000	3990000	4930000 J	4630000 J	5630000	1310000
THALLIUM	5.1 U	4.8 U	7.8 J	11.5 J	10 UJ	10 UJ
VANADIUM	2.9 UJ	2.9 UJ	20 U	20 U	5 UJ	5 UJ
ZINC	4.6 U	84.2 J	7.4 J	4.9 J	2 U	2 U
PETROLEUM HYDROCARBONS (µg/L)						
TPH	1100 U		2000 U	2000 U	500 U	
WATER QUALITY PARAMETERS						
DISSOLVED OXYGEN (MG/L)	0.56					
REDOX POTENTIAL (MV)	67.5					
SALINITY (PPT)	11.9					
SPECIFIC CONDUCTIVITY (MS/CM)	19.89					
TEMPERATURE (C)	17.85					
MISCELLANEOUS PARAMETERS						
ALKALINITY AS CACO3 (MG/L)	94					
AMMONIA, AS NITROGEN (MG/L)	0.10 U					
CHLORIDE (MG/L)	7200					
DIVALENT IRON (MG/L)	0					
HARDNESS AS CaCO3 (MG/L)	2200				3500	
METHANE (UG/L)	31					
NITRATE, AS NITROGEN (MG/L)	0.12					
PHOSPHORUS (MG/L)	0.41 J					
SULFATE (MG/L)	1200					
TOTAL ORGANIC CARBON (MG/L)	4.8 J					
TURBIDITY (NTU)	0.89					

TABLE 7-13 (PAGE 11 OF 41)
SUMMARY OF POSITIVE GROUNDWATER ANALYTICAL RESULTS FOR ZONE 4
LOWER SUBASE; NSB-NLON; GROTON, CONNECTICUT

SAMPLE NUMBER:	LS4GW13MW1401	LS4GW13MW1401-F	012291-13MW15S	012291-13MW19S	13GW15	13GW15
INVESTIGATION:	1997RI	1997RI	PH1	PH1	PH2-1	PH2-1
SAMPLE DATE:	10/28/97	10/28/97	01/22/91	01/22/91	03/07/94	03/07/94
LOCATION:	13MW14	13MW14	13MW15	13MW15	13MW15	13MW15
VALIDATED:	VALIDATED	VALIDATED	VALIDATED	VALIDATED	VALIDATED	VALIDATED
FILTERING:	Unfiltered	Filtered	Unfiltered	Unfiltered	Unfiltered	Filtered
FIELD DUPLICATE OF:				012291-13MW15S		
GENERAL CHEMISTRY						
PH	6.60					

TABLE 7-13 (PAGE 12 OF 41)
SUMMARY OF POSITIVE GROUNDWATER ANALYTICAL RESULTS FOR ZONE 4
LOWER SUBASE; NSB-NLON; GROTON, CONNECTICUT

SAMPLE NUMBER:	13GW15-2	13GW152	LS4GW13MW1501	LS4GW13MW1501-F	012391-13MW16S	13GW16
INVESTIGATION:	PH2-2	PH2-2	1997RI	1997RI	PH1	PH2-1
SAMPLE DATE:	06/25/94	06/25/94	11/03/97	11/03/97	01/23/91	03/07/94
LOCATION:	13MW15	13MW15	13MW15	13MW15	13MW16	13MW16
VALIDATED:	VALIDATED	VALIDATED	VALIDATED	VALIDATED	VALIDATED	VALIDATED
FILTERING:	Unfiltered	Filtered	Unfiltered	Filtered	Unfiltered	Unfiltered
FIELD DUPLICATE OF:						
VOLATILES (µg/L)						
1,1,1-TRICHLOROETHANE	10 U				5 U	10 U
1,1-DICHLOROETHANE	10 U				5 U	10 U
1,1-DICHLOROETHENE	10 U				5 U	10 U
ETHYLBENZENE	10 U				5 U	10 U
METHYLENE CHLORIDE	10 U				5 U	10 U
TOLUENE	10 U				5 U	10 U
VINYL CHLORIDE	10 U				10 U	10 U
XYLENES, TOTAL	10 U				5 U	10 U
SEMIVOLATILES (µg/L)						
2,4-DIMETHYLPHENOL	10 U		11 U			10 U
ACENAPHTHENE	10 U		0.9 J			1 J
BENZO(A)ANTHRACENE	10 U		11 U			10 U
BENZO(A)PYRENE	10 U		11 U			10 U
BENZO(B)FLUORANTHENE	10 U		11 U			10 U
BENZO(G,H,I)PERYLENE	10 U		11 U			10 U
BENZO(K)FLUORANTHENE	10 U		11 U			10 U
BIS(2-ETHYLHEXYL)PHTHALATE	10 U		11 U			10 U
CARBAZOLE	10 U		11 U			10 U
CHRYSENE	10 U		11 U			10 U
DI-N-BUTYL PHTHALATE	10 U		11 U			10 U
DIBENZOFURAN	10 U		11 U			10 U
FLUORANTHENE	10 U		11 U			10 U
FLUORENE	10 U		11 U			10 U
INDENO(1,2,3-CD)PYRENE	10 U		11 U			10 U

TABLE 7-13 (PAGE 13 OF 41)
SUMMARY OF POSITIVE GROUNDWATER ANALYTICAL RESULTS FOR ZONE 4
LOWER SUBASE; NSB-NLON; GROTON, CONNECTICUT

SAMPLE NUMBER:	13GW15-2	13GW152	LS4GW13MW1501	LS4GW13MW1501-F	012391-13MW16S	13GW16
INVESTIGATION:	PH2-2	PH2-2	1997RI	1997RI	PH1	PH2-1
SAMPLE DATE:	06/25/94	06/25/94	11/03/97	11/03/97	01/23/91	03/07/94
LOCATION:	13MW15	13MW15	13MW15	13MW15	13MW16	13MW16
VALIDATED:	VALIDATED	VALIDATED	VALIDATED	VALIDATED	VALIDATED	VALIDATED
FILTERING:	Unfiltered	Filtered	Unfiltered	Filtered	Unfiltered	Unfiltered
FIELD DUPLICATE OF:						
SEMIVOLATILES (µg/L)						
NAPHTHALENE	10 U		11 U			0.6 J
PHENANTHRENE	10 U		11 U			10 U
PYRENE	1 J		1 J			10 U
METALS (µg/L)						
ALUMINUM	42 U	10 U	78.4 U	85.7 U	30 U	14 U
ANTIMONY	3 UR	12 U	2.5 U	2.5 U	25 U	15 U
ARSENIC	11 J	20 U	2.5 U	2.5 U	3 U	20 U
BARIUM	39.3 J	53.5	39.5 J	45.3 J	39.6	37.6 U
BERYLLIUM	1.1 J	1 U	0.11 UJ	0.11 UJ	1 U	1 U
BORON	2070 J	2370			5.3 R	1530 J
CADMIUM	1.9 R	2 U	0.22 U	0.22 U	2 UJ	2 UJ
CALCIUM	179000	238000	246000	251000	150000	145000
CHROMIUM	1.4 J	3 U	4.7 J	2.7 U	5 U	3 U
COBALT	1 U	3 U	0.80 U	1.1 J	5 U	4 U
COPPER	1 U	4.3	1.6 U	1.0 U	5 U	5.6 J
IRON	3490	4530	247	339 J	522 J	2930
LEAD	20 UJ	2 U	1.3 U	1.3 U	10 UR	1.6 J
MAGNESIUM	776000	686000	861000	878000	489000	435000
MANGANESE	51.5	63.3	42.1	45.4	88	48.8
MERCURY	0.2 U	0.2 U	0.03 U	0.01 UJ	0.2 UJ	0.2 U
NICKEL	12 U	7 U	2.5 U	2.6 U	19.3 J	11.6
POTASSIUM	256000	252000	285000	291000	163000	189000 J
SELENIUM	4 UR	10 U	1.9 U	1.9 U	1 UJ	30 UJ
SILVER	1 U	2 U	4.1	5.3 U	7 UJ	2 U

TABLE 7-13 (PAGE 14 OF 41)
SUMMARY OF POSITIVE GROUNDWATER ANALYTICAL RESULTS FOR ZONE 4
LOWER SUBASE; NSB-NLON; GROTON, CONNECTICUT

SAMPLE NUMBER:	13GW15-2	13GW152	LS4GW13MW1501	LS4GW13MW1501-F	012391-13MW16S	13GW16
INVESTIGATION:	PH2-2	PH2-2	1997RI	1997RI	PH1	PH2-1
SAMPLE DATE:	06/25/94	06/25/94	11/03/97	11/03/97	01/23/91	03/07/94
LOCATION:	13MW15	13MW15	13MW15	13MW15	13MW16	13MW16
VALIDATED:	VALIDATED	VALIDATED	VALIDATED	VALIDATED	VALIDATED	VALIDATED
FILTERING:	Unfiltered	Filtered	Unfiltered	Filtered	Unfiltered	Unfiltered
FIELD DUPLICATE OF:						
METALS (µg/L)						
SODIUM	6310000	142 U	7120000	7260000	2250000 J	4800000
THALLIUM	20 UR	20 U	4.8 U	4.8 U	3.6 J	10 UJ
VANADIUM	1 U	3 U	0.63 J	0.55 U	20 U	5.3 J
ZINC	10.3	2 U	1.2 UJ	1.2 UJ	9.8 J	10 U
PETROLEUM HYDROCARBONS (µg/L)						
TPH	500 U		1100 U		5400	800
WATER QUALITY PARAMETERS						
DISSOLVED OXYGEN (MG/L)			0.06			
REDOX POTENTIAL (MV)			-490.8 R			
SALINITY (PPT)			21.88			
SPECIFIC CONDUCTIVITY (MS/CM)			34.71			
TEMPERATURE (C)			16.79			
MISCELLANEOUS PARAMETERS						
ALKALINITY AS CACO3 (MG/L)			190			
AMMONIA, AS NITROGEN (MG/L)			1.5 J			
CHLORIDE (MG/L)			13000			
DIVALENT IRON (MG/L)			0			
HARDNESS AS CaCO3 (MG/L)	5900		4000			2560
METHANE (UG/L)			1000			
NITRATE, AS NITROGEN (MG/L)			0.15			
PHOSPHORUS (MG/L)			1.4 J			
SULFATE (MG/L)			71			
TOTAL ORGANIC CARBON (MG/L)			8.4 J			
TURBIDITY (NTU)			5.91			

TABLE 7-13 (PAGE 15 OF 41)
SUMMARY OF POSITIVE GROUNDWATER ANALYTICAL RESULTS FOR ZONE 4
LOWER SUBASE; NSB-NLON; GROTON, CONNECTICUT

SAMPLE NUMBER:	13GW15-2	13GW152	LS4GW13MW1501	LS4GW13MW1501-F	012391-13MW16S	13GW16
INVESTIGATION:	PH2-2	PH2-2	1997RI	1997RI	PH1	PH2-1
SAMPLE DATE:	06/25/94	06/25/94	11/03/97	11/03/97	01/23/91	03/07/94
LOCATION:	13MW15	13MW15	13MW15	13MW15	13MW16	13MW16
VALIDATED:	VALIDATED	VALIDATED	VALIDATED	VALIDATED	VALIDATED	VALIDATED
FILTERING:	Unfiltered	Filtered	Unfiltered	Filtered	Unfiltered	Unfiltered
FIELD DUPLICATE OF:						
GENERAL CHEMISTRY						
PH			7.2			

TABLE 7-13 (PAGE 16 OF 41)
SUMMARY OF POSITIVE GROUNDWATER ANALYTICAL RESULTS FOR ZONE 4
LOWER SUBASE; NSB-NLON; GROTON, CONNECTICUT

SAMPLE NUMBER:	13GW16	13GW16-2	13GW162	LS4GW13MW1601	LS4GW13MW1601-F	LS4GW00101
INVESTIGATION:	PH2-1	PH2-2	PH2-2	1997RI	1997RI	1997RI
SAMPLE DATE:	03/07/94	06/25/94	06/25/94	11/03/97	11/03/97	10/29/97
LOCATION:	13MW16	13MW16	13MW16	13MW16	13MW16	MW1-4RI
VALIDATED:	VALIDATED	VALIDATED	VALIDATED	VALIDATED	VALIDATED	VALIDATED
FILTERING:	Filtered	Unfiltered	Filtered	Unfiltered	Filtered	Unfiltered
FIELD DUPLICATE OF:						
VOLATILES (µg/L)						
1,1,1-TRICHLOROETHANE		10 U				
1,1-DICHLOROETHANE		10 U				
1,1-DICHLOROETHENE		10 U				
ETHYLBENZENE		10 U				
METHYLENE CHLORIDE		10 U				
TOLUENE		10 U				
VINYL CHLORIDE		10 U				
XYLENES, TOTAL		10 U				
SEMIVOLATILES (µg/L)						
2,4-DIMETHYLPHENOL		10 U		1 J		11 U
ACENAPHTHENE		0.8 J		2 J		11 U
BENZO(A)ANTHRACENE		10 U		11 U		11 U
BENZO(A)PYRENE		10 U		11 U		11 U
BENZO(B)FLUORANTHENE		10 U		11 U		11 U
BENZO(G,H,I)PERYLENE		10 U		11 U		11 U
BENZO(K)FLUORANTHENE		10 U		11 U		11 U
BIS(2-ETHYLHEXYL)PHTHALATE		10 U		15 U		11 U
CARBAZOLE		10 U		0.7 J		11 U
CHRYSENE		10 U		11 U		11 U
DI-N-BUTYL PHTHALATE		0.6 J		11 U		11 U
DIBENZOFURAN		10 U		1 J		11 U
FLUORANTHENE		10 U		11 UJ		11 UJ
FLUORENE		10 U		0.8 J		11 U
INDENO(1,2,3-CD)PYRENE		10 U		11 U		11 U

TABLE 7-13 (PAGE 17 OF 41)
SUMMARY OF POSITIVE GROUNDWATER ANALYTICAL RESULTS FOR ZONE 4
LOWER SUBASE; NSB-NLON; GROTON, CONNECTICUT

SAMPLE NUMBER:	13GW16	13GW16-2	13GW162	LS4GW13MW1601	LS4GW13MW1601-F	LS4GW00101
INVESTIGATION:	PH2-1	PH2-2	PH2-2	1997RI	1997RI	1997RI
SAMPLE DATE:	03/07/94	06/25/94	06/25/94	11/03/97	11/03/97	10/29/97
LOCATION:	13MW16	13MW16	13MW16	13MW16	13MW16	MW1-4RI
VALIDATED:	VALIDATED	VALIDATED	VALIDATED	VALIDATED	VALIDATED	VALIDATED
FILTERING:	Filtered	Unfiltered	Filtered	Unfiltered	Filtered	Unfiltered
FIELD DUPLICATE OF:						
SEMIVOLATILES (µg/L)						
NAPHTHALENE		10 U		4 J		11 U
PHENANTHRENE		10 U		0.6 J		11 U
PYRENE		10 U		11 U		11 U
METALS (µg/L)						
ALUMINUM	14 U	42 U	11	48.3 U	14.1 U	10.0 UJ
ANTIMONY	15 U	3 UR	12 U	2.5 U	2.5 U	5.6
ARSENIC	20 U	10 U	20 U	2.5 U	2.5 U	2.5 U
BARIUM	39.1 U	94 J	124	57.0	256	111
BERYLLIUM	1 U	1 U	1 U	0.19 U	0.19 U	0.11 UJ
BORON	1590 J	1910 J	2150			
CADMIUM	2 UJ	1 U	2 U	0.22 U	0.22 U	0.22 U
CALCIUM	148000	179000	230000	141000	137000	75900
CHROMIUM	3 U	1 U	3 U	3.1 U	3.1 U	0.68 U
COBALT	4 U	1 U	3 U	2.9 U	2.9 U	0.80 U
COPPER	5 J	1 U	20.4	1.7 J	1.5 U	2.7 U
IRON	2900	650	901	1320	1140	13.0 U
LEAD	1 UJ	20 UJ	20 U	2.6 J	1.3 U	1.3 U
MAGNESIUM	451000	727000	781000	395000	397000	7280
MANGANESE	48.8	28.9	36.7	54.6	51.6	9.4
MERCURY	0.2 U	0.2 U	0.2 U	0.02 U	0.06 U	0.08 U
NICKEL	10 U	12 U	7 U	9.0 U	9.0 U	0.75 U
POTASSIUM	202000 J	230000	243000	122000	118000	17000
SELENIUM	30 UJ	4 UR	10 U	1.9 U	1.9 U	1.9 U
SILVER	2 U	1 U	2 U	2.8 U	2.8 U	1.1 U

TABLE 7-13 (PAGE 18 OF 41)
SUMMARY OF POSITIVE GROUNDWATER ANALYTICAL RESULTS FOR ZONE 4
LOWER SUBASE; NSB-NLON; GROTON, CONNECTICUT

SAMPLE NUMBER:	13GW16	13GW16-2	13GW162	LS4GW13MW1601	LS4GW13MW1601-F	LS4GW00101
INVESTIGATION:	PH2-1	PH2-2	PH2-2	1997RI	1997RI	1997RI
SAMPLE DATE:	03/07/94	06/25/94	06/25/94	11/03/97	11/03/97	10/29/97
LOCATION:	13MW16	13MW16	13MW16	13MW16	13MW16	MW1-4RI
VALIDATED:	VALIDATED	VALIDATED	VALIDATED	VALIDATED	VALIDATED	VALIDATED
FILTERING:	Filtered	Unfiltered	Filtered	Unfiltered	Filtered	Unfiltered
FIELD DUPLICATE OF:						
METALS (µg/L)						
SODIUM	4630000	5810000	6350000	3160000	3110000	266000
THALLIUM	10 UJ	20 UR	20 U	4.8 U	4.8 U	4.8 U
VANADIUM	5 UJ	1 U	5.7	2.9 UJ	2.9 UJ	0.74 U
ZINC	2 U	20.2	2 U	14.5 U	5.7 U	8.8 U
PETROLEUM HYDROCARBONS (µg/L)						
TPH		700		1100 U		1100 U
WATER QUALITY PARAMETERS						
DISSOLVED OXYGEN (MG/L)				1.34		4.63
REDOX POTENTIAL (MV)				-193.6		84.3
SALINITY (PPT)				11.59		0.86
SPECIFIC CONDUCTIVITY (MS/CM)				19.52		1.689
TEMPERATURE (C)				15.92		18.93
MISCELLANEOUS PARAMETERS						
ALKALINITY AS CACO3 (MG/L)				77		73
AMMONIA, AS NITROGEN (MG/L)				0.51		0.10 U
CHLORIDE (MG/L)				6000		450
DIVALENT IRON (MG/L)				1.6		0
HARDNESS AS CaCO3 (MG/L)		3700		2000		210
METHANE (UG/L)				190		5.4 U
NITRATE, AS NITROGEN (MG/L)				0.057 J		4.6
PHOSPHORUS (MG/L)				0.67 J		0.20 J
SULFATE (MG/L)				890		45
TOTAL ORGANIC CARBON (MG/L)				4.3 J		1.7 J
TURBIDITY (NTU)				3.5		1

TABLE 7-13 (PAGE 19 OF 41)
SUMMARY OF POSITIVE GROUNDWATER ANALYTICAL RESULTS FOR ZONE 4
LOWER SUBASE; NSB-NLON; GROTON, CONNECTICUT

SAMPLE NUMBER:	13GW16	13GW16-2	13GW162	LS4GW13MW1601	LS4GW13MW1601-F	LS4GW00101
INVESTIGATION:	PH2-1	PH2-2	PH2-2	1997RI	1997RI	1997RI
SAMPLE DATE:	03/07/94	06/25/94	06/25/94	11/03/97	11/03/97	10/29/97
LOCATION:	13MW16	13MW16	13MW16	13MW16	13MW16	MW1-4RI
VALIDATED:	VALIDATED	VALIDATED	VALIDATED	VALIDATED	VALIDATED	VALIDATED
FILTERING:	Filtered	Unfiltered	Filtered	Unfiltered	Filtered	Unfiltered
FIELD DUPLICATE OF:						
GENERAL CHEMISTRY						
PH				6.66		6.51

TABLE 7-13 (PAGE 20 OF 41)
SUMMARY OF POSITIVE GROUNDWATER ANALYTICAL RESULTS FOR ZONE 4
LOWER SUBASE; NSB-NLON; GROTON, CONNECTICUT

SAMPLE NUMBER:	LS4GW00101-F	LS4GW00201	LS4GW00201-F	012191-NESOMW10S	NESO10	NESO10
INVESTIGATION:	1997RI	1997RI	1997RI	PH1	PH2-1	PH2-1
SAMPLE DATE:	10/29/97	10/29/97	10/29/97	01/21/91	03/07/94	03/07/94
LOCATION:	MW1-4RI	MW2-4RI	MW2-4RI	NESO10	NESO10	NESO10
VALIDATED:	VALIDATED	VALIDATED	VALIDATED	VALIDATED	VALIDATED	VALIDATED
FILTERING:	Filtered	Unfiltered	Filtered	Unfiltered	Unfiltered	Filtered
FIELD DUPLICATE OF:						
VOLATILES (µg/L)						
1,1,1-TRICHLOROETHANE				5 U	10 U	
1,1-DICHLOROETHANE				3 J	3 J	
1,1-DICHLOROETHENE				5 U	10 U	
ETHYLBENZENE				2 J	10 U	
METHYLENE CHLORIDE				5 U	10 U	
TOLUENE				36	10 U	
VINYL CHLORIDE				10 U	10 U	
XYLENES, TOTAL				18	10 U	
SEMIVOLATILES (µg/L)						
2,4-DIMETHYLPHENOL		12 U			10 U	
ACENAPHTHENE		12 U			10 U	
BENZO(A)ANTHRACENE		12 U			10 U	
BENZO(A)PYRENE		12 U			10 U	
BENZO(B)FLUORANTHENE		12 U			10 U	
BENZO(G,H,I)PERYLENE		12 U			10 U	
BENZO(K)FLUORANTHENE		12 UJ			10 U	
BIS(2-ETHYLHEXYL)PHTHALATE		12 U			10 U	
CARBAZOLE		12 U			10 U	
CHRYSENE		12 U			10 U	
DI-N-BUTYL PHTHALATE		12 U			10 U	
DIBENZOFURAN		12 U			10 U	
FLUORANTHENE		12 UJ			10 U	
FLUORENE		12 U			10 U	
INDENO(1,2,3-CD)PYRENE		12 U			10 U	

TABLE 7-13 (PAGE 21 OF 41)
SUMMARY OF POSITIVE GROUNDWATER ANALYTICAL RESULTS FOR ZONE 4
LOWER SUBASE; NSB-NLON; GROTON, CONNECTICUT

SAMPLE NUMBER:	LS4GW00101-F	LS4GW00201	LS4GW00201-F	012191-NESOMW10S	NESO10	NESO10
INVESTIGATION:	1997RI	1997RI	1997RI	PH1	PH2-1	PH2-1
SAMPLE DATE:	10/29/97	10/29/97	10/29/97	01/21/91	03/07/94	03/07/94
LOCATION:	MW1-4RI	MW2-4RI	MW2-4RI	NESO10	NESO10	NESO10
VALIDATED:	VALIDATED	VALIDATED	VALIDATED	VALIDATED	VALIDATED	VALIDATED
FILTERING:	Filtered	Unfiltered	Filtered	Unfiltered	Unfiltered	Filtered
FIELD DUPLICATE OF:						
SEMIVOLATILES (µg/L)						
NAPHTHALENE		12 U			10 U	
PHENANTHRENE		12 U			10 U	
PYRENE		12 U			10 U	
METALS (µg/L)						
ALUMINUM	10.0 UJ	46.1 U	17.6 U	30 U	14 U	14 U
ANTIMONY	4.6 J	9.0	11.4	25 U	15 U	17.5 U
ARSENIC	2.5 U	2.5 U	2.5 U	3 U	5.4 J	2 UJ
BARIUM	298	72.5	344	51.3	89 J	81.6 J
BERYLLIUM	0.11 UJ	0.19 U	0.19 U	1 U	1 U	1 U
BORON				19 R	458	442
CADMIUM	0.22 U	0.22 U	0.22 U	25.5 J	2 U	2 U
CALCIUM	75100	63100	68600	51800	91400	89100
CHROMIUM	0.68 U	3.1 U	3.1 U	5 U	3 UJ	3 UJ
COBALT	0.80 U	2.9 U	2.9 U	5 U	4 U	4 U
COPPER	3.1 U	1.5 U	1.6 J	5.2	2 U	2 U
IRON	13.0 U	34.8 U	27.2 U	4560 J	8570	3390
LEAD	1.3 U	1.3 U	1.3 U	10 UR	2 UJ	2 UJ
MAGNESIUM	7250	5710	6280	116000	128000	124000
MANGANESE	8.7	17.6 U	18.5 U	403	458	454
MERCURY	0.05 U	0.01 UJ	0.05 U	0.2 UJ	0.2 UJ	0.2 UJ
NICKEL	9.0 U	9.0 U	9.0 U	18.9 J	10 U	10 U
POTASSIUM	16300	13200	13600	37600	52000	50400
SELENIUM	1.9 U	3.5 U	4.6 U	1 UJ	3 UJ	3 UJ
SILVER	1.1 U	2.8 U	2.8 U	7 UJ	2 UJ	2 UJ

TABLE 7-13 (PAGE 22 OF 41)
SUMMARY OF POSITIVE GROUNDWATER ANALYTICAL RESULTS FOR ZONE 4
LOWER SUBASE; NSB-NLON; GROTON, CONNECTICUT

SAMPLE NUMBER:	LS4GW00101-F	LS4GW00201	LS4GW00201-F	012191-NESOMW10S	NESO10	NESO10
INVESTIGATION:	1997RI	1997RI	1997RI	PH1	PH2-1	PH2-1
SAMPLE DATE:	10/29/97	10/29/97	10/29/97	01/21/91	03/07/94	03/07/94
LOCATION:	MW1-4RI	MW2-4RI	MW2-4RI	NESO10	NESO10	NESO10
VALIDATED:	VALIDATED	VALIDATED	VALIDATED	VALIDATED	VALIDATED	VALIDATED
FILTERING:	Filtered	Unfiltered	Filtered	Unfiltered	Unfiltered	Filtered
FIELD DUPLICATE OF:						
METALS (µg/L)						
SODIUM	264000	105000	119000	1440000 J	1130000	1110000
THALLIUM	4.8 U	4.8 U	4.8 U	2 UR	10 UJ	10 UJ
VANADIUM	0.58 U	2.9 U	2.9 U	20 U	5 U	5 U
ZINC	90.8 J	4.3 U	105 J	63.4	14.4 J	20.6
PETROLEUM HYDROCARBONS (µg/L)						
TPH		1100 U		3000 U	500 U	
WATER QUALITY PARAMETERS						
DISSOLVED OXYGEN (MG/L)		4.7				
REDOX POTENTIAL (MV)		52.1				
SALINITY (PPT)		0.45				
SPECIFIC CONDUCTIVITY (MS/CM)		0.908				
TEMPERATURE (C)		17.7				
MISCELLANEOUS PARAMETERS						
ALKALINITY AS CACO3 (MG/L)		130				
AMMONIA, AS NITROGEN (MG/L)		0.10 U				
CHLORIDE (MG/L)		230				
DIVALENT IRON (MG/L)		0				
HARDNESS AS CaCO3 (MG/L)		190			820	
METHANE (UG/L)		5.4 U				
NITRATE, AS NITROGEN (MG/L)		7.9 J				
PHOSPHORUS (MG/L)		0.19 J				
SULFATE (MG/L)		37				
TOTAL ORGANIC CARBON (MG/L)		5.1 J				
TURBIDITY (NTU)		0.95				

TABLE 7-13 (PAGE 23 OF 41)
SUMMARY OF POSITIVE GROUNDWATER ANALYTICAL RESULTS FOR ZONE 4
LOWER SUBASE; NSB-NLON; GROTON, CONNECTICUT

SAMPLE NUMBER:	LS4GW00101-F	LS4GW00201	LS4GW00201-F	012191-NESOMW10S	NESO10	NESO10
INVESTIGATION:	1997RI	1997RI	1997RI	PH1	PH2-1	PH2-1
SAMPLE DATE:	10/29/97	10/29/97	10/29/97	01/21/91	03/07/94	03/07/94
LOCATION:	MW1-4RI	MW2-4RI	MW2-4RI	NESO10	NESO10	NESO10
VALIDATED:	VALIDATED	VALIDATED	VALIDATED	VALIDATED	VALIDATED	VALIDATED
FILTERING:	Filtered	Unfiltered	Filtered	Unfiltered	Unfiltered	Filtered
FIELD DUPLICATE OF:						
GENERAL CHEMISTRY						
PH		6.83				

TABLE 7-13 (PAGE 24 OF 41)
SUMMARY OF POSITIVE GROUNDWATER ANALYTICAL RESULTS FOR ZONE 4
LOWER SUBASE; NSB-NLON; GROTON, CONNECTICUT

SAMPLE NUMBER:	NESO10-2	NESO10-2	LS4GWNESO1001	LS4GWNESO1001-F	012191-NESO11	NESO11
INVESTIGATION:	PH2-2	PH2-2	1997RI	1997RI	PH1	PH2-1
SAMPLE DATE:	06/23/94	06/23/94	10/30/97	10/30/97	01/21/91	03/08/94
LOCATION:	NESO10	NESO10	NESO10	NESO10	NESO11	NESO11
VALIDATED:	VALIDATED	VALIDATED	VALIDATED	VALIDATED	VALIDATED	VALIDATED
FILTERING:	Unfiltered	Filtered	Unfiltered	Filtered	Unfiltered	Unfiltered
FIELD DUPLICATE OF:						
VOLATILES (µg/L)						
1,1,1-TRICHLOROETHANE	10 U				1 J	10 U
1,1-DICHLOROETHANE	3 J				1 J	10 U
1,1-DICHLOROETHENE	10 U				4 J	10 U
ETHYLBENZENE	10 U				5 U	10 U
METHYLENE CHLORIDE	10 U				5 U	10 U
TOLUENE	10 U				5 U	10 U
VINYL CHLORIDE	10 U				10 U	10 U
XYLENES, TOTAL	10 U				5 U	10 U
SEMIVOLATILES (µg/L)						
2,4-DIMETHYLPHENOL	10 U		12 U			10 U
ACENAPHTHENE	10 U		12 U			10 U
BENZO(A)ANTHRACENE	10 U		12 U			1 J
BENZO(A)PYRENE	10 U		12 U			0.8 J
BENZO(B)FLUORANTHENE	10 U		12 U			0.6 J
BENZO(G,H,I)PERYLENE	10 U		12 U			1 J
BENZO(K)FLUORANTHENE	10 U		12 U			1 J
BIS(2-ETHYLHEXYL)PHTHALATE	10 U		12 U			10 J
CARBAZOLE	10 U		12 U			10 U
CHRYSENE	10 U		12 U			0.9 J
DI-N-BUTYL PHTHALATE	10 U		12 U			10 U
DIBENZOFURAN	10 U		12 U			10 U
FLUORANTHENE	10 U		12 U			2 J
FLUORENE	10 U		12 U			10 U
INDENO(1,2,3-CD)PYRENE	10 U		12 U			0.7 J

TABLE 7-13 (PAGE 25 OF 41)
SUMMARY OF POSITIVE GROUNDWATER ANALYTICAL RESULTS FOR ZONE 4
LOWER SUBASE; NSB-NLON; GROTON, CONNECTICUT

SAMPLE NUMBER:	NESO10-2	NESO10-2	LS4GWNESO1001	LS4GWNESO1001-F	012191-NESO11	NESO11
INVESTIGATION:	PH2-2	PH2-2	1997RI	1997RI	PH1	PH2-1
SAMPLE DATE:	06/23/94	06/23/94	10/30/97	10/30/97	01/21/91	03/08/94
LOCATION:	NESO10	NESO10	NESO10	NESO10	NESO11	NESO11
VALIDATED:	VALIDATED	VALIDATED	VALIDATED	VALIDATED	VALIDATED	VALIDATED
FILTERING:	Unfiltered	Filtered	Unfiltered	Filtered	Unfiltered	Unfiltered
FIELD DUPLICATE OF:						
SEMIVOLATILES (µg/L)						
NAPHTHALENE	10 U		12 U			10 U
PHENANTHRENE	10 U		12 U			1 J
PYRENE	10 U		12 U			2 J
METALS (µg/L)						
ALUMINUM	35.2 U	15 U	10.0 UJ	10.0 UJ	30 U	40800
ANTIMONY	13 U	13 U	2.5 U	2.5 U	25 U	57.9 U
ARSENIC	19	11	2.8 J	3.1 J	3 U	17.1 J
BARIUM	134	139	117	452	25.8	283
BERYLLIUM	1 U	1 U	0.11 U	0.11 U	1 U	2.6 J
BORON	804	825			1.2 R	155
CADMIUM	3 U	3 U	0.60 U	0.47 U	6.9 J	13.2
CALCIUM	104000	107000	93700	94400	36100	59100
CHROMIUM	4 U	4 U	1.4 U	0.92 U	5 U	116
COBALT	5 U	5 U	0.80 U	0.80 U	5 U	25.6 J
COPPER	5 U	5 U	4.3 U	4.1 U	9.2	649
IRON	5270	3320	8780	6880 J	384 J	36700
LEAD	2 UJ	20 UJ	1.3 J	1.4 J	22.2 J	2760 J
MAGNESIUM	201000	208000	161000	162000	2530	11100
MANGANESE	249	258	435	408	234	1980
MERCURY	0.2 U	0.2 U	0.01 UJ	0.02 U	0.2 UJ	0.47 J
NICKEL	11 U	11 U	1.2 J	1.2 J	20.9 J	80
POTASSIUM	72000	75300	54200	55500	6700	12400
SELENIUM	2 UJ	2.1 J	1.9 U	1.9 U	1 UJ	3 UJ
SILVER	2 U	2 U	1.1 U	1.1 U	7 UJ	2 UJ

TABLE 7-13 (PAGE 26 OF 41)
SUMMARY OF POSITIVE GROUNDWATER ANALYTICAL RESULTS FOR ZONE 4
LOWER SUBASE; NSB-NLON; GROTON, CONNECTICUT

SAMPLE NUMBER:	NESO10-2	NESO10-2	LS4GWNESO1001	LS4GWNESO1001-F	012191-NESO11	NESO11
INVESTIGATION:	PH2-2	PH2-2	1997RI	1997RI	PH1	PH2-1
SAMPLE DATE:	06/23/94	06/23/94	10/30/97	10/30/97	01/21/91	03/08/94
LOCATION:	NESO10	NESO10	NESO10	NESO10	NESO11	NESO11
VALIDATED:	VALIDATED	VALIDATED	VALIDATED	VALIDATED	VALIDATED	VALIDATED
FILTERING:	Unfiltered	Filtered	Unfiltered	Filtered	Unfiltered	Unfiltered
FIELD DUPLICATE OF:						
METALS (µg/L)						
SODIUM	1850000	1970000	1320000	1330000	40800 J	81600
THALLIUM	10 UJ	10 UJ	4.8 U	4.8 U	2 UR	10 UJ
VANADIUM	4.6 J	4 U	0.55 U	0.65 U	20 U	105
ZINC	33.2	13.9	21.6	113	55.6 J	924
PETROLEUM HYDROCARBONS (µg/L)						
TPH	500 U		1100 U		2000 U	500 U
WATER QUALITY PARAMETERS						
DISSOLVED OXYGEN (MG/L)			15.36 R			
REDOX POTENTIAL (MV)			-147.3			
SALINITY (PPT)			3.26			
SPECIFIC CONDUCTIVITY (MS/CM)			5.945			
TEMPERATURE (C)			19.62			
MISCELLANEOUS PARAMETERS						
ALKALINITY AS CACO3 (MG/L)			150			
AMMONIA, AS NITROGEN (MG/L)			0.93 J			
CHLORIDE (MG/L)			2200			
DIVALENT IRON (MG/L)			2			
HARDNESS AS CaCO3 (MG/L)	1180		770			128
METHANE (UG/L)			1700			
NITRATE, AS NITROGEN (MG/L)			0.13			
PHOSPHORUS (MG/L)			0.74 J			
SULFATE (MG/L)			290			
TOTAL ORGANIC CARBON (MG/L)			6.7 J			
TURBIDITY (NTU)			18			

TABLE 7-13 (PAGE 27 OF 41)
SUMMARY OF POSITIVE GROUNDWATER ANALYTICAL RESULTS FOR ZONE 4
LOWER SUBASE; NSB-NLON; GROTON, CONNECTICUT

SAMPLE NUMBER:	NESO10-2	NESO10-2	LS4GWNESO1001	LS4GWNESO1001-F	012191-NESO11	NESO11
INVESTIGATION:	PH2-2	PH2-2	1997RI	1997RI	PH1	PH2-1
SAMPLE DATE:	06/23/94	06/23/94	10/30/97	10/30/97	01/21/91	03/08/94
LOCATION:	NESO10	NESO10	NESO10	NESO10	NESO11	NESO11
VALIDATED:	VALIDATED	VALIDATED	VALIDATED	VALIDATED	VALIDATED	VALIDATED
FILTERING:	Unfiltered	Filtered	Unfiltered	Filtered	Unfiltered	Unfiltered
FIELD DUPLICATE OF:						
GENERAL CHEMISTRY						
PH			6.94			

TABLE 7-13 (PAGE 28 OF 41)
SUMMARY OF POSITIVE GROUNDWATER ANALYTICAL RESULTS FOR ZONE 4
LOWER SUBASE; NSB-NLON; GROTON, CONNECTICUT

SAMPLE NUMBER:	NESO11	NESO11-2	NESO11-2	LS4GWNESO1101	LS4GWNESO1101-F	LS4GWQW401
INVESTIGATION:	PH2-1	PH2-2	PH2-2	1997RI	1997RI	1997RI
SAMPLE DATE:	03/08/94	06/23/94	06/23/94	10/29/97	10/29/97	10/30/97
LOCATION:	NESO11	NESO11	NESO11	NESO11	NESO11	QW-4
VALIDATED:	VALIDATED	VALIDATED	VALIDATED	VALIDATED	VALIDATED	VALIDATED
FILTERING:	Filtered	Unfiltered	Filtered	Unfiltered	Filtered	Unfiltered
FIELD DUPLICATE OF:						
VOLATILES (µg/L)						
1,1,1-TRICHLOROETHANE		10 U				
1,1-DICHLOROETHANE		2 J				
1,1-DICHLOROETHENE		10 U				
ETHYLBENZENE		10 U				
METHYLENE CHLORIDE		10 U				
TOLUENE		10 U				
VINYL CHLORIDE		10 U				
XYLENES, TOTAL		10 U				
SEMIVOLATILES (µg/L)						
2,4-DIMETHYLPHENOL		10 U		11 U		12 U
ACENAPHTHENE		10 U		11 U		12 U
BENZO(A)ANTHRACENE		10 U		11 U		12 U
BENZO(A)PYRENE		10 U		11 U		12 U
BENZO(B)FLUORANTHENE		10 U		11 U		12 U
BENZO(G,H,I)PERYLENE		10 U		11 U		12 U
BENZO(K)FLUORANTHENE		10 U		11 U		12 U
BIS(2-ETHYLHEXYL)PHTHALATE		10 U		11 U		12 U
CARBAZOLE		10 U		11 U		12 U
CHRYSENE		10 U		11 U		12 U
DI-N-BUTYL PHTHALATE		10 U		11 U		12 U
DIBENZOFURAN		10 U		11 U		12 U
FLUORANTHENE		10 U		11 UJ		12 UJ
FLUORENE		10 U		11 U		12 U
INDENO(1,2,3-CD)PYRENE		10 U		11 U		12 U

TABLE 7-13 (PAGE 29 OF 41)
SUMMARY OF POSITIVE GROUNDWATER ANALYTICAL RESULTS FOR ZONE 4
LOWER SUBASE; NSB-NLON; GROTON, CONNECTICUT

SAMPLE NUMBER:	NESO11	NESO11-2	NESO11-2	LS4GWNESO1101	LS4GWNESO1101-F	LS4GWQW401
INVESTIGATION:	PH2-1	PH2-2	PH2-2	1997RI	1997RI	1997RI
SAMPLE DATE:	03/08/94	06/23/94	06/23/94	10/29/97	10/29/97	10/30/97
LOCATION:	NESO11	NESO11	NESO11	NESO11	NESO11	QW-4
VALIDATED:	VALIDATED	VALIDATED	VALIDATED	VALIDATED	VALIDATED	VALIDATED
FILTERING:	Filtered	Unfiltered	Filtered	Unfiltered	Filtered	Unfiltered
FIELD DUPLICATE OF:						
SEMIVOLATILES (µg/L)						
NAPHTHALENE		10 U		11 U		12 U
PHENANTHRENE		10 U		11 U		12 U
PYRENE		10 U		11 U		12 U
METALS (µg/L)						
ALUMINUM	14 U	17.6 U	23.2 U	10.4 U	10.0 UJ	178 U
ANTIMONY	22.3 U	13 U	13 U	5.9	6.2	2.5 U
ARSENIC	2 UJ	1.3 J	1 U	3.1 J	2.5 U	3.5 J
BARIUM	39.7 J	39.6	42.4	26.2	289	33.3 J
BERYLLIUM	1 U	1 U	1 U	0.11 UJ	0.11 UJ	0.11 UJ
BORON	156	242	230			
CADMIUM	2 U	3 U	3 U	0.22 U	0.22 U	0.79 U
CALCIUM	52300	60800	62300	37000	33600	208000
CHROMIUM	3 UJ	4 U	4 U	0.68 U	0.68 U	3.4 U
COBALT	4 U	5 U	5 U	0.80 U	0.80 U	1.4 J
COPPER	3.5 J	5 J	5 U	7.0 U	7.5 U	17.2 U
IRON	50 U	40.6 U	17.8 U	23.2 U	13.0 U	4470
LEAD	10.9 J	11.4 J	14.1	10.2	3.0 U	14.4 J
MAGNESIUM	2900 J	3560	3430	2230	2180	652000
MANGANESE	44.3	182	188	53.9	47.3	201
MERCURY	0.2 UJ	0.2 U	0.2 U	0.05 U	0.05 U	0.02 U
NICKEL	10 U	11 U	11 U	1.0 J	9.0 U	3.5 J
POTASSIUM	8000	9480	9570	8440	7610	224000
SELENIUM	3 UJ	2 U	2 U	1.9 U	1.9 U	1.9 U
SILVER	2 UJ	2 U	2 U	1.1 U	1.1 U	3.0

TABLE 7-13 (PAGE 30 OF 41)
SUMMARY OF POSITIVE GROUNDWATER ANALYTICAL RESULTS FOR ZONE 4
LOWER SUBASE; NSB-NLON; GROTON, CONNECTICUT

SAMPLE NUMBER:	NESO11	NESO11-2	NESO11-2	LS4GWNESO1101	LS4GWNESO1101-F	LS4GWQW401
INVESTIGATION:	PH2-1	PH2-2	PH2-2	1997RI	1997RI	1997RI
SAMPLE DATE:	03/08/94	06/23/94	06/23/94	10/29/97	10/29/97	10/30/97
LOCATION:	NESO11	NESO11	NESO11	NESO11	NESO11	QW-4
VALIDATED:	VALIDATED	VALIDATED	VALIDATED	VALIDATED	VALIDATED	VALIDATED
FILTERING:	Filtered	Unfiltered	Filtered	Unfiltered	Filtered	Unfiltered
FIELD DUPLICATE OF:						
METALS (µg/L)						
SODIUM	81800	57800	57800	84200	87000	5380000
THALLIUM	1 UJ	10 U	1 UJ	5.3 U	4.8 U	4.8 UJ
VANADIUM	5 U	4 U	4 U	2.0 U	1.8 U	3.2 U
ZINC	11.1 J	16.2	14.4	9.4 U	126 J	198
PETROLEUM HYDROCARBONS (µg/L)						
TPH		500 U		1000 U		1100 U
WATER QUALITY PARAMETERS						
DISSOLVED OXYGEN (MG/L)				0.71		1.19
REDOX POTENTIAL (MV)				31.6		-30.5
SALINITY (PPT)				0.26		12.22
SPECIFIC CONDUCTIVITY (MS/CM)				0.54		20.38
TEMPERATURE (C)				20.2		16.58
MISCELLANEOUS PARAMETERS						
ALKALINITY AS CACO3 (MG/L)				110		92
AMMONIA, AS NITROGEN (MG/L)				0.10 U		0.20
CHLORIDE (MG/L)				350		8500
DIVALENT IRON (MG/L)				0		0.6
HARDNESS AS CaCO3 (MG/L)		164		93		3300
METHANE (UG/L)				5.4 U		6.1
NITRATE, AS NITROGEN (MG/L)				0.17		0.61
PHOSPHORUS (MG/L)				0.48 J		0.36 J
SULFATE (MG/L)				11		1500
TOTAL ORGANIC CARBON (MG/L)				4.5 J		2.7 J
TURBIDITY (NTU)				1.9		9.3

TABLE 7-13 (PAGE 31 OF 41)
SUMMARY OF POSITIVE GROUNDWATER ANALYTICAL RESULTS FOR ZONE 4
LOWER SUBASE; NSB-NLON; GROTON, CONNECTICUT

SAMPLE NUMBER:	NESO11	NESO11-2	NESO11-2	LS4GWNESO1101	LS4GWNESO1101-F	LS4GWQW401
INVESTIGATION:	PH2-1	PH2-2	PH2-2	1997RI	1997RI	1997RI
SAMPLE DATE:	03/08/94	06/23/94	06/23/94	10/29/97	10/29/97	10/30/97
LOCATION:	NESO11	NESO11	NESO11	NESO11	NESO11	QW-4
VALIDATED:	VALIDATED	VALIDATED	VALIDATED	VALIDATED	VALIDATED	VALIDATED
FILTERING:	Filtered	Unfiltered	Filtered	Unfiltered	Filtered	Unfiltered
FIELD DUPLICATE OF:						
GENERAL CHEMISTRY						
PH				6.75		6.73

TABLE 7-13 (PAGE 32 OF 41)
SUMMARY OF POSITIVE GROUNDWATER ANALYTICAL RESULTS FOR ZONE 4
LOWER SUBASE; NSB-NLON; GROTON, CONNECTICUT

SAMPLE NUMBER:	LS4GWQW401-F	012291-WEMW1S	WE-1	WE-1	WE1-2	WE1-2
INVESTIGATION:	1997RI	PH1	PH2-1	PH2-1	PH2-2	PH2-2
SAMPLE DATE:	10/30/97	01/22/91	03/07/94	03/07/94	06/23/94	06/23/94
LOCATION:	QW-4	WE1	WE1	WE1	WE1	WE1
VALIDATED:	VALIDATED	VALIDATED	VALIDATED	VALIDATED	VALIDATED	VALIDATED
FILTERING:	Filtered	Unfiltered	Unfiltered	Filtered	Unfiltered	Filtered
FIELD DUPLICATE OF:						
VOLATILES (µg/L)						
1,1,1-TRICHLOROETHANE		5 U	10 U		10 U	
1,1-DICHLOROETHANE		5 U	10 U		6 J	
1,1-DICHLOROETHENE		5 U	10 U		10 U	
ETHYLBENZENE		5 U	10 U		8 J	
METHYLENE CHLORIDE		5 U	10 U		10 U	
TOLUENE		5 U	10 U		10 U	
VINYL CHLORIDE		10 U	10 U		10 U	
XYLENES, TOTAL		5 U	10 U		27	
SEMIVOLATILES (µg/L)						
2,4-DIMETHYLPHENOL			10 U		10 U	
ACENAPHTHENE			10 U		10 U	
BENZO(A)ANTHRACENE			10 U		10 U	
BENZO(A)PYRENE			10 U		10 U	
BENZO(B)FLUORANTHENE			10 U		10 U	
BENZO(G,H,I)PERYLENE			10 U		10 U	
BENZO(K)FLUORANTHENE			10 U		10 U	
BIS(2-ETHYLHEXYL)PHTHALATE			10 U		1 J	
CARBAZOLE			10 U		10 U	
CHRYSENE			10 U		10 U	
DI-N-BUTYL PHTHALATE			10 U		10 U	
DIBENZOFURAN			10 U		10 U	
FLUORANTHENE			10 U		10 U	
FLUORENE			10 U		10 U	
INDENO(1,2,3-CD)PYRENE			10 U		10 U	

TABLE 7-13 (PAGE 33 OF 41)
SUMMARY OF POSITIVE GROUNDWATER ANALYTICAL RESULTS FOR ZONE 4
LOWER SUBASE; NSB-NLON; GROTON, CONNECTICUT

SAMPLE NUMBER:	LS4GWQW401-F	012291-WEMW1S	WE-1	WE-1	WE1-2	WE1-2
INVESTIGATION:	1997RI	PH1	PH2-1	PH2-1	PH2-2	PH2-2
SAMPLE DATE:	10/30/97	01/22/91	03/07/94	03/07/94	06/23/94	06/23/94
LOCATION:	QW-4	WE1	WE1	WE1	WE1	WE1
VALIDATED:	VALIDATED	VALIDATED	VALIDATED	VALIDATED	VALIDATED	VALIDATED
FILTERING:	Filtered	Unfiltered	Unfiltered	Filtered	Unfiltered	Filtered
FIELD DUPLICATE OF:						
SEMIVOLATILES (µg/L)						
NAPHTHALENE			10 U		10 U	
PHENANTHRENE			10 U		10 U	
PYRENE			10 U		10 U	
METALS (µg/L)						
ALUMINUM	10.0 UJ	30 U	14 U	14 U	15 U	15 U
ANTIMONY	2.5 U	25 U	15 U	15.9 U	13 U	13 U
ARSENIC	3.1 J	4.8	5.2 J	4.4 J	5.3	5.6
BARIUM	224	15 U	10.2 J	9.2 J	10.9 U	9.6 U
BERYLLIUM	0.11 UJ	1 U	1 U	1 U	1 U	1 U
BORON		1.4 R	80.8	79.5	81.9 J	78.8 J
CADMIUM	0.45 U	2 UJ	2 U	2 U	3 U	3 U
CALCIUM	221000	23500	30700	31200	31200	29000
CHROMIUM	0.68 U	5 U	3 UJ	3 UJ	4 U	4 U
COBALT	0.80 U	5 U	4 U	4 U	5 U	5 U
COPPER	5.7 U	5 U	2 U	2 U	5 U	5 U
IRON	574	1080 J	1630	1320	1310	1170
LEAD	1.3 U	2.1 J	2 UJ	2 UJ	2 UJ	11.2
MAGNESIUM	701000	7570	8360	8740	8490	7720
MANGANESE	117	95.2	148	150	127	118
MERCURY	0.02 U	0.2 UJ	0.2 UJ	0.2 UJ	0.2 U	0.2 U
NICKEL	9.0 U	17.3 J	10 U	10 U	11 U	11 U
POTASSIUM	246000	6410	6770	7400	7450	6950
SELENIUM	1.9 U	1 UJ	3 UJ	3 UJ	2 U	2 U
SILVER	3.4	7 UJ	2 UJ	2 UJ	2 U	2 U

TABLE 7-13 (PAGE 34 OF 41)
SUMMARY OF POSITIVE GROUNDWATER ANALYTICAL RESULTS FOR ZONE 4
LOWER SUBASE; NSB-NLON; GROTON, CONNECTICUT

SAMPLE NUMBER:	LS4GWQW401-F	012291-WEMW1S	WE-1	WE-1	WE1-2	WE1-2
INVESTIGATION:	1997RI	PH1	PH2-1	PH2-1	PH2-2	PH2-2
SAMPLE DATE:	10/30/97	01/22/91	03/07/94	03/07/94	06/23/94	06/23/94
LOCATION:	QW-4	WE1	WE1	WE1	WE1	WE1
VALIDATED:	VALIDATED	VALIDATED	VALIDATED	VALIDATED	VALIDATED	VALIDATED
FILTERING:	Filtered	Unfiltered	Unfiltered	Filtered	Unfiltered	Filtered
FIELD DUPLICATE OF:						
METALS (µg/L)						
SODIUM	5810000	48900 J	65300	67900	60500	56200
THALLIUM	6.2 U	2 UR	10 UJ	1 UJ	1 UJ	1 UJ
VANADIUM	0.55 U	20 U	5 U	5 U	4 U	4 U
ZINC	118 J	8.2 J	2 U	4.8 U	3 U	3 U
PETROLEUM HYDROCARBONS (µg/L)						
TPH		2000 U	500 U		500	
MISCELLANEOUS PARAMETERS						
HARDNESS AS CaCO3 (MG/L)			116		106	

TABLE 7-13 (PAGE 35 OF 41)
SUMMARY OF POSITIVE GROUNDWATER ANALYTICAL RESULTS FOR ZONE 4
LOWER SUBASE; NSB-NLON; GROTON, CONNECTICUT

SAMPLE NUMBER:	LS4GWWE101	LS4GWWE101-F	012291-WEMW4S	012391-WEMW5S	WE-5	WE-5
INVESTIGATION:	1997RI	1997RI	PH1	PH1	PH2-1	PH2-1
SAMPLE DATE:	10/29/97	10/29/97	01/22/91	01/23/91	03/07/94	03/07/94
LOCATION:	WE1	WE1	WE4	WE5	WE5	WE5
VALIDATED:	VALIDATED	VALIDATED	VALIDATED	VALIDATED	VALIDATED	VALIDATED
FILTERING:	Unfiltered	Filtered	Unfiltered	Unfiltered	Unfiltered	Filtered
FIELD DUPLICATE OF:						
VOLATILES (µg/L)						
1,1,1-TRICHLOROETHANE			5 U	5 U	10 U	
1,1-DICHLOROETHANE			5 U	5 U	10 U	
1,1-DICHLOROETHENE			5 U	5 U	10 U	
ETHYLBENZENE			5 U	5 U	10 U	
METHYLENE CHLORIDE			5 U	5 U	10 U	
TOLUENE			5 U	5 U	10 U	
VINYL CHLORIDE			10 U	10 U	10 U	
XYLENES, TOTAL			5 U	5 U	5 J	
SEMIVOLATILES (µg/L)						
2,4-DIMETHYLPHENOL	12 U				10 U	
ACENAPHTHENE	12 U				10 U	
BENZO(A)ANTHRACENE	12 U				10 U	
BENZO(A)PYRENE	12 U				10 U	
BENZO(B)FLUORANTHENE	12 U				10 U	
BENZO(G,H,I)PERYLENE	12 U				10 U	
BENZO(K)FLUORANTHENE	12 UJ				10 U	
BIS(2-ETHYLHEXYL)PHTHALATE	12 U				10 U	
CARBAZOLE	12 U				10 U	
CHRYSENE	12 U				10 U	
DI-N-BUTYL PHTHALATE	12 U				10 U	
DIBENZOFURAN	12 U				10 U	
FLUORANTHENE	12 UJ				10 U	
FLUORENE	12 U				10 U	
INDENO(1,2,3-CD)PYRENE	12 U				10 U	

TABLE 7-13 (PAGE 36 OF 41)
SUMMARY OF POSITIVE GROUNDWATER ANALYTICAL RESULTS FOR ZONE 4
LOWER SUBASE; NSB-NLON; GROTON, CONNECTICUT

SAMPLE NUMBER:	LS4GWWE101	LS4GWWE101-F	012291-WEMW4S	012391-WEMW5S	WE-5	WE-5
INVESTIGATION:	1997RI	1997RI	PH1	PH1	PH2-1	PH2-1
SAMPLE DATE:	10/29/97	10/29/97	01/22/91	01/23/91	03/07/94	03/07/94
LOCATION:	WE1	WE1	WE4	WE5	WE5	WE5
VALIDATED:	VALIDATED	VALIDATED	VALIDATED	VALIDATED	VALIDATED	VALIDATED
FILTERING:	Unfiltered	Filtered	Unfiltered	Unfiltered	Unfiltered	Filtered
FIELD DUPLICATE OF:						
SEMIVOLATILES (µg/L)						
NAPHTHALENE	12 U				10 U	
PHENANTHRENE	12 U				10 U	
PYRENE	12 U				10 U	
METALS (µg/L)						
ALUMINUM	30.7 U	15.0 U	30 U	30 U	116 J	14 U
ANTIMONY	2.5 U	2.5 U	25 U	25 U	15 U	15 U
ARSENIC	2.5 U	2.5 U	3 U	5.2	29.6 J	2.3 J
BARIUM	10.7	210	17.1	32.2	50.7 J	34.3 J
BERYLLIUM	0.19 U	0.19 U	1 U	1 U	1 U	1 U
BORON			1.8 R	0.4 R	192	195
CADMIUM	0.22 U	0.22 U	2 UJ	2 UJ	2 U	2 U
CALCIUM	33000	30800	23600	22400	25200	24500
CHROMIUM	3.1 U	3.1 U	5 U	5 U	3 UJ	3 UJ
COBALT	2.9 U	2.9 U	5 U	5 U	4 U	4 U
COPPER	1.5 U	1.5 U	5 U	5 U	2 U	2 U
IRON	1500	453	1020 J	10200 J	28900	2780
LEAD	1.3 U	1.3 U	2.9 J	2 J	140 J	2 UJ
MAGNESIUM	9410	8650	3630	3950	4810 J	4740 J
MANGANESE	99.9 U	89.4 U	68.9	673	759	611
MERCURY	0.05 U	0.05 U	0.2 UJ	0.2 UJ	0.2 UJ	0.2 UJ
NICKEL	9.0 U	9.0 U	14.9	17.1 J	10 U	10 U
POTASSIUM	7830	7070	4490	6380	7660	7540
SELENIUM	1.9 U	1.9 U	1 UJ	1 UJ	3 UJ	3 UJ
SILVER	2.8 U	2.8 U	7 UJ	7 UJ	2 UJ	2 UJ

TABLE 7-13 (PAGE 37 OF 41)
SUMMARY OF POSITIVE GROUNDWATER ANALYTICAL RESULTS FOR ZONE 4
LOWER SUBASE; NSB-NLON; GROTON, CONNECTICUT

SAMPLE NUMBER:	LS4GWWE101	LS4GWWE101-F	012291-WEMW4S	012391-WEMW5S	WE-5	WE-5
INVESTIGATION:	1997RI	1997RI	PH1	PH1	PH2-1	PH2-1
SAMPLE DATE:	10/29/97	10/29/97	01/22/91	01/23/91	03/07/94	03/07/94
LOCATION:	WE1	WE1	WE4	WE5	WE5	WE5
VALIDATED:	VALIDATED	VALIDATED	VALIDATED	VALIDATED	VALIDATED	VALIDATED
FILTERING:	Unfiltered	Filtered	Unfiltered	Unfiltered	Unfiltered	Filtered
FIELD DUPLICATE OF:						
METALS (µg/L)						
SODIUM	73900	76800	50900 J	48900 J	58100	57500
THALLIUM	4.8 U	4.8 U	2 UR	2 UR	1 UJ	1 UJ
VANADIUM	2.9 U	2.9 U	20 U	20 U	5 U	5 U
ZINC	7.8 U	115 J	11 J	9.6 J	7.7 U	3.3 U
PETROLEUM HYDROCARBONS (µg/L)						
TPH	1100 U		2000 U	3000 U	500 U	
WATER QUALITY PARAMETERS						
DISSOLVED OXYGEN (MG/L)	0.82					
REDOX POTENTIAL (MV)	-97.3					
SALINITY (PPT)	0.3					
SPECIFIC CONDUCTIVITY (MS/CM)	0.624					
TEMPERATURE (C)	23.72					
MISCELLANEOUS PARAMETERS						
ALKALINITY AS CACO3 (MG/L)	78					
AMMONIA, AS NITROGEN (MG/L)	1.3					
CHLORIDE (MG/L)	160					
DIVALENT IRON (MG/L)	1					
HARDNESS AS CaCO3 (MG/L)	110				80	
METHANE (UG/L)	410					
NITRATE, AS NITROGEN (MG/L)	1.0 J					
PHOSPHORUS (MG/L)	0.87 J					
SULFATE (MG/L)	15					
TOTAL ORGANIC CARBON (MG/L)	3.6 J					
TURBIDITY (NTU)	1.23					

TABLE 7-13 (PAGE 38 OF 41)
SUMMARY OF POSITIVE GROUNDWATER ANALYTICAL RESULTS FOR ZONE 4
LOWER SUBASE; NSB-NLON; GROTON, CONNECTICUT

SAMPLE NUMBER:	LS4GWWE101	LS4GWWE101-F	012291-WEMW4S	012391-WEMW5S	WE-5	WE-5
INVESTIGATION:	1997RI	1997RI	PH1	PH1	PH2-1	PH2-1
SAMPLE DATE:	10/29/97	10/29/97	01/22/91	01/23/91	03/07/94	03/07/94
LOCATION:	WE1	WE1	WE4	WE5	WE5	WE5
VALIDATED:	VALIDATED	VALIDATED	VALIDATED	VALIDATED	VALIDATED	VALIDATED
FILTERING:	Unfiltered	Filtered	Unfiltered	Unfiltered	Unfiltered	Filtered
FIELD DUPLICATE OF:						
GENERAL CHEMISTRY						
PH	6.56					

TABLE 7-13 (PAGE 39 OF 41)
SUMMARY OF POSITIVE GROUNDWATER ANALYTICAL RESULTS FOR ZONE 4
LOWER SUBASE; NSB-NLON; GROTON, CONNECTICUT

SAMPLE NUMBER:	WE5-2	WE5-2				
INVESTIGATION:	PH2-2	PH2-2				
SAMPLE DATE:	07/12/94	07/12/94	/ /	/ /	/ /	/ /
LOCATION:	WE5	WE5				
VALIDATED:	VALIDATED	VALIDATED				
FILTERING:	Unfiltered	Filtered				
FIELD DUPLICATE OF:						
VOLATILES (µg/L)						
1,1,1-TRICHLOROETHANE	10 U					
1,1-DICHLOROETHANE	10 U					
1,1-DICHLOROETHENE	10 U					
ETHYLBENZENE	10 U					
METHYLENE CHLORIDE	9 J					
TOLUENE	10 U					
VINYL CHLORIDE	10 U					
XYLENES, TOTAL	10 U					
SEMIVOLATILES (µg/L)						
2,4-DIMETHYLPHENOL	10 U					
ACENAPHTHENE	10 U					
BENZO(A)ANTHRACENE	10 U					
BENZO(A)PYRENE	10 U					
BENZO(B)FLUORANTHENE	10 U					
BENZO(G,H,I)PERYLENE	10 U					
BENZO(K)FLUORANTHENE	10 U					
BIS(2-ETHYLHEXYL)PHTHALATE	10 U					
CARBAZOLE	10 U					
CHRYSENE	10 U					
DI-N-BUTYL PHTHALATE	10 U					
DIBENZOFURAN	10 U					
FLUORANTHENE	10 U					
FLUORENE	10 U					
INDENO(1,2,3-CD)PYRENE	10 U					

TABLE 7-13 (PAGE 40 OF 41)
SUMMARY OF POSITIVE GROUNDWATER ANALYTICAL RESULTS FOR ZONE 4
LOWER SUBASE; NSB-NLON; GROTON, CONNECTICUT

SAMPLE NUMBER:	WE5-2	WE5-2				
INVESTIGATION:	PH2-2	PH2-2				
SAMPLE DATE:	07/12/94	07/12/94	/ /	/ /	/ /	/ /
LOCATION:	WE5	WE5				
VALIDATED:	VALIDATED	VALIDATED				
FILTERING:	Unfiltered	Filtered				
FIELD DUPLICATE OF:						
SEMIVOLATILES (µg/L)						
NAPHTHALENE	10 U					
PHENANTHRENE	10 U					
PYRENE	10 U					
METALS (µg/L)						
ALUMINUM	78.7 U	37.6 U				
ANTIMONY	12 U	12 U				
ARSENIC	11.8	4.9				
BARIUM	41.4	43.1				
BERYLLIUM	1 U	1 U				
BORON	129	131				
CADMIUM	2 U	2 U				
CALCIUM	25000	27800				
CHROMIUM	3 U	3 U				
COBALT	3 U	3 U				
COPPER	2 U	2 U				
IRON	12400	8490				
LEAD	48.9 J	2.5				
MAGNESIUM	4720	4980				
MANGANESE	522	536				
MERCURY	0.2 UJ	0.2 UJ				
NICKEL	7 U	7 U				
POTASSIUM	7680	7870				
SELENIUM	3 U	3 U				
SILVER	2 U	2 U				

TABLE 7-13 (PAGE 41 OF 41)
SUMMARY OF POSITIVE GROUNDWATER ANALYTICAL RESULTS FOR ZONE 4
LOWER SUBASE; NSB-NLON; GROTON, CONNECTICUT

SAMPLE NUMBER:	WE5-2	WE5-2				
INVESTIGATION:	PH2-2	PH2-2				
SAMPLE DATE:	07/12/94	07/12/94	/ /	/ /	/ /	/ /
LOCATION:	WE5	WE5				
VALIDATED:	VALIDATED	VALIDATED				
FILTERING:	Unfiltered	Filtered				
FIELD DUPLICATE OF:						
METALS (µg/L)						
SODIUM	63400	67500				
THALLIUM	5.5 J	6.8 J				
VANADIUM	3 U	3 U				
ZINC	2 U	7.5 U				
PETROLEUM HYDROCARBONS (µg/L)						
TPH	500 U					
MISCELLANEOUS PARAMETERS						
HARDNESS AS CaCO3 (MG/L)	90					

TABLE 7-14

SUMMARY OF HISTORICAL AND LOWER SUBASE RI GROUNDWATER ANALYTICAL RESULTS - ZONE 4
LOWER SUBASE
NSB-NLON, GROTON, CONNECTICUT
PAGE 1 OF 4

Analyte	Historical Data[1]				Lower Subase RI[2]		
	Frequency of Detection	Concentration Range	Maximum Detection		Frequency of Detection	Concentration Range	Location of Maximum Detection
			Location	Investigation[3]			
VOLATILE ORGANICS (µg/L)							
1,1,1-Trichloroethane	1/26	1	NESO11	PH1	NA	NA	ND
1,1-Dichloroethane	7/26	1 - 15	13MW13	PH1	NA	NA	ND
1,1-Dichloroethene	4/26	4 - 57	13MW13	PH1	NA	NA	ND
Ethylbenzene	2/26	2 - 8	WE1	PH2-2	NA	NA	ND
Methylene chloride	1/26	9	WE5	PH2-2	NA	NA	ND
Toluene	1/26	36	NESO10	PH1	NA	NA	ND
Vinyl chloride	2/26	5 - 12	13MW13	PH1	NA	NA	ND
Xylenes, total	3/26	5 - 27	WE1	PH2-2	NA	NA	ND
SEMIVOLATILE ORGANICS (µg/L)							
2,4-Dimethylphenol	0/16	ND	ND	ND	1/10	1	13MW16
Acenaphthene	2/16	0.8 - 1	13MW16	PH2-1	2/10	0.9 - 2	13MW16
Benzo(a)anthracene	1/16	1	NESO11	PH2-1	0/10	ND	ND
Benzo(a)pyrene	1/16	0.8	NESO11	PH2-1	0/10	ND	ND
Benzo(b)fluoranthene	1/16	0.6	NESO11	PH2-1	0/10	ND	ND
Benzo(g,h,i)perylene	1/16	1	NESO11	PH2-1	0/10	ND	ND
Benzo(k)fluoranthene	1/16	1	NESO11	PH2-1	0/10	ND	ND
Bis(2-Ethylhexyl)phthalate	2/16	1 - 10	NESO11	PH2-1	0/10	ND	ND
Carbazole	0/16	ND	ND	ND	1/10	0.7	13MW16
Chrysene	1/16	0.9	NESO11	PH2-1	0/10	ND	ND
Di-N-butyl phthalate	1/16	0.6	13MW16	PH2-2	0/10	ND	ND
Dibenzofuran	0/16	ND	ND	ND	1/10	1	13MW16
Fluoranthene	1/16	2	NESO11	PH2-1	0/10	ND	ND
Fluorene	0/16	ND	ND	ND	1/10	0.8	13MW16
Indeno(1,2,3-Cd)pyrene	1/16	0.7	NESO11	PH2-1	0/10	ND	ND
Naphthalene	2/16	0.6 - 0.8	13MW15	PH2-1	1/10	4	13MW16

TABLE 7-14

SUMMARY OF HISTORICAL AND LOWER SUBASE RI GROUNDWATER ANALYTICAL RESULTS - ZONE 4
LOWER SUBASE
NSB-NLON, GROTON, CONNECTICUT
PAGE 2 OF 4

Analyte	Historical Data[1]				Lower Subase RI[2]		
	Frequency of Detection	Concentration Range	Maximum Detection		Frequency of Detection	Concentration Range	Location of Maximum Detection
			Location	Investigation[3]			
Phenanthrene	1/16	1	NESO11	PH2-1	1/10	0.6	13MW16
Pyrene	3/16	1 - 2	NESO11	PH2-1	1/10	1	13MW15
INORGANICS (μg/L)							
Aluminum	5/26	18.2 - 40800	NESO11	PH2-1	0/10	ND	ND
Aluminum, filtered	1/16	11	13MW16	PH2-2	0/10	ND	ND
Antimony	0/23	ND	ND	ND	3/10	5.6 - 9	MW2-4RI
Antimony, filtered	2/16	8.1 - 14.8	13MW14	PH2-2	3/10	4.6 - 11.4	MW2-4RI
Arsenic	14/25	1.3 - 29.6	WE5	PH2-1	4/10	2.8 - 21.4	13MW13
Arsenic, filtered	5/16	2.3 - 11	NESO10	PH2-2	3/10	3.1 - 14.7	13MW13
Barium	21/26	6 - 283	NESO11	PH2-1	10/10	3.6 - 117	NESO10
Barium, filtered	13/16	6 - 139	NESO10	PH2-2	10/10	45.3 - 452	NESO10
Beryllium	2/26	1.1 - 2.6	NESO11	PH2-1	0/10	ND	ND
Boron	16/16	80.8 - 2070	13MW15	PH2-2	NA	NA	ND
Boron, filtered	16/16	78.8 - 2370	13MW15	PH2-2	NA	NA	ND
Cadmium	4/25	1.5 - 25.5	NESO10	PH1	0/10	ND	ND
Calcium	26/26	22400 - 181000	13MW15	PH2-1	10/10	33000 - 246000	13MW15
Calcium, filtered	16/16	24500 - 238000	13MW15	PH2-2	10/10	30800 - 251000	13MW15
Chromium	2/26	1.4 - 116	NESO11	PH2-1	1/10	4.7	13MW15
Cobalt	1/26	25.6	NESO11	PH2-1	1/10	1.4	QW-4
Cobalt, filtered	0/16	ND	ND	ND	1/10	1.1	13MW15
Copper	8/25	5 - 649	NESO11	PH2-1	2/10	1.7 - 8.7	13MW14
Copper, filtered	6/15	3.5 - 20.4	13MW16	PH2-2	2/10	1.6 - 8.5	13MW14
Iron	24/26	95.2 - 36700	NESO11	PH2-1	6/10	247 - 12000	13MW13
Iron, filtered	13/16	56.2 - 8490	WE5	PH2-2	6/10	339 - 9280	13MW13
Lead	13/22	1.6 - 2760	NESO11	PH2-1	5/10	1.3 - 14.4	QW-4
Lead, filtered	4/15	2.5 - 14.1	NESO11	PH2-2	2/10	1.4 - 6.8	13MW14

TABLE 7-14

SUMMARY OF HISTORICAL AND LOWER SUBASE RI GROUNDWATER ANALYTICAL RESULTS - ZONE 4
LOWER SUBASE
NSB-NLON, GROTON, CONNECTICUT
PAGE 3 OF 4

Analyte	Historical Data[1]				Lower Subase RI[2]		
	Frequency of Detection	Concentration Range	Maximum Detection		Frequency of Detection	Concentration Range	Location of Maximum Detection
			Location	Investigation[3]			
Magnesium	26/26	2530 - 776000	13MW15	PH2-2	10/10	2230 - 861000	13MW15
Magnesium, filtered	16/16	2900 - 781000	13MW16	PH2-2	10/10	2180 - 878000	13MW15
Manganese	25/26	3.4 - 1980	NESO11	PH2-1	8/10	9.4 - 435	NESO10
Manganese, filtered	15/16	6.1 - 611	WE5	PH2-1	8/10	8.7 - 408	NESO10
Mercury	1/26	0.47	NESO11	PH2-1	0/10	ND	ND
Nickel	12/26	11.6 - 80	NESO11	PH2-1	4/10	0.83 - 3.5	QW-4
Nickel, filtered	0/16	ND	ND	ND	1/10	1.2	NESO10
Potassium	26/26	4490 - 259000	13MW15	PH2-1	10/10	7830 - 285000	13MW15
Potassium, filtered	16/16	6950 - 263000	13MW15	PH2-1	10/10	7070 - 291000	13MW15
Selenium	1/23	7.7	13MW14	PH1	0/10	ND	ND
Selenium, filtered	1/15	2.1	NESO10	PH2-2	0/10	ND	ND
Silver	0/26	ND	ND	ND	3/10	1.5 - 4.1	13MW15
Silver, filtered	0/26	ND	ND	ND	1/10	3.4	QW-4
Sodium	26/26	40800 - 6310000	13MW15	PH2-2	10/10	73900 - 7120000	13MW15
Sodium, filtered	14/16	56200 - 6350000	13MW16	PH2-2	10/10	76800 - 7260000	13MW15
Thallium	4/17	3.6 - 11.5	13MW15	PH1	0/10	ND	ND
Thallium, filtered	1/15	6.8	WE5	PH2-2	0/10	ND	ND
Vanadium	3/26	4.6 - 105	NESO11	PH2-1	1/10	0.63	13MW15
Vanadium, filtered	1/16	5.7	13MW16	PH2-2	0/10	ND	ND
Zinc	18/25	4.9 - 924	NESO11	PH2-1	2/10	21.6 - 198	QW-4
Zinc, filtered	6/16	8.5 - 20.6	NESO10	PH2-1	8/10	84.2 - 126	NESO11
TOTAL PETROLEUM HYDROCARBONS (μg/L)							
TPH	4/26	500 - 5400	13MW16	PH1	0/10	ND	ND

TABLE 7-14

SUMMARY OF HISTORICAL AND LOWER SUBASE RI GROUNDWATER ANALYTICAL RESULTS - ZONE 4
LOWER SUBASE
NSB-NLON, GROTON, CONNECTICUT
PAGE 4 OF 4

1 Includes samples 011591-13MW14S, 012191-13MW13S, 012191-NESO11, 012191-NESOMW10S, 012291-13MW15S, 012291-13MW15S-D (field duplicate of 012291-13MW19S), 012291-WEMW1S, 012291-WEMW4S, 012391-13MW16S, 012391-WEMW5S, 13GW13, 13GW13-2, 13GW14-2, 13GW15, 13GW15-2, 13GW16-2, 13GW14, 13GW16, NESO10-2, NESO11-2, NESO10, NESO11, WE-1, WE-5, WE1-2, WE5-2.

2 Includes samples LS4GW00101, LS4GW00201, LS4GW13MW1301, LS4GW13MW1401, LS4GW13MW1501, LS4GW13MW1601, LS4GWNESO1001, LS4GWNESO1101, LS4GWQW401, LS4GWWE101.

3 PH1 = Phase I RI; PH2-1 = Round of Phase II RI; PH2-2 = Round 2 of Phase II RI.

NA - Not Analyzed.

ND - Not Detected.

TABLE 7-15

SUMMARY OF GROUNDWATER FLUORESCENCE SPECTROSCOPY DATA - ZONE 4
LOWER SUBASE
NSB-NLON, GROTON, CONNECTICUT

Sample	Observations
13MW13S[1]	No detection of these compounds was observed.
13MW14S[1]	Spectra is similar to waste oil/heavy residual fuel oil (i.e., No. 6 fuel oil) mixture.
13MW15S[1]	Spectra is similar to waste oil/heavy residual fuel oil (i.e., No. 6 fuel oil) mixture.
13MW16S[1]	Spectra is typical of heavy residual fuel oil.
WEMW1S[1]	No detection of these compounds was observed.
WEMW4S[1]	No detection of these compounds was observed.
WEMW5S[1]	No detection of these compounds was observed.
NESOMW10S[1][3]	Spectra is unresolved. Trace concentrations of petroleum hydrocarbons make oil identification by fluorescence impractical.
NESO11[1]	Spectra is unresolved. Trace concentrations of petroleum hydrocarbons make oil identification by fluorescence impractical.
NSB-WS-WE4-001[2]	Spectra typical of a heavy waste/fuel oil.
NSB-WS-WE1-002[2]	Spectra typical of a heavy waste/fuel oil.
NSB-WS-WE5-004[2]	Spectra typical of a heavy waste/fuel oil.
NSB-WE3-006[2]	Spectra typical of No. 6 fuel oil.
NSB-WS-WE3-007[2]	Results unavailable - sample lost during processing.
NSB-WS-MW10-008[2][3]	Spectra typical of No. 6 fuel oil

1 Data obtained from Phase I Remedial Investigation Report (Atlantic 1993).
2 Data obtained from Final Site Investigation Subsurface Oil Contamination (Wehran 1987).
3 This sample was collected from monitoring well currently called NESO10.

TABLE 7-16

SUMMARY OF NATURAL ATTENUATION AND WATER QUALITY PARAMETERS - ZONE 4
LOWER SUBASE
NSB-NLON, GROTON, CONNECTICUT

Analyte	Lower Subase RI[1]		
	Frequency of Detection	Concentration Range	Location of Maximum Detection
MISCELLANEOUS			
Alkalinity as CaCO3 (mg/L)	10/10	73 - 190	13MW15
Ammonia, as nitrogen (mg/L)	6/10	0.2 - 1.5	13MW15
Chloride (mg/L)	10/10	160 - 13000	13MW15
Dissolved oxygen (mg/L)	9/9	0.06 - 4.7	MW2-4RI
Divalent iron (mg/L)	5/10	0.6 - 4.6	13MW13
Hardness as CaCO3 (mg/L)	10/10	93 - 4000	13MW15
Methane (mg/L)	7/10	6.1 - 2100	NESO10
Nitrate, as nitrogen (mg/L)	10/10	0.057 - 7.9	MW2-4RI
pH	10/10	6.51 - 7.2	13MW15
Phosphorus (mg/L)	10/10	0.19 - 1.4	13MW13/13MW15
Redox potential (mV)	9/9	-193.6 - 84.3	MW1-4RI
Salinity (ppt)	10/10	0.26 - 21.88	13MW15
Specific conductivity (ms/cm)	10/10	0.54 - 34.71	13MW15
Sulfate (mg/L)	10/10	11 - 1500	QW-4
Temperature (C)	10/10	15.92 - 23.72	WE1
Total organic carbon (mg/L)	10/10	1.7 - 8.4	13MW15
Turbidity (NTU)	10/10	0.89 - 18	13MW13/NESO10

1 Includes samples LS4GW00101, LS4GW00201, LS4GW13MW1301, LS4GW13MW1401, LS4GW13MW1501, LS4GW13MW1601, LS4GWNESO1001, LS4GWNESO1101, LS4GWQW401, LS4GWWE101.

TABLE 7-17
SUMMARY OF POSITIVE STORM SEWER SURFACE WATER ANALYTICAL RESULTS FOR ZONE 4 LOWER SUBASE; NSB-NLON; GROTON, CONNECTICUT

SAMPLE NUMBER:	BLD_85	BLD_85	BLD_85			
INVESTIGATION:	ST_SEWER	ST_SEWER	ST_SEWER			
SAMPLE DATE:	02/28/95	10/08/96	06/19/97	/ /	/ /	/ /
LOCATION:	BLD_85	BLD_85	BLD_85			
VALIDATED:						
FILTERING:	Unfiltered	Unfiltered	Unfiltered			
FIELD DUPLICATE OF:						
METALS (µg/L)						
COPPER	0.12	0.26	0.01 U			
IRON			1.27			
LEAD	0.083	0.17	0.19			
SODIUM			121			
ZINC	0.12	0.45	0.01 U			
PETROLEUM HYDROCARBONS (µg/L)						
OIL & GREASE	2500	1000 U	1000 U			
MISCELLANEOUS PARAMETERS (mg/L)						
AMMONIA, AS NITROGEN			0.4			
CHEMICAL OXYGEN DEMAND	10	222	25.6			
CHLORIDE			286			
FECAL COLIFORM	100	2700	300			
NITRATE, AS NITROGEN	1.3	1.67	1.7			
SULFATE			66.5			
TOTAL DISSOLVED SOLIDS			60			
TOTAL KJELDAHL NITROGEN	0.32	1.26	1.68			
TOTAL PHOSPHORUS	0.1	0.21	0.16			
TOTAL SUSPENDED SOLIDS	110	201	370			
GENERAL CHEMISTRY						
PH	6.6	5.85	5.72			

TABLE 7-18

CHEMICALS OF CONCERN - ZONE 4
LOWER SUBASE
NSB-NLON, GROTON, CONNNECTICUT

Chemicals of Concern[1]		
Shallow Soil (0 - 5 Feet)	**All Soil (0 - 10 Feet)**	**Groundwater[2]**
Benzo(a)anthracene	Benzo(a)anthracene	1,1-Dichloroethene
Benzo(a)pyrene	Benzo(a)pyrene	Methylene Chloride
Benzo(b)fluoranthene	Benzo(b)fluoranthene	Vinyl Chloride
Benzo(k)fluoranthene	Benzo(k)fluoranthene	Benzo(a)anthracene
Carbazole	Carbazole	Benzo(a)pyrene
Chrysene	Chrysene	Benzo(b)fluoranthene
Dibenzo(a,h)anthracene	Dibenzo(a,h)anthracene	Benzo(g,h,i)perylene
Indeno(1,2,3-cd)pyrene	Indeno(1,2,3-cd)pyrene	Benzo(k)fluoranthene
Antimony	Antimony	Bis(2-ethylhexyl)phthalate
Arsenic	Arsenic	Chrysene
Beryllium	Beryllium	Indeno(1,2,3-cd)pyrene
Cadmium	Cadmium	Phenanthrene
Chromium (total)	Chromium (total)	Aluminum (unfiltered only)
Iron	Iron	Antimony
Lead	Lead	Arsenic
Nickel	Nickel	Barium
TPH	TPH	Beryllium (unfiltered only)
		Boron
		Cadmium (unfiltered only)
		Chromium (total) (unfiltered only)
		Copper
		Iron
		Lead
		Manganese
		Mercury (unfiltered only)
		Nickel (unfiltered only)
		Silver
		Sodium
		Thallium
		Vanadium (unfiltered only)
		Zinc
		TPH

1 Chemical is identified as a Chemical of Concern (COC) if the maximum detection in a single sample exceeds one or more criteria (i.e., Region III COC screening level, State Remediation Standards, Federal Soil Screening Levels, etc.).

2 Unless otherwise noted, the inorganic chemicals presented are COCs for the unfiltered and filtered groundwater sample matrix.

TABLE 7-19

EXPOSURE CONCENTRATIONS FOR DIRECT EXPOSURE CHEMICALS OF CONCERN - ZONE 4 LOWER SUBASE NSB-NLON, GROTON, CONNECTICUT

Direct Exposure Chemicals of Concern	Exposure Concentration		
	Surface Soil[1] (mg/kg)	All Soil[1] (mg/kg)	Groundwater[2] (mg/L)
VOLATILE ORGANIC COMPOUNDS			
1,1-Dichloroethene	NA[3]	NA	0.0068/0.0273
Methylene Chloride	NA	NA	0.0045/0.0055
Vinyl Chloride	NA	NA	0.0053/0.0073
SEMIVOLATILE ORGANIC COMPOUNDS			
Benzo(a)anthracene	1.2/5.3	2.7	0.001[4]
Benzo(a)pyrene	1.0/4.3	0.55/4.3	0.0008[4]
Benzo(b)fluoranthene	1.0/4.3	2.5	0.0006[4]
Benzo(k)fluoranthene	NA	NA	0.001[4]
Bis(2-ethylhexyl)phthalate	NA	NA	0.0058/0.010
Dibenzo(a,h)anthracene	0.41/1.5	0.61	NA
Indeno(1,2,3-cd)pyrene	0.83/3.4	0.45/3.4	0.0007[4]
INORGANICS			
Antimony	1.3/3.3	0.87/3.3	0.0076/0.009[4]
Arsenic	3.5/4.5	2.9/4.5	0.0054/0.0155
Barium	NA	NA	0.0508/0.111
Beryllium	0.15/0.28	0.13/0.28	0.00039/0.00091
Boron	NA	NA	0.787/1.98
Cadmium	NA	NA	0.0016/0.0071
Chromium (total)	NA	NA	0.0041/0.0302
Lead	2170/10600	1510/10600	0.0676/0.701
Manganese	NA	NA	0.188/0.651
Nickel	NA	NA	0.0088/0.0269
Thallium	NA	NA	0.0034/0.0057
Vanadium	NA	NA	0.0059/0.0295

1 UCL if single concentration is presented, otherwise average concentration is used for CTE and maximum detected concentration is used for RME unless otherwise noted. See Section 3.3.1.

2 Average concentration is used for CTE and maximum concentration is used for RME. Maximum is defined as the highest average concentration in a single well, and the average is defined as the overall average concentration of all well-specific averages.

3 NA - Not applicable. Chemical is not a chemical of concern for this medium.

4 Maximum concentration is presented since average concentration exceeds the maximum detected concentration.

TABLE 7-20

ESTIMATED RISKS[1] - ZONE 4
LOWER SUBASE
NSB-NLON, GROTON, CONNECTICUT

Exposure Route	Construction Worker		Full-Time Employee		Future Resident	
	RME[2]	CTE[3]	RME	CTE	RME	CTE
HAZARD INDEX						
Incidental Ingestion of Soil	0.053	0.009	0.014	0.004	0.037	0.005
Dermal Contact with Soil	0.009	0.0007	0.010	0.002	0.010	0.002
Total Risk from Soil	0.062	0.010	0.024	0.006	0.047	0.007
Dermal Contact with Groundwater	0.67	0.17	NA[4]	NA	NA	NA
Cumulative Risk:	0.73	0.18	0.024	0.006	0.047	0.007
INCREMENTAL CANCER RISK						
Incidental Ingestion of Soil	1.6E-06	1.9E-07	1.2E-05	4.5E-07	3.3E-05	9.1E-07
Dermal Contact with Soil	1.6E-06	6.7E-08	6.2E-05	3.2E-06	8E-05	1.5E-06
Total Risk from Soil	3.2E-06	2.6E-07	7.4E-05	3.7E-06	1.1E-04	2.4E-06
Dermal Contact with Groundwater	9.1E-07	2.4E-07	NA	NA	NA	NA
Cumulative Risk:	4.1E-06	5.0E-07	7.4E-05	3.7E-06	1.1E-04	2.4E-06

1 Chemical-specific risks presented in Appendix I.8.
2 RME - Reasonable Maximum Exposure.
3 CTE - Central Tendency Exposure.
4 NA - Not applicable; exposure route not evaluated for this receptor.

TABLE 7-21

SUMMARY OF MAJOR CONTRIBUTORS TO RISK - ZONE 4
LOWER SUBASE
NSB-NLON, GROTON, CONNECTICUT

Receptor	Chemical	Cancer Risk	Percent Contribution
Construction Worker - RME	Benzo(a)pyrene	8.6E-06	59%
Full-Time Employee - RME	Benzo(a)anthracene	5.3E-06	7%
	Benzo(a)pyrene	4.3E-05	58%
	Benzo(b)fluoranthene	4.3E-06	6%
	Dibenzo(a,h)anthracene	1.5E-05	20%
	Indeno(1,2,3-cd)pyrene	3.4E-06	5%
	Arsenic	3.1E-06	4%
Full-Time Employee - CTE	Benzo(a)pyrene	1.9E-06	29%
	Arsenic	3.2E-06	50%
Future Resident - RME	Benzo(a)anthracene	4.9E-06	4%
	Benzo(a)pyrene	7.9E-05	70%
	Benzo(b)fluoranthene	4.6E-06	4%
	Dibenzo(a,h)anthracene	1.1E-05	9.9%
	Indeno(1,2,3-cd)pyrene	6.2E-06	6%
	Arsenic	7.2E-06	6%

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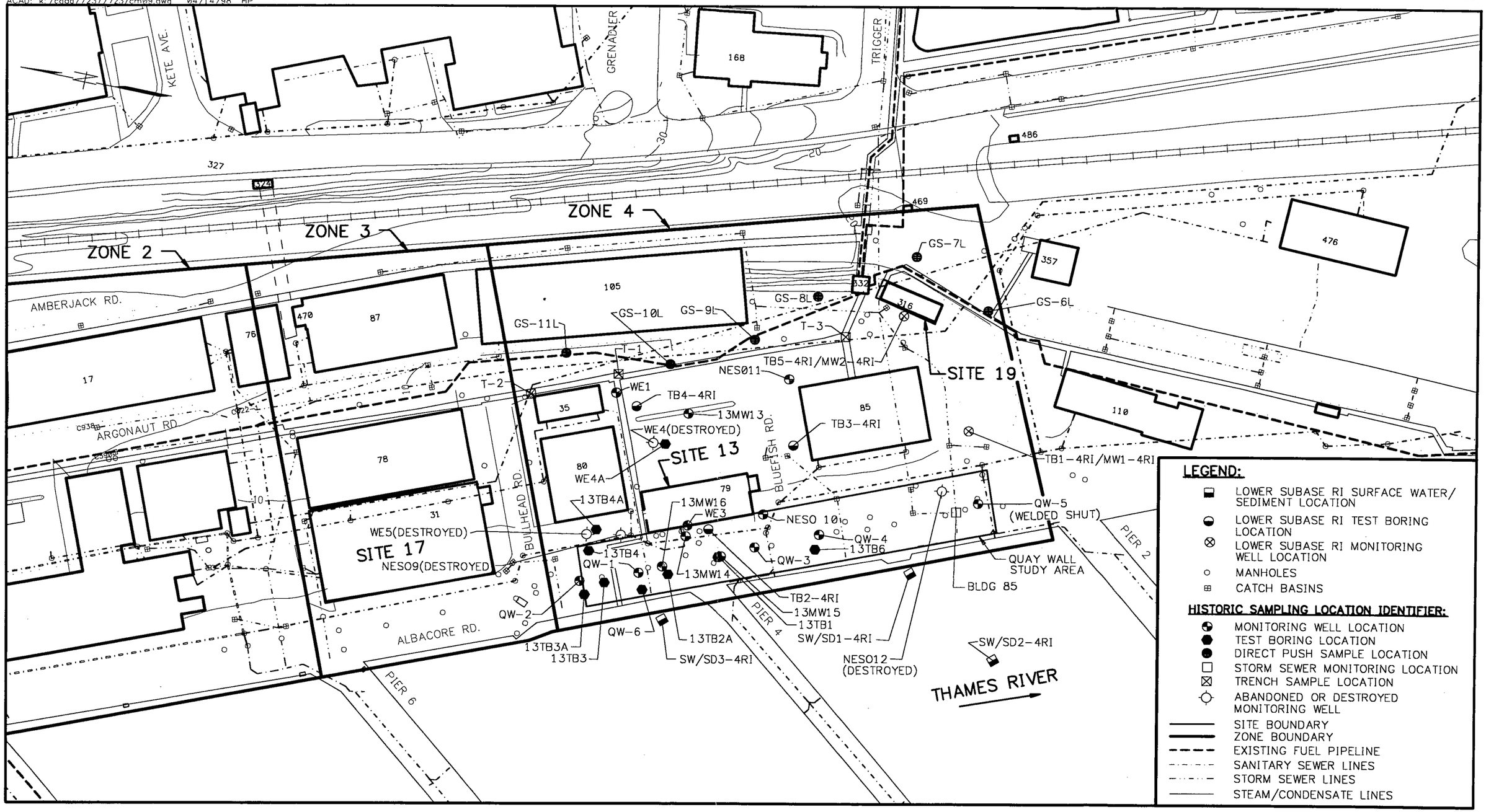

FIGURE 7-1

SAMPLE LOCATION MAP
ZONE 4
NSB-NLON, GROTON, CONNECTICUT

0 80 160
SCALE IN FEET

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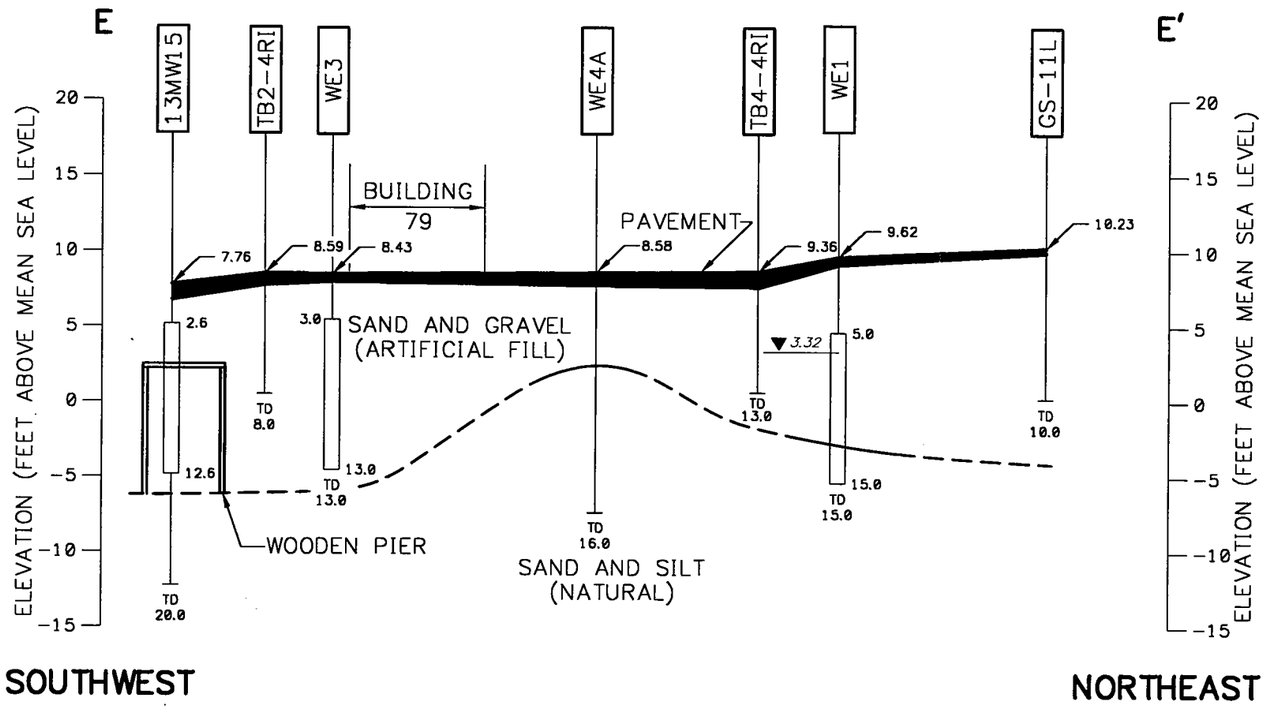

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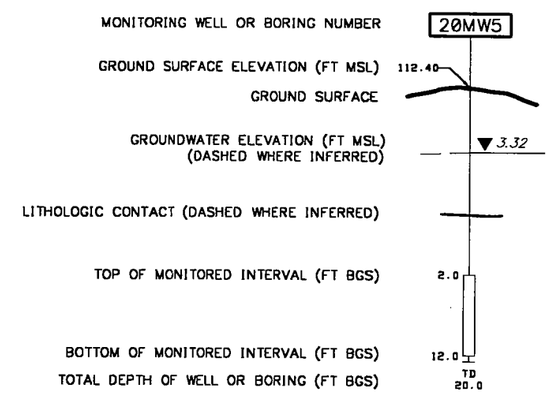

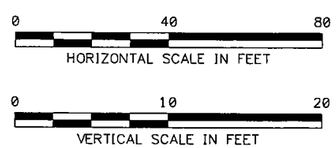

NOTES

1.) ELEVATIONS BASED ON SUBASE VERTICAL DATUM (1982)
2.) POTENTIOMETRIC SURFACE FOR LOW TIDE OCTOBER 27, 1997
3.) WOODEN PIER SUPPPORT LOCATIONS WERE ESTIMATED
4.) SEE DRAWING 5 FOR CROSS SECTION LOCATION

NO.	DATE	REVISIONS	BY	CHKD	APPD	REFERENCES

DRAWN BY MF DATE 2/15/98
CHECKED BY DATE
COST/SCHED-AREA
SCALE AS NOTED

Brown & Root Environmental

GENERALIZED GEOLOGIC CROSS SECTION E – E'
ZONE 4
LOWER SUBASE RI
NSB-NLON, GROTON, CONNECTICUT

CONTRACT NO. 7237
OWNER NO. 0260
APPROVED BY Corey A. Pink DATE 10/7/98
APPROVED BY DATE
DRAWING NO. FIGURE 7-2
REV. 0

FORM CADD NO. SOUTH_BH.DGN - REV 0 - 02/11/97

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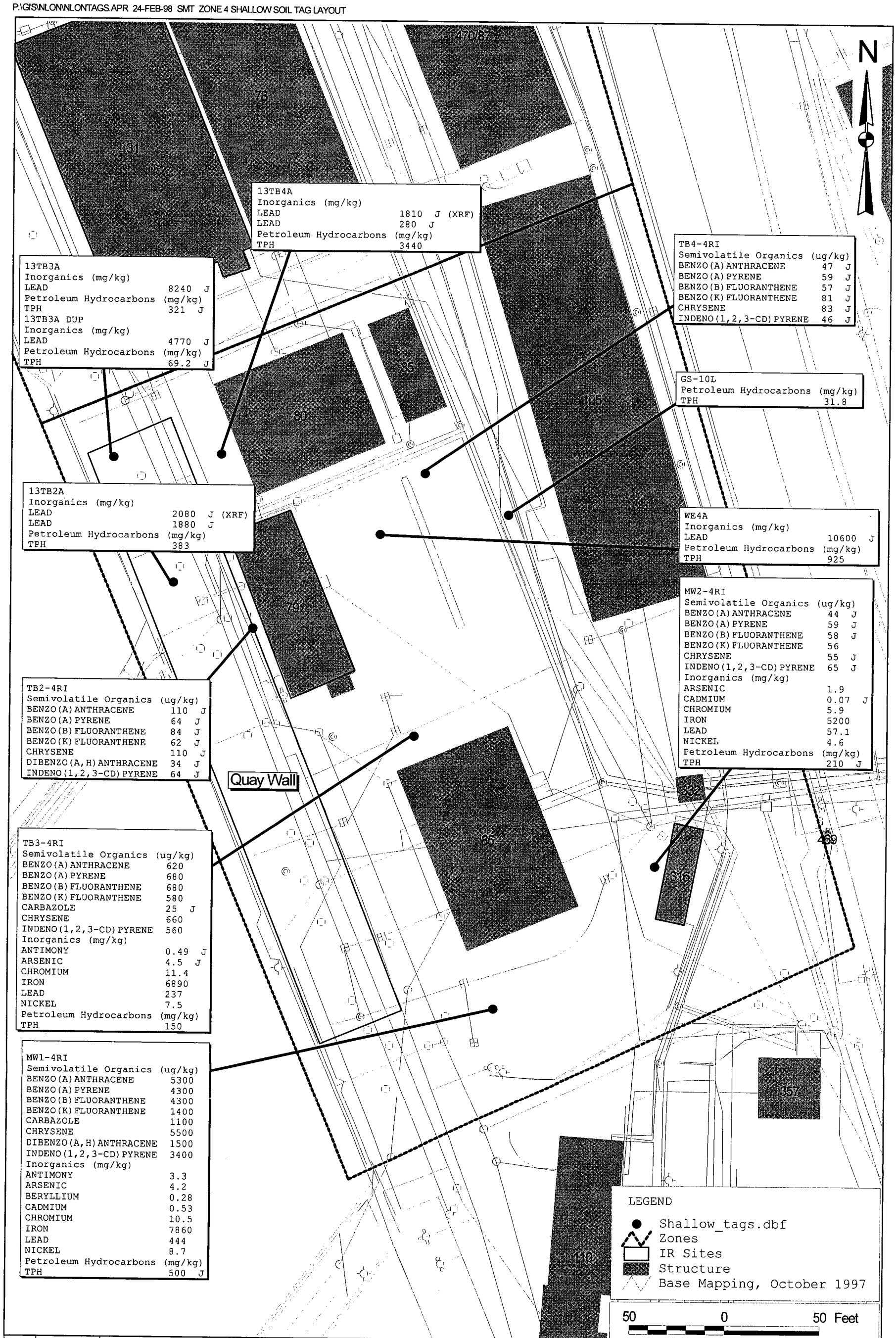


NO.	DATE	REVISIONS

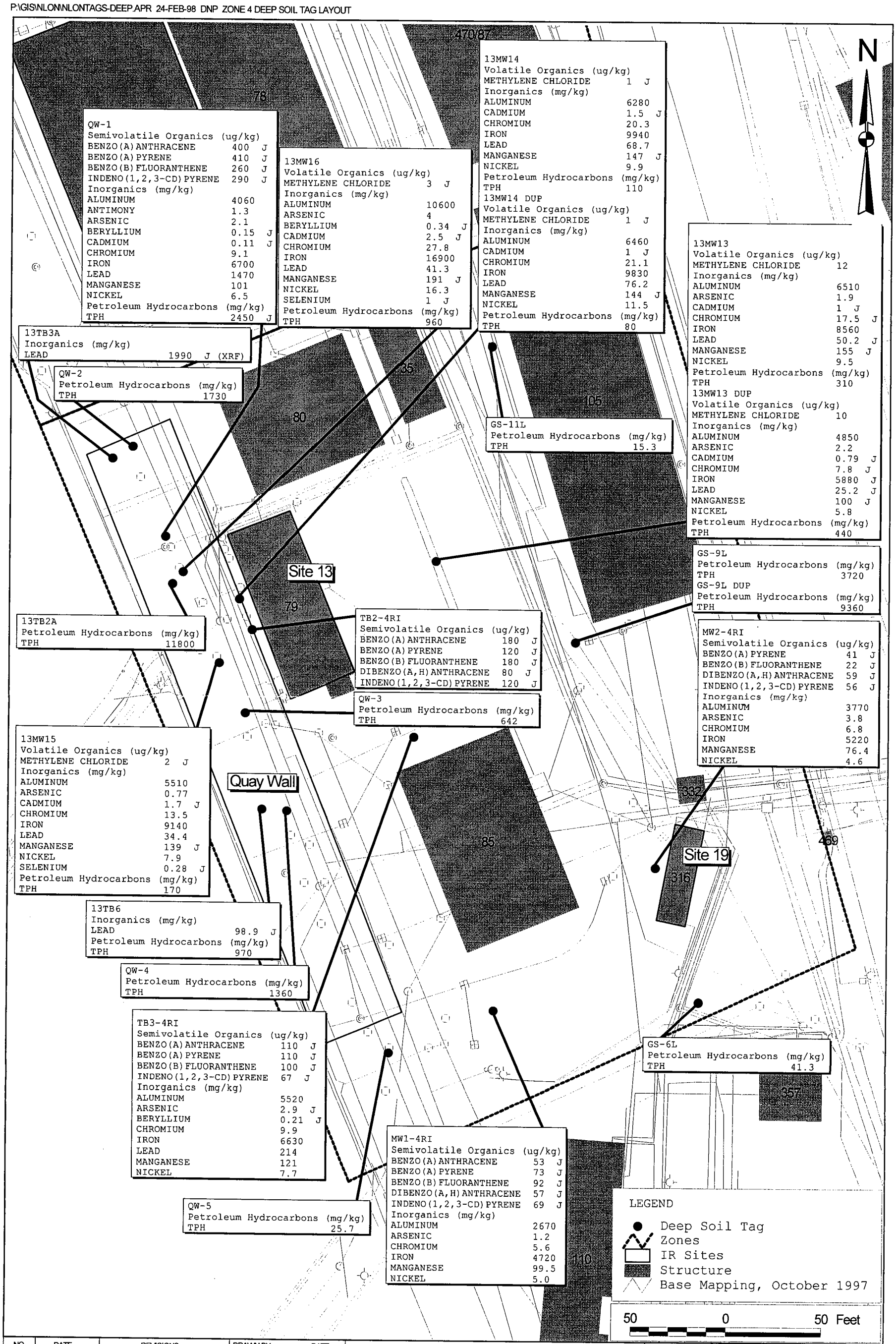
DRAWN BY D. PERRY DATE 17-FEB-98
CHECKED BY DATE
COST/SCHED-AREA
SCALE AS NOTED

Brown & Root Environmental

ZONE 4 SHALLOW SOIL
COPC POSITIVE DETECTS
LOWER SUBASE RI
NSB-NLON, GROTON, CONNECTICUT

CONTRACT NO. OWNER NO.
APPROVED BY Gary A Reid DATE 4/15/98
APPROVED BY DATE
DRAWING NO. FIGURE 7-3 REV. 0

P:\GIS\NLON\NLONTAGS-DEEP.APR 24-FEB-98 DNP ZONE 4 DEEP SOIL TAG LAYOUT



NO.	DATE	REVISIONS	DRAWN BY	DATE	Brown & Root Environmental	CONTRACT NO.	OWNER NO.
			D. PERRY	24-FEB-98			
			CHECKED BY	DATE	ZONE 4 DEEP SOIL COPC POSITIVE DETECTS LOWER SUBASE RI NSB-NLON, GROTON, CONNECTICUT	APPROVED BY Cory A Reid	DATE 4/15/98
			COST/SCHED-AREA			APPROVED BY	DATE
			SCALE AS NOTED			DRAWING NO. FIGURE 7-4	REV. 0

019809/P

REVISION 1
OCTOBER 1998

CTO 0260

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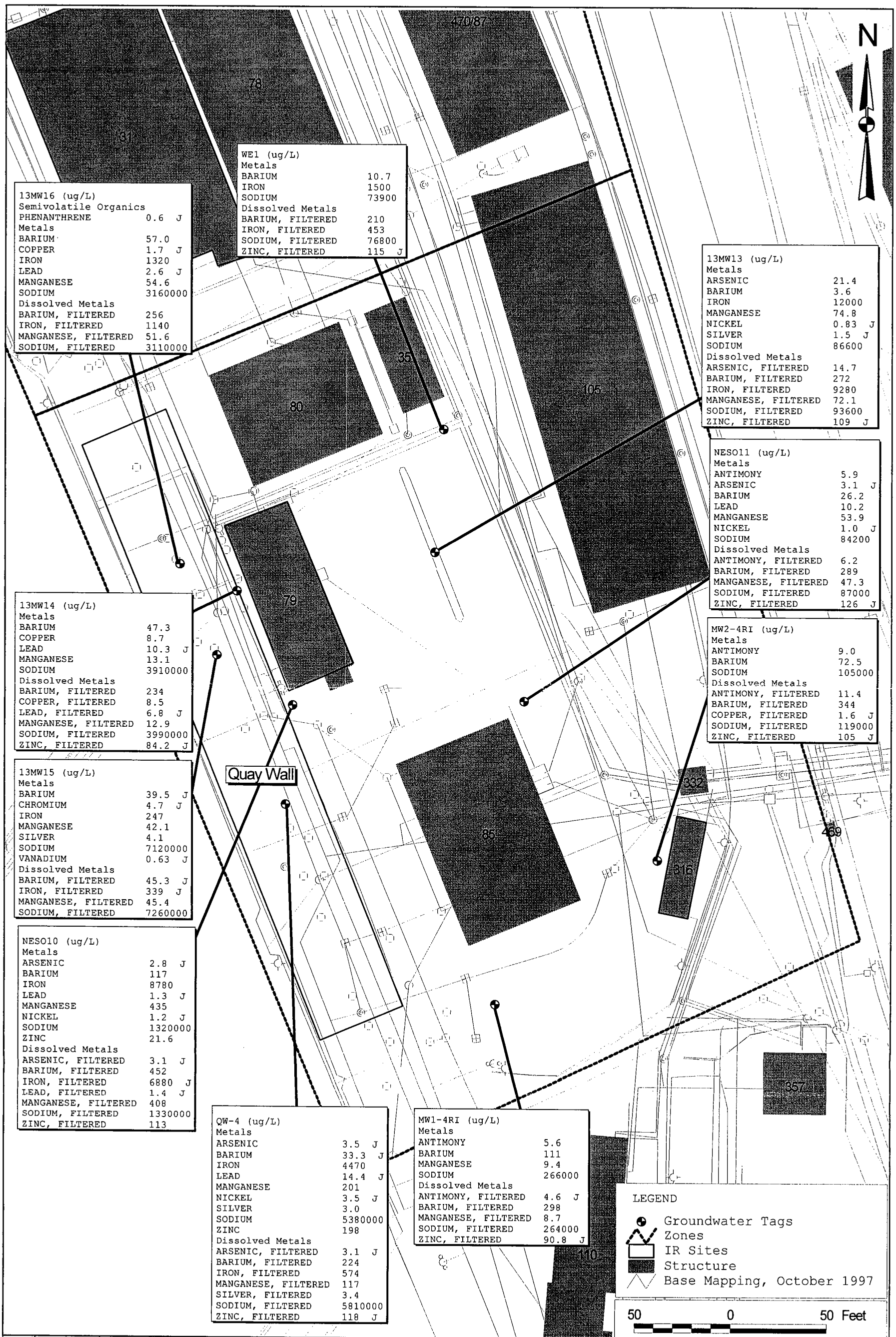

NO.	DATE	REVISIONS

DRAWN BY S. TABLER DATE 25-FEB-98
CHECKED BY DATE
COST/SCHED-AREA
SCALE AS NOTED

Brown & Root Environmental

ZONE 4 GROUNDWATER
COPC POSITIVE DETECTS
LOWER SUBASE RI
NSB-NLON, GROTON, CONNECTICUT

CONTRACT NO. OWNER NO.
APPROVED BY Gary A Rial DATE 4/15/98
APPROVED BY DATE
DRAWING NO. FIGURE 7-5 REV. 0

REVISION 1
OCTOBER 1998